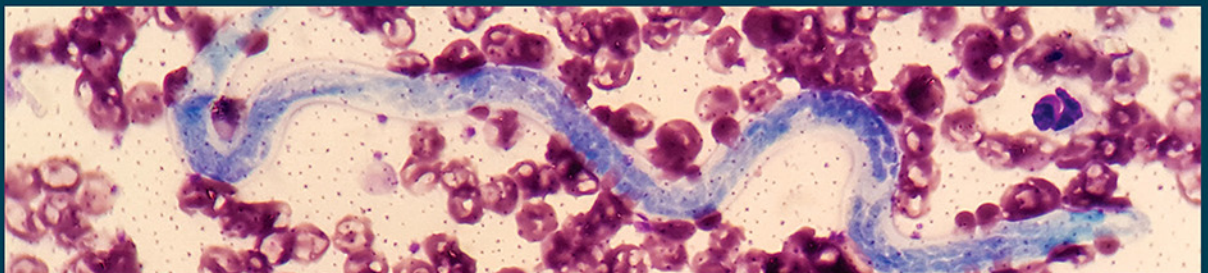


Charles M. Hendrix
Ed Robinson

Diagnostic Parasitology for Veterinary Technicians

Sixth Edition



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Sixth Edition

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*To Dr. Delmar Finco, an outstanding veterinary educator.
Thank you for teaching me how to think. SKI-U-MAH!*

—Charles M. Hendrix, DVM, PhD

*To Edward W. Robinson, who taught me to never stop learning
and to pass my knowledge on the next generation.*

—Ed Robinson, CVT

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Preface

Veterinary clinical parasitology is one of the most important disciplines in any veterinary curriculum, be it a curriculum that trains veterinary students or one that trains veterinary technicians/nurses.

Organization

This new edition was prepared to follow the educational structure used in parasitology classes in veterinary technology education. Our textbook is intended to inform the reader of the most commonly encountered internal and external parasites of both domesticated and laboratory animals.

The text begins with a list of parasites by host species with their corresponding page numbers for those instructors who use the parasite-by-host method of education in parasitology. Next, we detail the language of parasitology, defining the many terms that describe the intricate host-parasite relationships found in veterinary parasitology. These terms are the “framework” of the discipline and the means of communication among veterinary professionals and their clients. Every veterinary practitioner, veterinarian, veterinary technician/nurse, and student must learn to communicate effectively in this language. Each succeeding chapter describes a different parasite group: protozoans (one-celled organisms), trematodes (flukes), cestodes (tapeworms), nematodes (roundworms), acanthocephalans (thorny-headed worms), arthropods (insects, mites, and ticks), hirudineans (leeches), and pentastomes (tongue worms). As with the last edition, each of these parasite groups is described in detail, with specific emphasis placed on morphology, uniqueness of the life cycle, and important parasites within the group.

New to This Edition

One of the most important roles of veterinary professionals (veterinarians and veterinary technicians/nurses) is educating the public (clients) for the promotion of public health. In the case of parasitology, this includes education about zoonotic parasites in companion animals, production animals, working animals, and even wildlife. Because it is often difficult to engage students in the important role of client education, we have added an epilogue to this edition. This epilogue highlights the veterinary oath taken by veterinarians and the oath taken by veterinary technicians/nurses. It further highlights the similarities in public health promotion in both oaths. We have also included a template covering the *what*, *who*, *when*, *where*, *why*, and *how* questions regarding how humans and animals can be infected/infested with zoonotic parasites as a useful framework for communicating about parasitology. We have chosen five zoonotic parasites and organized the important information on these parasites into the template as a guideline for instructors and students to use for other parasites. In addition, these can be used to engage students in practice client education exercises so that they can gain experience in imparting such information to clients.

Throughout the text, the information on parasites has been updated, and new information has been added to better prepare the technician/nurse for the parasites currently seen in veterinary practice.

An appendix with treatments and preventatives has been added. The veterinary professional should refer to *Plumb's Veterinary Drug Handbook* or other pharmaceutical drug handbooks for species-specific dosages.

This latest edition of *Diagnostic Parasitology for Veterinary Technicians* was prepared with the veterinary technician/nurse in mind. Parasitology is a large part of the technician's/nurse's job in any veterinary clinic. Veterinary technicians/nurses are responsible for collecting, preparing, and examining fecal tests. In addition, the veterinary technician/nurse is responsible for client education in general and parasite education in particular. The information contained within this text will help veterinary technicians/nurses become familiar with the parasites seen in veterinary medicine. The text also includes case presentations and shows how the client was educated on the parasite in each case.

Evolve Resources

Case Questions have been created to accompany many of the pictures found throughout the text. The Case Questions will assist the student of parasitology in further learning the course material by using pictures of the parasites in different forms to answer the questions.

Compare and Contrast Charts have been included in the Evolve Resources. These charts can be filled in and used to study the different major parasites by noting the similarities and differences between the chosen parasites.

Listen and Spell Exercises have also been included; these help students ensure that they can spell and pronounce important terms correctly.

Finally, Flash Cards are provided that contain multiple categories for easy review: scientific name, common name, derivation of the name, audio pronunciation, type of parasite, adult morphology, immature stage morphology, location, clinical signs, infection route, diagnostic test, zoonosis, human disease, and a unique fact. These Flash Cards will help the student of parasitology learn the important facts about each parasite in an interactive way. They are an exciting addition to this text that will help make learning and teaching parasitology fun.

Charles M. Hendrix
Ed Robinson

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Parasites by Host Species

Parasite	Host	Location of Adult	Distribution	Common Name	Page
Canines and Felines					
Nematodes					
Gastrointestinal Tract					
<i>Spirocerca lupi</i>	Dogs and cats	Esophageal wall	Tropical and subtropical regions	Esophageal worm of dogs and cats	23
<i>Physaloptera</i> sp.	Dogs and cats	Lumen of stomach and small intestine	Worldwide	Stomach worm of dogs and cats	23
<i>Aonchotheca putorii</i>	Cats	Small intestine		Gastric capillarid of cats	24
<i>Ollulanus tricuspis</i>	Cats	Stomach		Feline trichostrongyle	25
<i>Toxocara canis</i>	Dogs	Small intestine	Worldwide	Canine roundworm	25
<i>Toxocara cati</i>	Cats	Small intestine	Worldwide	Feline roundworm	25
<i>Toxascaris leonina</i>	Dogs and cats	Small intestine	Worldwide	Roundworm of dogs and cats	25
<i>Baylisascaris procyonis</i>	Raccoons, dogs, cats, and other species	Small intestine	North America	Roundworm of raccoons	27
<i>Ancylostoma caninum</i>	Dogs	Small intestine	Worldwide	Canine hookworm	28
<i>Ancylostoma tubaeforme</i>	Cats	Small intestine	Worldwide	Feline hookworm	28
<i>Ancylostoma braziliense</i>	Dogs and cats	Small intestine	Worldwide	Hookworm of dogs and cats	28
<i>Uncinaria stenocephala</i>	Dogs	Small intestine	Northern regions of North America	Canine hookworm	28
<i>Strongyloides stercoralis</i>	Dogs, cats, and humans	Small intestine	Worldwide	Canine intestinal threadworm	30
<i>Strongyloides tumefaciens</i>	Dogs and cats	Small intestine	Worldwide	Canine intestinal threadworm	30

Continued

Parasites by Host Species —cont'd					
Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Trichuris vulpis</i>	Dogs	Cecum and colon	Worldwide	Canine whipworm	31
<i>Trichuris campanula</i>	Cats	Cecum and colon	Worldwide but rare in North America	Feline whipworm	31
<i>Trichuris serrata</i>	Cats	Cecum and colon	Worldwide but rare in North America	Feline whipworm	31
Circulatory System					
<i>Dirofilaria immitis</i>	Dogs, cats, and humans	Right ventricle and pulmonary artery	Warm to temperate climates	Heartworm	34
Respiratory System					
<i>Aelurostrongylus abstrusus</i>	Cats	Bronchioles and alveolar ducts	Worldwide	Feline lungworm	39
<i>Oslerus</i> (formerly <i>Filaroides</i>) <i>osleri</i>	Dogs	Trachea	North America, Europe, and Japan	Canine lungworm	39
<i>Oslerus</i> (formerly <i>Filaroides</i>) <i>hirthi</i>	Dogs	Lung parenchyma	North America, Europe, and Japan	Canine lungworm	39
<i>Oslerus</i> (formerly <i>Filaroides</i>) <i>milksi</i>	Dogs	Bronchioles	North America, Europe, and Japan	Canine lungworm	39
<i>Eucoleus</i> (formerly <i>Capillaria</i>) <i>aerophilus</i>	Dogs and cats	Bronchi and trachea		Capillarid lungworm of dogs and cats	41
<i>Eucoleus</i> (formerly <i>Capillaria</i>) <i>böehmi</i>	Dogs	Nasal cavity and frontal sinuses		Capillarid respiratory worm of dogs	41
Urinary Tract					
<i>Diectophyma renale</i>	Dogs	Right kidney	North America and Europe	Giant kidney worm of dogs	41
<i>Pearsonema</i> (formerly <i>Capillaria</i>) <i>plica</i>	Dogs	Urinary bladder		Bladder worm of dogs	42
<i>Pearsonema</i> (formerly <i>Capillaria</i>) <i>feliscati</i>	Cats	Urinary bladder		Bladder worm of cats	42
Skin					
<i>Rhabditis strongyloides</i>	Dogs	Superficial layers of the skin			40
<i>Acanthocheilonema</i> (formerly <i>Dipetalonema</i>) <i>reconditum</i>	Dogs	Subcutaneous tissues	Tropical and subtropical regions	Canine subcutaneous filarial worm	44
<i>Dracunculus insignis</i>	Dogs	Subcutaneous tissues		Guinea worm	44
Eye and Adnexa					
<i>Thelazia californiensis</i>	Dogs and cats	Conjunctival sac and lacrimal duct	North America	Eyeworm of dogs and cats	45

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
Cestodes					
Gastrointestinal Tract					
<i>Dipylidium caninum</i>	Dogs and cats	Small intestine	Worldwide	Cucumber seed tapeworm or double-pored tapeworm	95
<i>Taenia pisiformis</i>	Dogs	Small intestine		Canine taeniid	98
<i>Taenia hydatigena</i>	Dogs	Small intestine		Canine taeniid	98
<i>Taenia ovis</i>	Dogs	Small intestine		Mutton tapeworm of dogs	98
<i>Taenia taeniaeformis</i>	Cats	Small intestine		Feline taeniid	100
<i>Multiceps serialis</i>	Dogs	Small intestine		Coenurus-producing tapeworm	103
<i>Echinococcus granulosus</i>	Dogs	Small intestine	Worldwide	Unilocular hydatid tapeworm	104
<i>Echinococcus multilocularis</i>	Cats	Small intestine	Countries in the Northern Hemisphere	Multilocular hydatid tapeworm	104
<i>Mesocestoides</i> sp.	Dogs, cats, and carnivores	Small intestine	North America, Asia, Europe, and Africa	Tetrathyridium tapeworm	105
<i>Spirometra</i> sp.	Dogs and cats	Small intestine	North America, South America, Far East, and Australia	Zipper tapeworm	109
<i>Taenia multiceps</i>	Dogs	Small intestine	Worldwide	Coenurus-producing tapeworm	103
<i>Dipyllobothrium latum</i>	Dogs, cats, and humans	Small intestine	North America, Scandinavian countries, and Ukraine	Broad fish tapeworm	110
Trematodes					
<i>Platynosomum fastosum</i>	Cats	Bile ducts	South America, southern United States, West Africa, Pacific Islands, Malaysia, and the Caribbean	"Lizard-poisoning fluke" of cats	122
<i>Nanophyetus salmincola</i>	Dogs	Small intestine	Pacific Northwest region of North America	"Salmon-poisoning fluke" of dogs	123
<i>Alaria</i> sp.	Dogs and cats	Small intestine	Northern United States and Canada	Intestinal fluke of dogs and cats	124

Continued

Parasites by Host Species —cont'd					
Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Paragonimus kellicotti</i>	Dogs and cats	Lung parenchyma	North America	Lung fluke of dogs and cats	125
<i>Heterobilharzia americana</i>	Dogs	Mesenteric veins of small and large intestines and portal veins	North America	Schistosome of dogs	125
Protozoans					
Gastrointestinal Tract					
Flagellates					
<i>Giardia</i> sp.	Dogs, cats, horses, humans, exotic species	Intestinal mucosa	Worldwide	Giardia	135
<i>Tritrichomonas blagburni</i>					
	cats	cecum, colon	North America	Tritrichomonas	
Amoebae					
<i>Entamoeba histolytica</i>	Dogs, cats, primates, and humans	Large intestine	Worldwide	<i>Entamoeba</i>	135
Ciliates					
<i>Balantidium coli</i>	Dogs and pigs	Cecum and colon	Worldwide	<i>Balantidium</i>	136
Apicomplexans					
<i>Cystoisospora</i> sp.	Dogs, cats, and pigs	Small intestine		Coccidia	136
<i>Toxoplasma gondii</i>	Cats	Intestines	Worldwide	<i>Toxoplasma</i>	143
<i>Cryptosporidium</i> sp.	Dogs, cats, cattle, pigs, birds, guinea pigs, snakes, and mice	Small intestine		Cryptosporidia	145
<i>Sarcocystis</i> sp.	Dogs and cats	Small intestine	Worldwide	<i>Sarcocystis</i>	148
Circulatory System					
Flagellates					
<i>Trypanosoma cruzi</i>	Dogs and humans	Peripheral blood	Central and South America and southern United States	Trypanosomes	148

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Leishmania</i> sp.	Dogs	Reticuloendothelial cells of capillaries, spleen, and white blood cells (WBCs)	Worldwide	<i>Leishmania</i>	149
<i>Apicomplexans</i>					
<i>Babesia canis</i>	Dogs	Within red blood cells (RBCs)	Europe, Africa, Asia, North and South America	<i>Babesia</i>	149
<i>Cytauxzoon felis</i>	Cats	Within RBCs	Africa and United States		149
<i>Hepatozoon canis</i>	Dogs	Gamonts in WBCs; schizonts in spleen, bone marrow, and liver	United States, Africa, Asia, and southern Europe		150
<i>Pentastomes</i>					
<i>Linguatula serrata</i>	Dogs	Nasal passages and sinuses		Canine pentastome	268
Arthropods					
True Bugs					
Reduviid bugs	Dogs and humans	Periodic skin parasite		Kissing bugs	179
<i>Rhodnius</i> sp.	Dogs, humans, cats, guinea pigs, armadillos, rats, raccoons, and monkeys	Periodic skin of mouth and lips	South and Central America, southern and western United States	Kissing bugs	180
<i>Panstrongylus</i> sp.	Dogs, humans, cats, guinea pigs, armadillos, rats, raccoons, and monkeys	Periodic skin of mouth and lips	South and Central America, southern and western United States	Kissing bugs	180
<i>Triatoma</i> sp.	Dogs, humans, cats, guinea pigs, armadillos, rats, raccoons, and monkeys	Periodic skin of mouth and lips	South and Central America, southern and western United States	Kissing bugs	180
Lice					
Mallophagan order	Mammals and birds	Among hairs of host		Chewing lice	181

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Parasites by Host Species —cont'd					
Parasite	Host	Location of Adult	Distribution	Common Name	Page
Anopluran order	Mammals and birds	Among hairs of host		Sucking lice	181
<i>Dipterans</i>					
<i>Simulium</i> sp.	Domesticated animals, poultry, and humans	Skin surface when feeding	Worldwide	Black flies or buffalo gnats	187
<i>Lutzomyia</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	New World sand flies	188
<i>Phlebotomus</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Subtropical and Mediterranean regions	Sand flies	188
<i>Culicoides</i> sp.	Domestic animals and humans	Skin surface when feeding	Worldwide	No-see-ums, punkies, or sand flies	188
<i>Anopheles quadrimaculatus</i>	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Malaria mosquito	189
<i>Aedes aegypti</i>	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Yellow fever mosquito	189
<i>Culex</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Mosquito	189
<i>Chrysops</i> sp.	Large mammals, humans, and occasionally small mammals and birds	Skin surface when feeding	Worldwide	Deerflies	190
<i>Tabanus</i> sp.	Large mammals, humans, and occasionally small mammals and birds	Skin surface when feeding	Worldwide	Horseflies	190
<i>Glossina</i> sp.	Mammals, reptiles, birds, and humans	Skin surface when feeding	Africa	Tsetse fly	191
<i>Musca domestica</i>	Variety of animals and humans	Within the house	Worldwide	Housefly	192

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Calliphora</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Lucilia</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Phormia</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Phaenicia</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Sarcophaga</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Flesh fly	195
<i>Hippelates</i> sp.	Dogs and cattle	Mucocutaneous junction of eyes, lips, and penis		Dog penis gnats	195
<i>Cochliomyia hominivorax</i>	Domestic animals	Fresh, uncontaminated wounds	North America	Screw fly	198
<i>Cuterebra</i> sp.	Rabbits, squirrels, mice, rats, chipmunks, dogs, and cats	Larva around the head and neck		Warbles or wolves	199
<i>Siphonaptera</i>					
<i>Ctenocephalides felis</i>	Dogs and cats	Skin surface		Cat flea	204
<i>Ctenocephalides canis</i>	Dogs	Skin surface		Dog flea	204
<i>Mites</i>					
<i>Sarcoptes scabiei</i> variety <i>canis</i>	Dogs	Superficial layers of epidermis	Worldwide	Scabies mite of dogs	209
<i>Sarcoptes scabiei</i> variety <i>felis</i>	Cats	Superficial layers of epidermis	Worldwide	Scabies mite of cats	210
<i>Notoedres cati</i>	Cats and rabbits	Superficial layers of epidermis	Worldwide	Notoedric mange mite	210

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Parasites by Host Species —cont'd					
Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Otodectes cynotis</i>	Dogs, cats, and ferrets	External ear canal	Worldwide	Ear mites	216
<i>Demodex canis</i>	Dogs	Hair follicles and sebaceous glands	Worldwide	Demodectic mange mite of dogs	218
<i>Demodex cati</i>	Cats	Hair follicles and sebaceous glands	Worldwide	Demodectic mange mite of cats	218
<i>Trombicula</i> sp.	Domestic animals, wild animals, and humans	Larval stage on skin surface		Chiggers	219
<i>Pneumonyssus caninum</i>	Dogs	Nasal turbinates and nasal sinuses	Worldwide	Nasal mites	220
<i>Cheyletiella parasitivorax</i>	Dogs, cats, and rabbits	Surface of skin and hair coat	Worldwide	Walking dandruff	222
<i>Lynxacarus radovskyi</i>	Cats	Hair shafts on back, neck, thorax, and hind limbs	Tropical and warm regions of United States, Puerto Rico, Australia, and Fiji	Feline fur mite	223
Ticks					
<i>Otobius megnini</i>	Dogs, horses, cattle, sheep, and goats	Larval and nymphal stages in the external ear canal	Arid and semiarid regions in southwestern United States	Spinose ear tick	228
<i>Ixodes scapularis</i>	Adult on dogs, horses, deer, and humans	Attached to skin when feeding	Eastern United States	Deer tick	228
<i>Rhipicephalus sanguineus</i>	Small mammals, dogs, and humans	Below hair coat attached to skin, especially ear canal and between toes	North America	Brown dog tick	228
<i>Dermacentor variabilis</i>	Small mammals, dogs, and humans	Attached to skin when feeding	Eastern two thirds of United States	Wood tick or American dog tick	232
<i>Dermacentor andersoni</i>	Adult on dogs, horses, cattle, goats, sheep, and humans	Attached to skin when feeding	Rocky Mountain regions	Rocky Mountain wood tick	232
<i>Dermacentor occidentalis</i>	Adult on large mammals	Attached to skin when feeding	Sierra Nevada Mountains	Pacific Coast dog tick	233
<i>Amblyomma americanum</i>	Adult on wide range of mammals and humans	Attached to skin when feeding	Southern United States, Midwest and Atlantic Coast of United States	Lone star tick	233

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Amblyomma maculatum</i>	Adult on cattle, sheep, horses, dogs, and humans	Attached to skin when feeding	Atlantic and Gulf coasts of United States	Gulf Coast tick	233
<i>Haemaphysalis leporispalustris</i>	Larval and nymphal stages on rabbits, birds, dogs, cats, and humans	Attached to skin when feeding	United States	Continental rabbit tick	235
Ruminants					
Nematodes					
Gastrointestinal Tract					
<i>Gongylonema pulchrum</i>	Sheep, goats, cattle, and occasionally pigs	Submucosa and mucosa of esophagus		Esophageal worm of ruminants	45
<i>Bunostomum</i> sp.	Cattle, sheep, and goats	Abomasum, small and large intestines	Worldwide	Trichostrongyle of ruminants	46
<i>Chabertia</i> sp.	Cattle, sheep, and goats	Abomasum, small and large intestines	Worldwide	Trichostrongyle of ruminants	46
<i>Cooperia</i> sp.	Cattle, sheep, and goats	Abomasum, small and large intestines	Worldwide	Trichostrongyle of ruminants	46
<i>Haemonchus</i> sp.	Cattle, sheep, and goats	Abomasum, small and large intestines	Worldwide	Trichostrongyle of ruminants	46
<i>Oesophagostomum</i> sp.	Cattle, sheep, and goats	Abomasum, small and large intestines	Worldwide	Trichostrongyle of ruminants	46
<i>Ostertagia</i> sp.	Cattle, sheep, and goats	Abomasum, small and large intestines	Worldwide	Trichostrongyle of ruminants	46
<i>Trichostrongylus</i> sp.	Cattle, sheep, and goats	Abomasum, small and large intestines	Worldwide	Trichostrongyle of ruminants	46
<i>Nematodirus</i> sp.	Cattle, goats, and sheep	Abomasum, small and large intestines	Worldwide	Trichostrongyle of ruminants	47
<i>Marshallagia</i> sp.	Cattle, sheep, and goats	Abomasum, small and large intestines	Tropical and subtropical regions	Trichostrongyle of ruminants	47
<i>Strongyloides papillosus</i>	Cattle	Small intestine	Worldwide	Bovine intestinal threadworm	47
<i>Trichuris ovis</i>	Cattle, sheep, and goats	Cecum and colon	Worldwide	Whipworms	48
Circulatory System					
<i>Elaeophora schneideri</i>	Sheep	Common carotid artery	Western and southwestern United States	Arterial worm of sheep	54

Parasites by Host Species —cont'd					
Parasite	Host	Location of Adult	Distribution	Common Name	Page
Respiratory System					
<i>Dictyocaulus</i> sp.	Cattle, sheep, and goats	Bronchi	Worldwide	Lungworms of ruminants	49
<i>Muellerius capillaris</i>	Sheep and goats	Bronchioles	Worldwide	Hair lungworm of sheep and goats	50
<i>Protostrongylus</i> sp.	Sheep and goats	Small bronchioles	Worldwide		51
Skin					
<i>Stephanofilaria stilesi</i>	Cattle, goats, buffalo, and wild ruminants	Ventral midline		Skin worm of ruminants	51
Eye and Adnexa					
<i>Thelazia rhodesii</i>	Cattle, sheep, and goats	Conjunctival sac and lacrimal duct	Worldwide	Eyeworm of cattle, sheep, and goats	52
<i>Thelazia gulosa</i>	Cattle, sheep, and goats	Conjunctival sac and lacrimal duct	Worldwide	Eyeworm of cattle, sheep, and goats	52
Abdominal Cavity					
<i>Setaria cervi</i>	Cattle	Free within peritoneal cavity	Worldwide	Abdominal worm of cattle	52
Cestodes					
Gastrointestinal Tract					
<i>Moniezia benedini</i>	Cattle	Small intestine	Worldwide	Bovine tapeworm	88
<i>Moniezia expansa</i>	Cattle, sheep, and goats	Small intestine	Worldwide	Ruminant tapeworm	88
<i>Thysanosoma actinoides</i>	Cattle, sheep, and goats	Lumen of bile duct, pancreatic duct, and small intestine	North and South America	Fringed tapeworm of sheep and goats	90
Larval Stages in Musculature					
<i>Taenia saginata</i>	Cattle	Muscle	Worldwide	Beef tapeworm of humans	91
Larval Stages in Abdominal Cavity					
<i>Taenia hydatigena</i>	Cattle, sheep, and goats	Abdominal cavity	Worldwide	Canine taeniid	93

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
Trematodes					
<i>Dicrocoelium dendriticum</i>	Cattle, sheep, and goats	Bile ducts	Worldwide	Lancet fluke	119
<i>Paramphistomum</i> sp.	Cattle, sheep, and goats	Rumen and reticulum	Worldwide	Rumen flukes	119
<i>Cotylophoron</i> sp.	Cattle, sheep, and goats	Rumen and reticulum		Rumen flukes	119
<i>Fasciola hepatica</i>	Cattle, sheep	Bile duct	Worldwide	Liver fluke	121
<i>Fascioloides magna</i>	White-tailed deer	Liver parenchyma	North America, central and southwestern Europe	Liver fluke of wild ruminants	122
Protozoans					
Gastrointestinal Tract					
Apicomplexans					
<i>Eimeria</i> sp.	Ruminants	Cecum and colon	Worldwide	Coccidia of ruminants	151
<i>Eimeria bovis</i>	Ruminants	Cecum and colon	Worldwide	Coccidia of ruminants	151
<i>Eimeria zuernii</i>	Ruminants	Cecum and colon	Worldwide	Coccidia of ruminants	151
<i>Cryptosporidium</i> sp.	Dogs, cats, cattle, pigs, birds, guinea pigs, snakes, and mice	Small intestine		Cryptosporidia	151
Circulatory System					
Flagellates					
<i>Trypanosoma</i> sp.	Ruminants	Peripheral blood	Central and South America	Trypanosomes	151
Apicomplexans					
<i>Babesia bigemina</i>	Cattle	Within RBCs	Europe, Africa, Asia, South America, and North America	<i>Babesia</i>	152

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Parasites by Host Species —cont'd					
Parasite	Host	Location of Adult	Distribution	Common Name	Page
Urogenital System					
<i>Trichomonas foetus</i>	Cattle	Prepuce in bull; cervix, uterus, and vagina in cow	Worldwide	<i>Trichomonas</i>	152
Arthropods					
Lice					
<i>Mallophagan</i> sp.	Mammals and birds	Among hairs of host		Chewing lice	181
<i>Anopluran</i> sp.	Mammals and birds	Among hairs of host		Sucking lice	181
Dipterans					
<i>Simulium</i> sp.	Domesticated animals, poultry, and humans	Skin surface when feeding	Worldwide	Black flies or buffalo gnats	187
<i>Lutzomyia</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	New World sand flies	188
<i>Phlebotomus</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Subtropical and Mediterranean regions	Sand flies	209
<i>Culicoides</i> sp.	Domestic animals and humans	Skin surface when feeding	Worldwide	No-see-ums, punkies, or sand flies	188
<i>Anopheles quadrimaculatus</i>	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Malaria mosquito	189
<i>Aedes aegypti</i>	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Yellow fever mosquito	189
<i>Culex</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Mosquito	189
<i>Chrysops</i> sp.	Large mammals, humans, and occasionally small mammals and birds	Skin surface when feeding	Worldwide	Deerflies	190

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Tabanus</i> sp.	Large mammals, humans, and occasionally small mammals and birds	Skin surface when feeding	Worldwide	Horseflies	190
<i>Glossina</i> sp.	Mammals, reptiles, birds, and humans	Skin surface when feeding	Africa	Tsetse fly	191
<i>Stomoxys calcitrans</i>	Variety of animals and humans	Around large amounts of decaying vegetation	Worldwide	Stable fly	191
<i>Haematobia irritans</i>	Cattle and buffalo	Around horns, shoulders, back, side, and ventral abdomen	North America, Europe, and Australia	Horn fly	192
<i>Melophagus ovinus</i>	Sheep and goats	Deep within wool or fleece	Worldwide	Sheep ked	193
<i>Musca domestica</i>	Variety of animals and humans	Within the house	Worldwide	Housefly	195
<i>Musca autumnalis</i>	Predominantly cattle but also other large animals	Feeds around medial canthus of the eye	Worldwide	Face fly	195
<i>Calliphora</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Lucilia</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Phormia</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Phaenicia</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Sarcophaga</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Flesh fly	195

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Parasites by Host Species —cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Hippelates</i> sp.	Dogs and cattle	Mucocutaneous junction of eyes, lips, and penis		Dog penis gnats	195
<i>Cochliomyia hominivorax</i>	Domestic animals	Fresh, uncontaminated wounds	North America	Screw fly	198
<i>Hypoderma</i> sp.	Cattle, rarely in horses, sheep, and humans	Larva in large boil-like cyst on back	Northern and southern United States and Canada	Gadflies or cattle grubs	199
<i>Oestrus ovis</i>	Sheep and goats	Nasal passages	Worldwide	Nasal bot fly or grub	203
Mites					
<i>Sarcoptes scabiei</i> variety <i>bovis</i>	Cattle	Superficial layers of epidermis	Worldwide	Scabies of cattle	210
<i>Sarcoptes scabiei</i> variety <i>ovis</i>	Sheep and goats	Superficial layers of epidermis	Worldwide	Scabies of sheep and goats	210
<i>Psoroptes cuniculi</i>	Rabbits, horses, goats, and sheep	External ear canal	Worldwide	Rabbit ear mite	214
<i>Psoroptes ovis</i>	Sheep	Skin surface of body	Worldwide	Scabies of sheep	214
<i>Psoroptes bovis</i>	Cattle	Skin surface of withers, neck, and rump	Worldwide	Scabies of cattle	215
<i>Chorioptes bovis</i>	Cattle	Skin surface of lower hind legs, flanks, and shoulders	Worldwide	Foot and tail mite or itchy leg mite	215
<i>Chorioptes caprae</i>	Goats	Skin surface of lower hind legs, flanks, and shoulders	Worldwide	Foot and tail mite or itchy leg mite	215
<i>Chorioptes ovis</i>	Sheep	Skin surface of lower hind legs, flanks, and shoulders	Worldwide	Foot and tail mite or itchy leg mite	215
<i>Demodex bovis</i>	Cattle	Hair follicles and sebaceous glands	Worldwide	Demodectic mange mite of cattle	218
<i>Demodex caprae</i>	Goats	Hair follicles and sebaceous glands	Worldwide	Demodectic mange mite of goats	218
<i>Trombicula</i> sp.	Domestic animals, wild animals, and humans	Larval stage on skin surface		Chiggers	219

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
Ticks					
<i>Otobius megnini</i>	Dogs, horses, cattle, sheep, and goats	Larval and nymphal stages in the external ear canal	Arid and semiarid regions in southwestern United States	Spinose ear tick	228
<i>Ixodes scapularis</i>	Adult on dogs, horses, deer, and humans	Attached to skin when feeding	Eastern United States	Deer tick	228
<i>Dermacentor andersoni</i>	Adult on dogs, horses, cattle, goats, sheep, and humans	Attached to skin when feeding	Rocky Mountain regions	Rocky Mountain wood tick	232
<i>Dermacentor occidentalis</i>	Adult on large mammals	Attached to skin when feeding	Sierra Nevada Mountains	Pacific Coast dog tick	233
<i>Amblyomma americanum</i>	Adult on wide range of mammals and humans	Attached to skin when feeding	Southern United States, Midwest and Atlantic Coast of United States	Lone star tick	233
<i>Amblyomma maculatum</i>	Adult on cattle, sheep, horses, dogs, and humans	Attached to skin when feeding	Atlantic and Gulf Coasts of United States	Gulf Coast tick	234
<i>Rhipicephalus annulatus</i>	Cattle	Attached to skin when feeding	Mexico and enzootic areas of United States	Texas cattle fever tick or North American tick	234
Equines					
Nematodes					
Gastrointestinal Tract					
<i>Habronema microstoma</i>	Horses	Stomach mucosa	Worldwide	Stomach worm of horses	52
<i>Habronema muscae</i>	Horses	Stomach mucosa	Worldwide	Stomach worm of horses	52
<i>Draschia megastoma</i>	Horses	Stomach mucosa	Worldwide	Stomach worm of horses	52
<i>Trichostrongylus axei</i>	Horses, cattle, sheep, and pigs	Stomach	Worldwide	Stomach worm of horses and pigs	53
<i>Parascaris equorum</i>	Horses	Small intestine	Worldwide	Equine roundworm	53
<i>Strongylus vulgaris</i>	Horses	Large intestine	Worldwide	Strongyle of horses	54
<i>Strongylus edentatus</i>	Horses	Large intestine	Worldwide	Strongyle of horses	54

Continued

Parasites by Host Species —cont'd					
Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Strongylus equinus</i>	Horses	Large intestine	Worldwide	Strongyle of horses	54
<i>Strongyloides westeri</i>	Horses	Small intestine	Worldwide	Intestinal threadworm of horses	57
<i>Oxyuris equi</i>	Horses	Cecum, colon, and rectum	Worldwide	Pinworm of horses	58
Respiratory System					
<i>Dictyocaulus arnfieldi</i>	Horses, mules, and donkeys	Bronchi and bronchioles	Worldwide	Equine lungworm	59
Skin					
<i>Habronema microstoma</i>	Horses	Larvae in skin	Worldwide	Stomach worm of horses	59
<i>Habronema muscae</i>	Horses	Larvae in skin	Worldwide	Stomach worm of horses	59
<i>Draschia megastoma</i>	Horses	Larvae in skin	Worldwide	Stomach worm of horses	59
<i>Onchocerca cervicalis</i>	Horses	Adult in ligamentum nuchae; larvae in dermis	Worldwide	Equine filarial worm	60
Eye and Adnexa					
<i>Thelazia lacrymalis</i>	Horses	Conjunctival sac and lacrimal duct	Worldwide	Eyeworm of the horse	60
Abdominal Cavity					
<i>Setaria equina</i>	Horses	Free within peritoneal cavity	Europe and North America	Abdominal worm of horses	61
Cestodes					
Gastrointestinal Tract					
<i>Anoplocephala perfoliata</i>	Horses	Small and large intestines and cecum	Worldwide	Lappeted equine tapeworm	93
<i>Anoplocephala magna</i>	Horses	Stomach and small intestine	Worldwide	Equine tapeworm with large scolex	93
<i>Paranoplocephala mamillana</i>	Horses	Stomach and small intestine	Worldwide	Equine tapeworm	93

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
Protozoans					
Gastrointestinal Tract					
<i>Flagellates</i>					
<i>Giardia assemblage E</i>	Horses, cattle, sheep, goats, and pigs	Small intestine	Worldwide	<i>Giardia</i>	153
<i>Ciliates</i>					
<i>Eimeria leuckarti</i>	Horses	Small intestine	Worldwide	Coccidia	153
Circulatory System					
<i>Apicomplexans</i>					
<i>Babesia caballi</i>	Horses	Within RBCs	Europe, Africa, Asia, and North and South America	Equine piroplasm	154
<i>Theileria equi</i>	Horses	Within RBCs	Europe, Africa, Asia, and North and South America	Equine piroplasm	154
Urogenital System					
<i>Apicomplexans</i>					
<i>Klossiella equi</i>	Horses	Kidneys			155
Nervous System					
<i>Apicomplexans</i>					
<i>Sarcocystis neurona</i>	Horses	Asexual stage in nervous system			155
Arthropods					
<i>Lice</i>					
<i>Mallophagan</i> sp.	Mammals and birds	Among hairs of host		Chewing lice	181
<i>Anopluran</i> sp.	Mammals and birds	Among hairs of host		Sucking lice	181
<i>Dipterans</i>					
<i>Simulium</i> sp.	Domesticated animals, poultry, and humans	Skin surface when feeding	Worldwide	Black flies or buffalo gnats	187

Continued

Parasites by Host Species —cont'd					
Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Lutzomyia</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	New World sand flies	188
<i>Phlebotomus</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Subtropical and Mediterranean regions	Sand flies	188
<i>Culicoides</i> sp.	Domestic animals and humans	Skin surface when feeding	Worldwide	No-see-ums, punkies, or sand flies	188
<i>Anopheles quadrimaculatus</i>	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Malaria mosquito	189
<i>Aedes aegypti</i>	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Yellow fever mosquito	189
<i>Culex</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Mosquito	189
<i>Chrysops</i> sp.	Large mammals, humans, and occasionally small mammals and birds	Skin surface when feeding	Worldwide	Deerflies	190
<i>Tabanus</i> sp.	Large mammals, humans, and occasionally small mammals and birds	Skin surface when feeding	Worldwide	Horseflies	190
<i>Glossina</i> sp.	Mammals, reptiles, birds, and humans	Skin surface when feeding	Africa	Tsetse fly	191
<i>Stomoxys calcitrans</i>	Variety of animals and humans	Around large amounts of decaying vegetation	Worldwide	Stable fly	191
<i>Musca domestica</i>	Variety of animals and humans	Within the house	Worldwide	Housefly	195
<i>Musca autumnalis</i>	Predominantly cattle but also other large animals	Feeds around medial canthus of the eye	Worldwide	Face fly	195

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Calliphora</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Lucilia</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Phormia</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Phaenicia</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Sarcophaga</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Flesh fly	195
<i>Cochliomyia hominivorax</i>	Domestic animals	Fresh, uncontaminated wounds	North America	Screw fly	199
<i>Hypoderma</i> sp.	Cattle, rarely in horses, sheep, and humans	Larva in large boil-like cyst on back	Northern and southern United States and Canada	Gadflies or cattle grubs	201
<i>Gasterophilus</i> sp.	Horses	Attached to gastric mucosa	Worldwide	Bot flies or horse bots	202
Mites					
<i>Sarcoptes scabiei</i> variety <i>equi</i>	Horses	Superficial layers of epidermis	Worldwide	Scabies of horses	210
<i>Psoroptes cuniculi</i>	Rabbits, horses, goats, and sheep	External ear canal	Worldwide	Rabbit ear mite	214
<i>Psoroptes equi</i>	Horses	Skin surface of mane and tail	Worldwide	Scabies of horses	215
<i>Chorioptes equi</i>	Horses	Skin surface of lower hind limbs, flanks, and shoulders	Worldwide	Foot and tail mite or itchy leg mite	215
<i>Demodex equi</i>	Horses	Skin of face and eyes	Worldwide	Demodectic mange mite of horses	218

Continued

Parasites by Host Species —cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Trombicula</i> sp.	Domestic animals, wild animals, and humans	Larval stage on skin surface		Chiggers	219
Ticks					
<i>Otobius megnini</i>	Dogs, horses, cattle, sheep, and goats	Larval and nymphal stages in the external ear canal	Arid and semiarid regions in southwestern United States	Spinose ear tick	228
<i>Ixodes scapularis</i>	Adult on dogs, horses, deer, and humans	Attached to skin when feeding	Eastern United States	Deer tick	231
<i>Dermacentor andersoni</i>	Adult on dogs, horses, cattle, goats, sheep, and humans	Attached to skin when feeding	Rocky Mountain regions	Rocky Mountain wood tick	232
<i>Dermacentor occidentalis</i>	Adult on large mammals	Attached to skin when feeding	Sierra Nevada Mountains	Pacific Coast dog tick	233
<i>Amblyomma americanum</i>	Adult on wide range of mammals and humans	Attached to skin when feeding	Southern United States, Midwest and Atlantic Coast of United States	Lone star tick	233
<i>Amblyomma maculatum</i>	Adult on cattle, sheep, horses, dogs, and humans	Attached to skin when feeding	Atlantic and Gulf Coasts of United States	Gulf Coast tick	234
Swine					
Nematodes					
Gastrointestinal Tract					
<i>Ascarops strongylina</i>	Pigs	Stomach		Stomach worm of pigs	61
<i>Physocephalus sexalatus</i>	Pigs	Stomach		Stomach worm of pigs	61
<i>Hyoststrongylus rubidus</i>	Pigs	Stomach	Worldwide	Red stomach worm of pigs	61
<i>Trichostrongylus axei</i>	Horses, sheep, cattle, and pigs	Stomach	Worldwide	Stomach worm of pigs	62
<i>Ascaris suum</i>	Pigs	Small intestine	Worldwide	Large intestinal roundworm of pigs	62
<i>Strongyloides ransomi</i>	Pigs	Small intestine	Worldwide	Intestinal threadworm of pigs	62

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Oesophagostomum dentatum</i>	Pigs	Large intestine	Worldwide	Nodular worm of pigs	63
<i>Trichuris suis</i>	Pigs	Cecum and colon	Worldwide	Whipworm	64
<i>Trichinella spiralis</i>	Pigs, definitive hosts	Small intestine	Worldwide except Denmark and Australia	Trichina worm	64
Respiratory System					
<i>Metastrongylus elongatus</i>	Pigs	Bronchi and bronchioles	Worldwide	Swine lungworm	64
Urinary Tract					
<i>Stephanurus dentatus</i>	Pigs	Cystic spaces around kidneys, ureters, and perirenal tissue		Swine kidney worm	65
Musculoskeletal System					
<i>Trichinella spiralis</i>	Pigs	Small intestine, larvae in muscle	Worldwide except Denmark and Australia	Trichina worm	65
Cestodes					
Larvae in Muscle					
<i>Taenia solium</i>	Pigs, intermediate host	Larvae in muscle tissue	Underdeveloped countries	Pork tapeworm of humans	92
Protozoans					
Gastrointestinal Tract					
Ciliates					
<i>Balantidium coli</i>	Pigs and dogs	Large intestine	Worldwide	<i>Balantidium</i>	155
Apicomplexans					
<i>Cystoisospora suis</i>	Pigs	Small intestine		Coccidia	156
<i>Cryptosporidium</i> sp.	Canines, felines, bovines, swine, avians, guinea pigs, snakes, and mice	Small intestine		<i>Cryptosporidium</i>	157
Arthropods					
Lice					
<i>Mallophagan</i> sp.	Mammals and birds	Among hairs of host		Chewing lice	181

Continued

Parasites by Host Species —cont'd					
Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Anopluran</i> sp.	Mammals and birds	Among hairs of host		Sucking lice	181
<i>Dipterans</i>					
<i>Simulium</i> sp.	Domesticated animals, poultry, and humans	Skin surface when feeding	Worldwide	Black flies or buffalo gnats	187
<i>Lutzomyia</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	New World sand flies	188
<i>Phlebotomus</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Subtropical and Mediterranean regions	Sand flies	188
<i>Culicoides</i> sp.	Domestic animals and humans	Skin surface when feeding	Worldwide	No-see-ums, punkies, or sand flies	188
<i>Anopheles quadrimaculatus</i>	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Malaria mosquito	189
<i>Aedes aegypti</i>	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Yellow fever mosquito	189
<i>Culex</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Mosquito	189
<i>Chrysops</i> sp.	Large mammals, humans, and occasionally small mammals and birds	Skin surface when feeding	Worldwide	Deerflies	190
<i>Tabanus</i> sp.	Large mammals, humans, and occasionally small mammals and birds	Skin surface when feeding	Worldwide	Horseflies	190
<i>Glossina</i> sp.	Mammals, reptiles, birds, and humans	Skin surface when feeding	Africa	Tsetse fly	191
<i>Stomoxys calcitrans</i>	Variety of animals and humans	Around large amounts of decaying vegetation	Worldwide	Stable fly	191

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Musca domestica</i>	Variety of animals and humans	Within the house	Worldwide	Housefly	192
<i>Calliphora</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	196
<i>Lucilia</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Phormia</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Phaenicia</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Bottle flies or blowflies	195
<i>Sarcophaga</i> sp.	Domestic animals, wild animals, and humans	Free living in environment		Flesh fly	195
<i>Cochliomyia hominivorax</i>	Domestic animals	Fresh, uncontaminated wounds	North America	Screw fly	199
Mites					
<i>Sarcoptes scabiei</i> variety <i>suis</i>	Pigs	Superficial layers of epidermis	Worldwide	Scabies of pigs	209
<i>Demodex phylloides</i>	Pigs	Hair follicles and sebaceous glands	Worldwide	Demodectic mange mite	218
<i>Trombicula</i> sp.	Domestic animals, wild animals, and humans	Larval stage on skin surface		Chiggers	219
Ticks					
<i>Amblyomma americanum</i>	Adult on wide range of mammals and humans	Attached to skin when feeding	Southern United States, Midwest and Atlantic coast of United States	Lone star tick	233

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Parasites by Host Species —cont'd					
Parasite	Host	Location of Adult	Distribution	Common Name	Page
Exotic Animals and Birds					
Nematodes					
Gastrointestinal Tract					
<i>Syphacia obvelata</i>	Mice, rats, hamsters, and gerbils	Cecum and rectum		Pinworms of rodents	66
<i>Aspiculuris tetraptera</i>	Mice	Cecum and rectum		Pinworms of mice	66
<i>Syphacia muris</i>	Mice, rats, hamsters, and gerbils	Cecum and rectum		Pinworms of rodents	66
<i>Dentostomella translucida</i>	Gerbils	Stomach and proximal third of small intestine		Pinworm of gerbils	69
<i>Paraspidodera uncinata</i>	Guinea pig	Cecum and colon		Ascarid of guinea pigs	70
<i>Passalurus ambiguus</i>	Rabbits	Cecum and colon		Pinworm of rabbits	71
<i>Obeliscoides cuniculi</i>	Rabbits	Stomach		Trichostrongyle of rabbits	72
<i>Trichostrongylus calcaratus</i>	Rabbits	Small intestine		Trichostrongyle of rabbits	72
<i>Ascaridia</i> sp.	Birds	Small intestine	Worldwide	Ascarid of birds	72
<i>Spiroptera incesta</i>	Australian finches	Ventriculus		Spirurid of birds	73
<i>Dispharynx nasuta</i>	Finches	Ventriculus	Tropical and subtropical regions	Spirurid of birds	73
<i>Tetrameres</i> sp.	Pigeons	Proventriculus		Spirurid of birds	73
<i>Capillaria</i> sp.	Pheasants, peafowl, and poultry	Crop and upper alimentary tract	Worldwide	<i>Capillaria</i>	73
Urinary Tract					
<i>Trichosomoides crassicauda</i>	Rats	Urinary bladder		Bladder worm of rats	69
Cestodes					
Gastrointestinal Tract					
<i>Hymenolepis nana</i>	Mice, rats, gerbils, hamsters, dogs, and humans	Small intestine		Tapeworm of rodents	86

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Hymenolepis diminuta</i>	Mice, rats, gerbils, hamsters, dogs, and humans	Small intestine		Tapeworm of rodents	86
Trematodes					
Circulatory System					
<i>Schistosoma</i> sp.	Birds	Blood vasculature	North America	Avian schistosomes	127
Protozoans					
Gastrointestinal Tract					
Flagellates					
<i>Giardia psittaci</i>	Birds	Intestinal mucosa		<i>Giardia</i>	157
<i>Histomonas meleagridis</i>	Turkeys, peafowl, chickens, and pheasants	Liver	Worldwide	"Blackhead"	157
<i>Trichomonas gallinae</i>	Pigeons, doves, poultry, and raptors	Crop		Trichomonas	158
<i>Tetratrichomonas microti</i>	Mice	Small intestine		Flagellate of mice	162
<i>Tritrichomonas muris</i>	Mice	Cecum and colon		Flagellate of mice	162
<i>Giardia assemblage G</i>	Rodents	Proximal small intestine		<i>Giardia</i>	153
<i>Spironucleus muris</i>	Mice	Proximal small intestine		Flagellate of mice	162
<i>Tritrichomonas caviae</i>	Guinea pigs	Cecum		Flagellate of guinea pigs	165
Apicomplexans					
<i>Eimeria irresidua</i>	Rabbits	Small intestine		Coccidia of rabbits	161
<i>Eimeria magna</i>	Rabbits	Small intestine		Coccidia of rabbits	161
<i>Eimeria media</i>	Rabbits	Small intestine and large intestine		Coccidia of rabbits	161
<i>Eimeria perforans</i>	Rabbits	Small intestine		Coccidia of rabbits	161
<i>Eimeria stiedae</i>	Rabbits	Bile ducts		Coccidia of rabbits	162
<i>Eimeria falciformis</i>	Mice	Small intestine		Coccidia of mice	163
<i>Eimeria ferrisi</i>	Mice	Cecum		Coccidia of mice	163

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Parasites by Host Species —cont'd					
Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Eimeria hansonorum</i>	Mice	Small intestine		Coccidia of mice	163
<i>Eimeria nieschultzi</i>	Rats	Intestines		Coccidia of rats	164
<i>Eimeria caviae</i>	Guinea pigs	Large intestine		Coccidia of guinea pigs	166
<i>Cryptosporidium wrairi</i>	Guinea pigs	Tips of intestinal villi of the ileum			166
Amoeba					
<i>Entamoeba caviae</i>	Guinea pigs	Cecum		Amoeba of guinea pigs	166
Circulatory System					
Flagellates					
<i>Trypanosoma</i> sp.	Cockatoos	Peripheral blood	Worldwide	Trypanosomes of birds	151
Apicomplexans					
<i>Haemoproteus</i> sp.	Cockatoos, macaws, and conures	Within RBCs	Worldwide		159
<i>Plasmodium</i> sp.	Birds	Within RBCs	Worldwide		159
<i>Leucocytozoon</i> sp.	Raptors	Within RBCs	Worldwide		160
<i>Aegyptianella</i> sp.	Pet birds	Within RBCs			160
Respiratory System					
Apicomplexans					
<i>Cystoisospora serini</i>	Canaries and finches	Lung, liver, and spleen		Coccidia of birds or atoxoplasmosis	160
Urogenital System					
Apicomplexans					
<i>Klossiella muris</i>	Mice	Kidneys			164
Skin					
Ciliates					
<i>Ichthyophthirius multifiliis</i>	Freshwater and ornamental fish	Skin, gills, fins, and eyes		Ciliate of fish	167
Arthropods					
True Bugs					
<i>Cimex lectularius</i>	Humans, rabbits, poultry, and pigeons			Bedbugs	179

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Rhodnius</i> sp.	Dogs, humans, cats, guinea pigs, armadillos, rats, raccoons, and monkeys	Periodic skin of mouth and lips	South and Central America and southern and western United States	Kissing bugs	180
<i>Panstrongylus</i> sp.	Dogs, humans, cats, guinea pigs, armadillos, rats, raccoons, and monkeys	Periodic skin of mouth and lips	South and Central America and southern and western United States	Kissing bugs	180
<i>Triatoma</i> sp.	Dogs, humans, cats, guinea pigs, armadillos, rats, raccoons, and monkeys	Periodic skin of mouth and lips	South and Central America and southern and western United States	Kissing bugs	180
Lice					
<i>Polyplax serrata</i>	Mice	Within hair coat		Mouse louse	184
<i>Polyplax spinulosa</i>	Rat	Within hair coat		Rat louse	185
<i>Hoplopleura meridionidis</i>	Gerbil	Within hair coat		Gerbil louse	185
<i>Gliricola porcelli</i>	Guinea pig	Within hair coat		Guinea pig louse	185
<i>Gyropus ovalis</i>	Guinea pig	Within hair coat		Guinea pig louse	185
<i>Hemodipsus ventricosus</i>	Rabbit	Within hair coat		Rabbit louse	186
Dipterans					
<i>Simulium</i> sp.	Domesticated animals, poultry, and humans	Skin surface when feeding	Worldwide	Black flies or buffalo gnats	187
<i>Lutzomyia</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	New World sand flies	188
<i>Phlebotomus</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Subtropical and Mediterranean regions	Sand flies	188
<i>Anopheles quadrimaculatus</i>	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Malaria mosquito	189

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Parasites by Host Species —cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Aedes aegypti</i>	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Yellow fever mosquito	189
<i>Culex</i> sp.	Mammals, reptiles, avians, and humans	Skin surface when feeding	Worldwide	Mosquito	189
<i>Chrysops</i> sp.	Large mammals, humans, and occasionally small mammals and birds	Skin surface when feeding	Worldwide	Deerflies	190
<i>Tabanus</i> sp.	Large mammals, humans, and occasionally small mammals and birds	Skin surface when feeding	Worldwide	Horseflies	190
<i>Glossina</i> sp.	Mammals, reptiles, birds, and humans	Skin surface when feeding	Africa	Tsetse fly	191
<i>Lynchia</i> sp.	Wild birds	Deep within feathers		Bird keds	194
<i>Pseudolynchia</i> sp.	Wild birds	Deep within feathers		Bird keds	194
<i>Cuterebra</i> sp.	Rabbits, squirrels, mice, rats, chipmunks, dogs, and cats	Larva around the head and neck		Warbles or wolves	201
<i>Siphonaptera</i>					
<i>Cediopsylla simplex</i>	Rabbits	On skin		Common Eastern rabbit flea	204
<i>Odontopsylla multispinosus</i>	Rabbits	On skin		Giant Eastern rabbit flea	204
<i>Echidnophaga gallinacea</i>	Poultry	On skin		Poultry flea	204
<i>Mites</i>					
<i>Notoedres cati</i>	Cats and rabbits	Superficial layers of epidermis	Worldwide	Notoedric mange mite	210
<i>Notoedres muris</i>	Rats	Superficial layers of epidermis		Scabies mite of rats	211
<i>Cnemidocoptes pilae</i>	Budgerigars and parakeets	Superficial epidermis of feet, cere, and beak	Worldwide	Scaly leg mite of parakeets	213

Parasites by Host Species—cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Cnemidocoptes mutans</i>	Poultry	Superficial epidermis of feet	Worldwide	Scaly leg mite of chickens	213
<i>Trixacarus caviae</i>	Guinea pigs	Superficial layers of epidermis		Burrowing mite of guinea pigs	214
<i>Psoroptes cuniculi</i>	Rabbits, horses, goats, and sheep	External ear canal	Worldwide	Rabbit ear mite	214
<i>Otodectes cynotis</i>	Dogs, cats, and ferrets	External ear canal	Worldwide	Ear mites	216
<i>Demodex aurati</i>	Hamsters and gerbils	Hair follicles and sebaceous glands	Worldwide	Demodectic mange mite of hamsters and gerbils	218
<i>Demodex criceti</i>	Hamsters and gerbils	Hair follicles and sebaceous glands	Worldwide	Demodectic mange mite of hamsters and gerbils	218
<i>Ornithonyssus sylviarum</i>	Poultry	On skin	Worldwide in temperate zones	Northern fowl mite	221
<i>Dermanyssus gallinae</i>	Poultry	In environment	Worldwide	Red fowl mite	221
<i>Ornithonyssus bacoti</i>	Rats, mice, hamsters, and guinea pigs	On skin when feeding	Tropical and subtropical regions	Tropical rat mite	222
<i>Cheyletiella parasitivorax</i>	Dogs, cats, and rabbits	Surface of skin and hair coat	Worldwide	Walking dandruff	222
<i>Myobia musculi</i>	Mice	Hair shafts		Mouse fur mite	223
<i>Myocoptes musculinus</i>	Mice	Hair shafts		Mouse fur mite	223
<i>Radfordia affinis</i>	Mice	Hair shafts		Mouse fur mite	223
<i>Radfordia ensifera</i>	Rats	Hair shafts		Rat fur mite	224
<i>Chirodiscoides caviae</i>	Guinea pigs	Within pelt		Guinea pig fur mite	226
<i>Listrophorus gibbus</i>	Rabbits	Hair shafts		Rabbit fur mite	227
Ticks					
<i>Argas persicus</i>	Chickens, turkeys, and wild birds	Attached to skin when feeding		Fowl tick	230
<i>Ixodes scapularis</i>	Adult on dogs, horses, deer, and humans	Attached to skin when feeding	Eastern United States	Deer tick	231
<i>Dermacentor andersoni</i>	Adult on dogs, horses, cattle, goats, sheep, and humans	Attached to skin when feeding	Rocky Mountain regions	Rocky Mountain wood tick	232

Continued

Parasites by Host Species —cont'd

Parasite	Host	Location of Adult	Distribution	Common Name	Page
<i>Dermacentor occidentalis</i>	Adult on large mammals	Attached to skin when feeding	Sierra Nevada Mountains	Pacific Coast dog tick	233
<i>Amblyomma americanum</i>	Adult on wide range of mammals and humans	Attached to skin when feeding	Southern United States, Midwest and Atlantic Coast of United States	Lone star tick	233
<i>Amblyomma maculatum</i>	Adult on cattle, sheep, horses, dogs, and humans	Attached to skin when feeding	Atlantic and Gulf Coasts of United States	Gulf Coast tick	234
<i>Haemaphysalis leporispalustris</i>	Larval and nymphal stages on rabbits, birds, dogs, cats, and humans; adult stage on rabbits	Attached to skin when feeding	United States	Continental rabbit tick	235

Chapter

1

The Language of Veterinary Parasitology

OUTLINE

Symbiosis	2
Parasitism	3
Life Cycle	5
The Linnaean Classification Scheme	7

LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Briefly discuss the importance of veterinarians in public health.
- Briefly discuss the importance of veterinary parasitology.
- Describe the important types of symbiotic relationships.
- Become fluent in the language of veterinary parasitology.
- Use the Linnaean classification scheme within the discipline of veterinary parasitology.
- Define and describe terms associated with veterinary parasitology and give examples of parasites that exemplify these terms.

KEY TERMS

Aberrant parasite	Encysted
Acaricides	Endoparasite
Animalia	Endoparasitism
Anthelmintics	Erratic parasite
Antiprotozoals	Euryxenous parasite
Classification scheme	Facultative parasite
Commensalism	Fungi
Common name	Genus name
Definitive host	Homoxenous parasite
Ectoparasite	Host
Ectoparasitism	Incidental parasite

Infection	Periodic parasite
Infestation	Phoresis
Insecticides	Plantae
Intermediate host	Predator
Life cycle	Predator-prey relationship
Metazoan parasite	Prey
Monera	Protista
Monoxenous parasite	Pseudoparasite
Mutualism	Reservoir host
Obligatory parasite	Scientific name
Parasite	Specific epithet
Parasitiasis	Stenoxenous parasite
Parasiticides	Symbiont
Parasitism	Symbiosis
Parasitology	Transport host
Parasitosis	Veterinary parasitology
Paratenic host	Zoonosis

Veterinary medicine continues to be one of the most rapidly evolving health care professions of the twenty-first century. Veterinarians are responsible for many aspects of human health promotion and disease prevention, especially in the areas of food safety, environmental health, prevention and control of zoonotic diseases, and the human-animal bond. To accomplish these important missions, successful veterinarians, along with their professional associates, must learn to communicate effectively with a variety of individuals, ranging from health care professionals in other disciplines to print and electronic journalists to the day-to-day clients who walk off the street into the veterinary practice.

Technician's Note

Veterinarians and technicians are responsible for many aspects of human health promotion and disease prevention.

One of the most important lines of communication, however, exists between veterinary practitioners and the members of their veterinary health care teams. Veterinary technicians serve as vital members of these health care teams. As such, these technicians must be able to understand and correctly use the nomenclature and terminology for almost every specialty discipline within veterinary medicine. This is especially true for the discipline of **veterinary parasitology**, the study of parasitic relationships affecting domesticated, wild, exotic, and laboratory animals and, to some extent, parasites that have the potential to be transmitted directly from animals to humans. If animal parasites are to be effectively treated and controlled, the veterinary technician must become “fluent” in the language of parasitology and be able to communicate effectively using the specialized terminology associated with these parasites and with the complex interactions between parasites and their animal hosts. This chapter assists the veterinary technician in acquiring fluency with regard to veterinary parasitology.

Symbiosis

Planet Earth is home to millions of species of diverse living organisms that include plants, animals, fungi, algae, and unicellular organisms. Inevitably, there are millions of complex relationships taking place between and among these differing species. Many organisms live together in varied, intricate relationships. The term **symbiosis** (*sym* meaning “together” and *biosis* meaning “living,” thus “living together”) describes any association, either temporary or permanent, between at least two living organisms of different species. Each member of this association is called a **symbiont**. For example, lichen growing on the side of a tree (Fig. 1.1) is actually a very complex symbiotic relationship between a fungus and an alga. Even the act of a human

owning a dog and living with that dog is a type of symbiotic relationship. Two different living species cohabitate; the human “owner” and the “pet” dog are members of a very ancient symbiotic relationship.

Technician’s Note



Symbiosis means living together between two different species or organisms. Some of these relationships are beneficial, some are indifferent, and others are detrimental to one or more of the organisms.

There are five types of symbiotic relationships: predator-prey, phoresis, mutualism, commensalism, and parasitism. A **predator-prey relationship** is an extremely short-term relationship in which one symbiont benefits at the expense of the other. For example, a lion (the **predator**) will kill a zebra (the **prey**). The prey pays with its life and serves as a food source for the predator.

In **phoresis** (*phore* meaning “to carry”), the smaller member of the symbiotic relationship is mechanically carried about by the larger member. The bacterium *Moraxella bovis*, the etiologic agent of infectious bovine keratoconjunctivitis, or pinkeye of cattle, is mechanically carried from the eyes of one cow to those of another on the sticky footpads of the face fly, *Musca autumnalis* (Fig. 1.2).

The term **mutualism** describes an association in which both organisms in a symbiotic relationship benefit. For example, within the liquid rumen environment of a cow are millions of microscopic, swimming, unicellular, ciliated protozoans. The cow provides these tiny creatures with a warm, liquid environment in which to live. In return, the rumen ciliates break down cellulose for the cow and aid in its digestion processes.



Fig. 1.1 Lichen growing on the side of a tree is a symbiotic relationship between fungus and alga.



Fig. 1.2 *Moraxella bovis*, the etiologic agent of infectious bovine keratoconjunctivitis (pinkeye), is mechanically carried from the eyes of one cow to those of another on the sticky footpads of the face fly, *Musca autumnalis*.

Technician's Note

In mutualistic symbiosis, both organisms benefit from the relationship.

The term **commensalism** describes an association in which one symbiont benefits and the other is neither benefited nor harmed. An example is the relationship between the shark and the remora, its “hitchhiker.” The remora attaches to the underside of the shark and hitches a ride. The remora also eats the food scraps, or leftovers, after the shark’s meals. The remora benefits from this relationship, whereas the shark is neither benefited nor harmed.

In **parasitism**, an association exists between two organisms of different species in which one member (the **parasite**) lives on or within the other member (the **host**) and may cause harm. The parasite becomes metabolically dependent on the host.

This book discusses the host-parasite relationships between domesticated and wild animals and their parasites. **Parasitology** is the study of such parasitic relationships.

Parasitism

Parasitism can occur in differing degrees. In **parasitiasis**, the parasite is present on or within the host and is potentially pathogenic (harmful); however, the animal does not exhibit outward clinical signs of disease. For example, healthy cattle on pasture may harbor bovine trichostrongyles (roundworms) in their gastrointestinal tracts, but the cattle do not exhibit outward clinical signs of parasitism (Fig. 1.3). Parasitiasis describes this type of parasitic relationship.



Fig. 1.3 Healthy cattle on pasture may harbor bovine trichostrongyles (roundworms) in their gastrointestinal tracts but not exhibit outward clinical signs of parasitism. This condition is known as *parasitiasis*.

In **parasitosis**, the parasite is present on or within the host and does produce obvious injury or harm to the host animal. The host exhibits obvious outward signs of clinical parasitism (Fig. 1.4). For example, an emaciated cow on pasture certainly harbors bovine trichostrongyles (roundworms) in its gastrointestinal tract. Parasitosis describes this type of parasitic relationship.

Technician's Note

Throughout the book, the symbol  will be used to denote the fact that a parasite has **zoonotic potential**. This emblem means the reader should pay close attention to the parasite and remember that it may be transmitted between animals and human beings.

A parasite can cause parasitiasis in some animals with a low parasite burden or number; however, it may also cause parasitosis with a high parasite burden.

In any parasitic relationship, the parasite lives on or within the body of the host. If the parasite lives *on* the body of the host, it is called an **ectoparasite**. Cat fleas (*Ctenocephalides felis*) on a dog are ectoparasites (Fig. 1.5). If a parasite lives *within* the body of the host, it is called an **endoparasite**. The dog heartworm (*Dirofilaria immitis*) is an endoparasite (Fig. 1.6). **Ectoparasitism** is parasitism by an external parasite. **Endoparasitism** is parasitism by an internal parasite. Similarly, an ectoparasite will produce an **infestation** on the host, and an endoparasite will produce an **infection** within that host.



Fig. 1.4 This emaciated cow probably harbors millions of bovine trichostrongyles (roundworms) in its gastrointestinal tract. As a result of this parasitism, the cow exhibits obvious outward clinical signs. This condition is referred to as *parasitosis*.

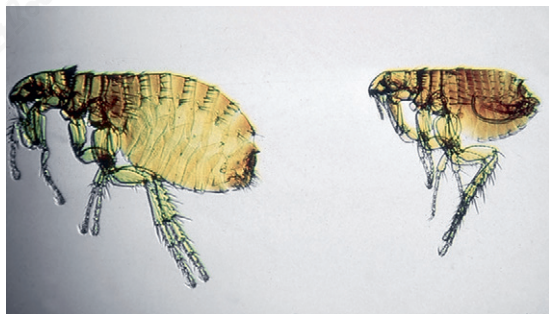


Fig. 1.5 These cat fleas (*Ctenocephalides felis*) live within a dog's hair coat. They are ectoparasites and produce *ectoparasitism*. Similarly, these fleas produce infestations in the host's hair coat.

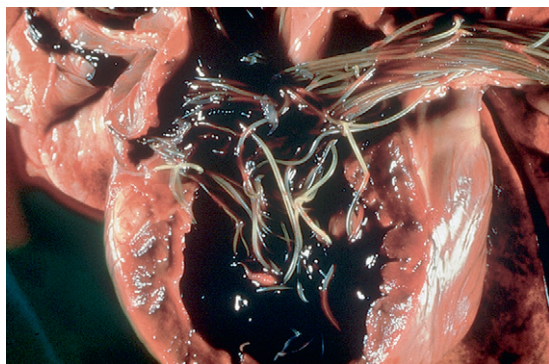


Fig. 1.6 These heartworms (*Dirofilaria immitis*) live in a dog's heart. They are endoparasites and produce *endoparasitism*. Heartworms produce infection within the host's heart. The dog is a definitive host for canine heartworm and harbors adult, sexual, or mature stages of the parasite.

Technician's Note



It is important to understand that an infection is a condition caused inside the host's body, whereas an infestation is a condition caused on the outside of the host's body.

Both endoparasitism and ectoparasitism in domestic animals can be treated by administering **parasiticides**, chemical compounds (both simple and complex) used to treat specific internal and external parasites. The different types of parasiticides include **anthelmintics** (or anthelminthics; compounds developed to kill roundworms, tapeworms, flukes, and thorny-headed worms), **acaricides** (compounds developed to kill mites and ticks), **insecticides**

(compounds developed to kill insects), and **antiprotozoals** (compounds developed to kill protozoan organisms).

Sometimes a parasite will wander from its usual site of infection into an organ or location in which it does not ordinarily live. When this happens, the parasite is called an **erratic parasite** or **aberrant parasite**. For example, *Cuterebra* species, called *warbles* or *wolves*, found in the skin of dogs or cats may accidentally “wander” or migrate into the cranial vault. When this happens, *Cuterebra* becomes an erratic (aberrant) parasite (Fig. 1.7).

A parasite can be found in a host in which it does not usually live. When this occurs, the parasite is called an **incidental parasite**. For example, humans can become infected with larval stages of *D. immitis*, the canine heartworm. Because humans are not the usual host, the canine heartworm is an incidental parasite in people.

Organisms that are “free living” (nonparasitic) can become parasitic in certain hosts. These organisms are called **facultative parasites**. An example is *Pelodera strongyloides*, a free-living soil nematode (roundworm) that usually lives in the superficial layers of the soil as a “non-parasite.” However, this roundworm is capable of penetrating the skin of many domesticated animals, particularly dogs lying in moist dirt and “downer cattle,” and establishing a parasitic skin infection. *P. strongyloides* is therefore a facultative parasite.

An **obligatory parasite**, however, is a parasite that must lead a parasitic existence. These are not capable of leading a free-living existence. *D. immitis*, the canine heartworm, is an obligatory parasite; most of the parasites that affect domesticated and wild animals are obligatory parasites.

Technician's Note



Some parasites can have obligatory stages in their development when they need a host, and some life stages can be nonparasitic. In addition, with some parasites, only the female adult is parasitic, whereas the free-living immature males and females are nonparasitic.

A parasite does not necessarily have to live on or within a host. It can make frequent short visits to its host to obtain nourishment or other benefits. Such a parasite is called a **periodic parasite**. The best example of a periodic parasite is the female mosquito, which sucks blood from the vertebrate host. The host's blood is required for her egg development; without a blood meal, the female mosquito will not have sufficient protein to lay her eggs.

Living creatures or objects that are not parasitic may be mistaken for or erroneously identified as parasites. These are referred to as **pseudoparasites**. Sometimes, fecal flotation procedures reveal pollen grains from trees, such as



Fig. 1.7 **A**, *Cuterebra* species (warbles, wolves) in the skin of dogs or cats may migrate into the cranial vault; *Cuterebra* is then an erratic (aberrant) parasite that has become “lost” on its migration path. **B**, Enlargement of a parasite in the cranial vault.

pine pollen (**Fig. 1.8**), or from flowering plants. A novice veterinary student or veterinary technician may view these pollen grains on fecal flotation and erroneously identify them as parasites, but they are pseudoparasites.

Technician’s Note



Novice veterinary students and veterinary technicians might mistake tiny, round air bubbles on a fecal flotation slide for a parasite egg as well.

Life Cycle

Each parasite has its own **life cycle** (**Fig. 1.9**). The life cycle is the development of a parasite through its various life stages. Every parasite has at least one definitive host and may have one or more intermediate hosts. The **definitive host** is the host that harbors the adult, sexual, or mature stages of the parasite. For example, the dog is the definitive host for *D. immitis*; mature male and female heartworms (the sexual stages of the parasite) are found in the right ventricle and pulmonary arteries of the dog’s heart (see **Fig. 1.6**). The **intermediate host** is the host that harbors the larval, juvenile, immature, or asexual stages of the parasite. The female mosquito is the intermediate host for *D. immitis*; larval or immature heartworms (the developing stages of the parasite) are found in the Malpighian tubules and

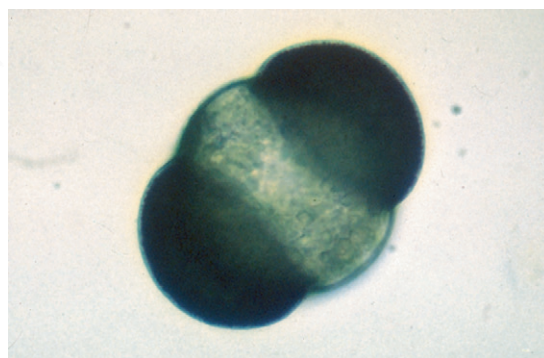


Fig. 1.8 Pollen grains from a pine tree revealed on fecal flotation. A beginning veterinary student or technician may view this pollen on fecal flotation and erroneously assume the grains are parasites when they are actually pseudoparasites.

proboscis of the mosquito (**Figs. 1.10 and 1.11**). The intermediate host transfers the parasite from one definitive host to another. A parasite may have more than one intermediate host. In the life cycle of *Platynosomum concinnum*, the lizard-poisoning fluke of cats, a land snail is the first intermediate host for the parasite, and a lizard is the second intermediate host. This liver fluke requires two intermediate hosts to infect the cat.

In a special type of intermediate host, a parasite does not undergo any development but instead remains arrested or **encysted** (“in suspended animation”) within the host’s tissues (either definitive host or intermediate host). This host is called the **transport host** or **paratenic host**. The larvae

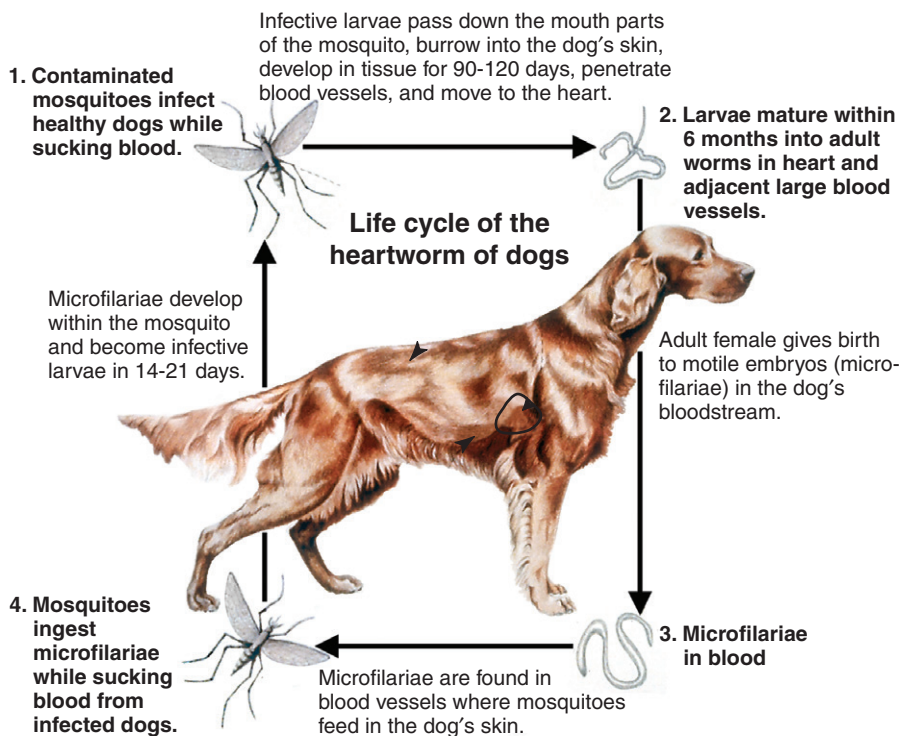


Fig. 1.9 Life cycle of *Dirofilaria immitis*. In this life cycle, the dog is a definitive host and the mosquito is an intermediate host. Mature male and female heartworms (sexual stages of the parasite) are found in the right ventricle and pulmonary arteries of a dog's heart.



Fig. 1.10 The mosquito is intermediate host for *Dirofilaria immitis*; larval or immature heartworms (developing stages of the parasite) are found in the mosquito's Malpighian tubules.



Fig. 1.11 Larval or immature heartworms (developing stages of the parasite) may also be found in the mosquito's proboscis. The mosquito (intermediate host) transmits heartworm infection from one dog to another.

remain in this suspended state until the definitive host eats the transport host. Once within the definitive host, the larvae “wake up,” establish an infection, migrate to their predilection site, and grow to adult parasites within the definitive host.

A **reservoir host** is a vertebrate host in which a parasite or disease occurs in nature and is a source of infection for humans and domesticated animals. Heartworms may develop in the right ventricle and pulmonary artery of wild wolves and coyotes. Wolves and coyotes may be reservoir hosts for heartworm; the infection may be spread from the wolf or coyote to the family pet by the mosquito as the intermediate host.

Technician's Note

Some parasites can serve as intermediate hosts for other parasites as well as being parasites themselves. For example, the mosquito feeds off animals and is thus a parasite but also acts as an intermediate host to the parasite that causes heartworm disease.

A **homoxenous** or **monoxenous parasite** is a parasite that infects only one type of host. For example, *Eimeria tenella*, a coccidian, infects only chickens. Similarly, a **stenoxenous parasite** is a parasite with a narrow host range. Because *E. tenella* will only infect chickens, it is a stenoxenous parasite. This protozoan parasite infects only the ceca of chickens (Fig. 1.12). A **euryxenous** parasite is a parasite with a very broad host range. For example, *Toxoplasma gondii* infects more than 300 species of warm-blooded vertebrates; therefore it is a euryxenous parasite.



Fig. 1.12 *Eimeria tenella* infects only the ceca of chickens; therefore it is a homoxenous or monoxenous parasite.

Technician's Note

It should be noted that immature asexual stages of *Toxoplasma gondii* infects more than 300 species of warm-blooded vertebrates; its sexual stages occur only in the feline.

A **zoonosis** is any disease or parasite that is transmissible from animals to humans. Examples of zoonotic parasites are *T. gondii*, *Trichinella spiralis*, *Ancylostoma caninum*, and *Toxocara canis*. Zoonotic parasites are discussed in later chapters.

The Linnaean Classification Scheme

In beginning biology, students must learn the classification scheme perfected by Carl Linnaeus, an early Swedish biologist. Every organism can be classified using the following **classification scheme**: kingdom, phylum, class, order, family, genus, and species (Fig. 1.13). Students often remember this classification scheme with the simple mnemonic device “King Philip came over for good spaghetti,” in which the first letter of each word in the sentence corresponds to the first letter in the Linnaean classification scheme.

The Linnaean classification scheme works in the following manner. Several million species of animals, plants, fungi, protozoans, and algae live on the earth. These creatures may have different **common names** in different regions of the world. A common name may refer to different organisms in different places. The solution to this problem was to give each organism a **scientific name** composed of two

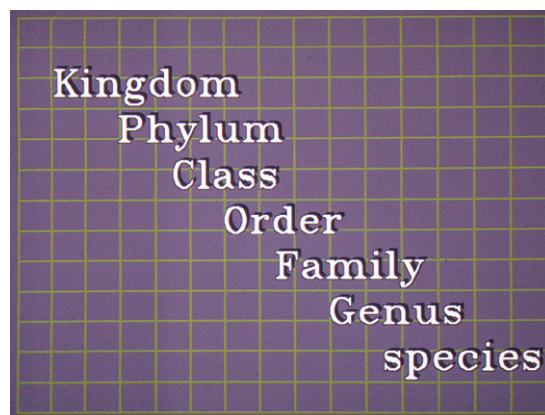


Fig. 1.13 All organisms can be classified using the Linnaean classification scheme.

Latin words, which are commonly written in italics. The first word is capitalized and is the **genus name**. The genus indicates the group to which a particular type of animal or plant belongs. The second word is not capitalized; it is the **specific epithet** and indicates the type of animal itself. Examples of common names of animals and their corresponding scientific names are the dog, *Canis familiaris*; the cat, *Felis catus*; the housefly, *Musca domestica*; and a bacterium normally found in the gut, *Escherichia coli*. Similar species are grouped together into the same genus. Similar genera (plural form of *genus*) are grouped together in the same family. Similar families are grouped together in the same order. Similar orders are grouped together in the same class. Similar classes are grouped together in the same phylum. Similar phyla are grouped together in the same kingdom. Therefore the classification scheme for the dog is as follows:

Technician's Note



For ease in finding particular parasites, this book is organized by phylum/class. Tables are provided showing the parasites by the hosts they affect, along with the corresponding pages on which they are described.

Domain: Eukaryota
 Kingdom: Animalia
 Phylum: Chordata
 Subphylum: Vertebrata
 Class: Mammalia
 Order: Carnivora
 Family: Canidae
 Genus: *Canis*
 Species: *familiaris*

Every living creature has its own unique classification scheme. This text discusses many parasites that affect domesticated animals. It is important to learn the scientific names, the common names, the hosts, and the key identifying features for all of these parasites.

The domain has been added to the Linnaean classification scheme. There are three recognized domains in the scheme: Bacteria, Archaea, and Eukaryota. Eukaryota includes the kingdoms Plantae, Animalia, Protista, Monera, and Fungi.

The classification scheme contains the following five kingdoms: **Plantae** (plants), **Animalia** (animals), **Protista** (unicellular organisms), **Monera** (algae), and **Fungi** (fungi). Veterinary parasitology is concerned with only two of these kingdoms as true parasites of domesticated animals. The first is the kingdom Animalia, which contains the **metazoan parasites** (multicellular organisms) such as the platyhelminths (Flatworms—trematodes [flukes] and cestodes

[tapeworms]), nematodes (roundworms), acanthocephalans (thorny-headed worms), annelids (leeches), and arthropods (insects, mites, ticks, spiders, pentastomes, and other creatures with jointed appendages). The second is the kingdom Protista, which contains protozoans (unicellular organisms). The following chapters present parasites from each of these groups and describe their significance in veterinary parasitology.

Technician's Note



Most parasites of domestic animals belong to the kingdom Animalia.

Any student of veterinary parasitology must use the terms presented in this chapter and their definitions as the “framework” on which to build greater proficiency in this discipline. As with the veterinarians with whom they work, veterinary technicians must be encouraged to embrace continual improvement in their professional knowledge and competence.

All of the scientific terms or phrases detailed in this first chapter are terms of veterinary significance in understanding the discipline of veterinary parasitology. There is one parasitologic term, however, that stands out above all of the other terms described in the chapter. That term is the word *zoonosis* and its associated derivative, the term *zoonotic parasite*. These two terms hold all veterinary professionals up to one of the basic tenets ascribed to the veterinary profession, that is, the promotion of public health for all of the citizens of our nation and for the entire world. Health promotion and disease prevention of zoonotic parasites set the veterinary profession apart from most of the other human health care professions. As veterinary professionals, we must always be able to transmit the basic information of the “Who?,” “What?,” “When?,” “Where?,” “Why?,” and “How?” regarding zoonotic parasites and any other zoonotic disease. Veterinarians and their technicians must be able to communicate clearly and succinctly the multitude of parasites and other diseases of animals that may be transmitted to citizens of the world. Veterinary professionals must possess the knowledge, competence, confidence, and expertise to serve in these important roles. Left on their own, some clients may seek online sites that do not provide enough quality information as the Centers for Disease Control and Prevention, the American Veterinary Medical Association, the American Heartworm Society, and the American Association of Veterinary Parasitologists. These organizations have become tried and tested as outstanding resources for disseminating additional supportive information regarding zoonotic parasites and other transmissible diseases.

Chapter One Test

MATCHING—Match the term in the left hand column with the correct phrase or term in the right hand column.

A. Phoresis	1. Parasite that wanders into an organ in which it does not normally live
B. Parasitology	2. Parasite in a host in which it does not usually live
C. Ectoparasite	3. Study of parasitic relationships
D. Endoparasite	4. Creature or object that is mistaken for a parasite
E. Erratic/aberrant parasite	5. Parasite that makes frequent visits to a host to obtain nourishment
F. Pseudoparasite	6. Kingdom, phylum, class, order, family, genus, species
G. Incidental parasite	7. Face fly that carries the pinkeye bacterium from one cow to another
H. Periodic parasite	8. Disease or parasite that is transmissible from animals to humans
I. Zoonosis	9. Parasitism by an internal parasite
J. Linnaean classification scheme	10. Parasitism by an external parasite

Questions for Thought and Discussion

- Why is it important for a veterinary technician to know and understand the terminology associated with veterinary parasitology?
- Compare and contrast the following terms. Why is it important to understand the difference between each pair of terms?
 - Intermediate host versus definitive host
 - Parasitosis versus parasitiasis
 - Infestation versus infection
 - Common name versus scientific name
 - Anthelmintic versus insecticide
 - Obligatory parasite versus facultative parasite
 - Stenoxenous parasite versus euryxenous parasite
- Define three types of symbiotic relationships, and give one example of each.
- Briefly discuss the importance of the Linnaean classification scheme.
- What are the five kingdoms within the Linnaean classification scheme? Which two are most important in veterinary parasitology?
- Of all of the scientific terms listed in the previous matching section (items A through J), which one is the most important term with regard to veterinary public health? Why?

Parasites That Infect and Infest Domestic Animals

OUTLINE	
Monogenetic Trematodes (Monogenetic Flukes)	10
Digenetic Trematodes (Digenetic Flukes)	11
Eucestodes (True Tapeworms)	11
Cotyloda (Pseudotapeworms)	11
Nematodes (Roundworms)	11
Acanthocephalans (Thorny-Headed Worms)	12
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- LEARNING OBJECTIVES**
- After studying this chapter, the reader should be able to do the following:
- Understand that many types of living “creatures” are capable of parasitizing domesticated, wild, exotic, and laboratory animals.
 - Understand that the Linnaean classification scheme is an important tool for studying veterinary parasitology.

KEY TERMS	
Acanthocephalans	Parasitism
Alimentary canal	Pseudotapeworms
Arthropoda	Roundworms
Causal agents	Tegument
Digenetic flukes	Toxins
Intermediate hosts	True tapeworms
Leeches	Vectors
Monogenetic flukes	Venomous substances

Chapter 1 describes **parasitism** as an association between two organisms of different species in which one member (the parasite) lives on or within the other member (the host) and may cause harm. The parasite is metabolically dependent on the host.

In parasitology, the study of parasitic relationships, parasitic groups are classified according to the Linnaean classification system. This chapter presents the parasites that infect and infest domesticated animals, indicating their important characteristics and their place in the Linnaean system.

Monogenetic Trematodes (Monogenetic Flukes)

Kingdom: Animalia (animals)
Phylum: Platyhelminthes (flatworms)
Class: Trematoda (flukes)
Subclass: Monogenea (monogenetic flukes)

Monogenetic flukes are ectoparasites of fish, amphibians, and reptiles. They are rarely parasites of mammals. These flukes are seen most often as ectoparasites of the gills, skin, fins, and mouths of fishes and are rarely observed in a veterinary clinical situation. They might be seen by a veterinarian who specializes in diseases of aquarium fish, also by some veterinarians who may specialize in fish farming or some aspect of aquaculture. Under these conditions, monogenetic flukes may be frequently observed.

Technician’s Note



Monogenetic flukes are ectoparasites that parasitize fish, amphibians, and reptiles. They are rarely seen in a veterinary clinic setting.

Digenetic Trematodes (Digenetic Flukes)

Kingdom: Animalia (animals)
 Phylum: Platyhelminthes (flatworms)
 Class: Trematoda (flukes)
 Subclass: Digenea (digenetic flukes)

Digenetic flukes are important parasites of both large and small animals. These flattened, leaf shaped flukes are primarily endoparasites of the gastrointestinal tract; however, digenetic flukes can also infect the lungs and blood vasculature. Regardless of the site of infection, the operculated eggs of these flukes can be identified in the feces of domestic animals.

Technician's Note



Digenetic flukes infect both large and small animals and are seen in a veterinary clinic setting.

Eucestodes (True Tapeworms)

Kingdom: Animalia (animals)
 Phylum: Platyhelminthes (flatworms)
 Class: Eucestoda (true tapeworms)

Adult **true tapeworms** are ribbon-like flatworms found in the gastrointestinal tract of their definitive hosts. True tapeworms lack a "gut" or **alimentary canal**; they absorb nutrients through their **tegument** (skin). The eggs of these tapeworms are frequently observed on fecal flotation. The larval stages of these true tapeworms may be found in a variety of extraintestinal tissue sites in domestic animals; the animals harboring the larval stages serve as the intermediate hosts. In these extraintestinal sites, the larval stages of these tapeworms may cause more pathology to the intermediate hosts than the adult tapeworm does to the definitive host in its intestinal sites.

Technician's Note



True tapeworms absorb nutrients from the host through their tegument.

Cotyloda (Pseudotapeworms)

Kingdom: Animalia (animals)
 Phylum: Platyhelminthes (flatworms)
 Class: Cotyloda (pseudotapeworms)

Similar to true tapeworms, adult **pseudotapeworms** are flattened and ribbon-like. They resemble true tapeworms and also are found in the gastrointestinal tract of their definitive hosts. Their egg stages may be diagnosed on fecal flotation; they produce operculated eggs. The larval stages of pseudotapeworms are found in microscopic aquatic crustaceans and in the musculature of fish and reptiles. These larval stages seldom produce pathology in domestic animals.

Technician's Note



Pseudotapeworms use microscopic aquatic crustaceans and the musculature of fish and reptiles as intermediate hosts for part of their life cycle.

Nematodes (Roundworms)

Kingdom: Animalia (animals)
 Phylum: Nematoda (roundworms)

Nematodes, or **roundworms**, are elongated, unsegmented, cylindric worms. They are called *roundworms* because they are round when observed in cross section on histopathologic examination. Nematodes are the most numerous, complex, and variable among the helminth parasites of domesticated animals. They come in all sizes and shapes and can infect a variety of organs and organ systems. They can produce significant pathology in domesticated animals. On planet Earth, nematodes are second only to arthropods with regard to their numbers and complexity of life cycles. The eggs and larvae of nematodes are most often diagnosed on fecal flotation, so it is important that veterinary technicians become proficient in their identification. Both adult and larval stages of nematodes can produce significant pathology in domesticated animals.

Technician's Note



The nematodes are the largest group of helminths that parasitize domesticated animals.

Acanthocephalans (Thorny-Headed Worms)

Kingdom: Animalia (animals)

Phylum: Acanthocephala (thorny-headed worms)

Acanthocephalans, or thorny-headed worms, are elongated, unsegmented, cylindric worms. They are different from nematodes, however, in that they possess a spiny proboscis on their anterior end. This spiny proboscis is used as an organ of attachment. Because of this anterior proboscis, acanthocephalans are often referred to as *thorny-headed worms*. As with the cestodes (tapeworms), thorny-headed worms lack a gut or alimentary tract; they also absorb nutrients through their tegument (skin). Adult acanthocephalans are very uncommon parasites and are most often found in the gastrointestinal tract. The eggs of these unusual parasites are diagnosed on fecal flotation.

Technician's Note



Acanthocephalans are referred to as *thorny-headed worms* because of the spiny proboscis; which is used as an organ of attachment on the anterior end of the parasite.

Hirudineans (Leeches)

Kingdom: Animalia (animals)

Phylum: Annelida (segmented worms)

Class: Hirudinea (leeches)

Leeches are blood-feeding ectoparasites of both wild and domesticated animals. These annulated (ringed) worms are typically found in fresh water, although there may be marine and terrestrial varieties. Leeches may produce significant pathology in both wild and domesticated animals, or they may be beneficial when used after reconstructive surgical procedures in both animals and humans.

Technician's Note



Some species of leeches are used for medicinal purposes in reconstructive surgical procedures in both humans and animals.

Arthropods

Kingdom: Animalia (animals)

Phylum: Arthropoda (animals with chitinous exoskeletons and with jointed legs)

The phylum **Arthropoda** is the largest phylum in the animal kingdom. This phylum is quite complex, containing pentastomes, crustaceans, centipedes, millipedes, insects, mites, ticks, scorpions, and spiders.

Arthropods are important in veterinary medicine for the following four reasons:

1. Arthropods may serve as **causal agents** themselves.
2. They may serve as **intermediate hosts** for certain helminths and protozoans.
3. They may serve as **vectors** for bacteria, viruses, spirochetes, and chlamydial agents.
4. They may produce **toxins** or **venomous substances**.

Arthropods may parasitize the host in both the adult and juvenile stages.

Technician's Note



Arthropoda is the largest phylum in the animal kingdom and includes most of the ectoparasites seen in the veterinary profession.

Protista (Protozoans)

Kingdom: Protista (protozoans—unicellular, or single-celled, organisms)

Trematodes, tapeworms, pseudotapeworms, roundworms, thorny-headed worms, leeches, and arthropods are all members of the animal kingdom. All the parasites described here are metazoan, or multicellular, organisms. The remaining parasites belong to the kingdom Protista, which is made up of all the unicellular organisms. The majority of protozoans on planet Earth are free living; however, those that are parasitic can cause significant pathology in domesticated animals. Within this kingdom are several phyla that include flagellates, amoebae, apicomplexans, and ciliates. These protozoans are the primary protozoans that cause significant pathology in domesticated animals. Despite their tiny size, protozoans have complex life cycles and may cause significant pathologic changes in the tissues and organs of domesticated animals.

Technician's Note

The protozoans are single-celled endoparasites that include such organisms as *Giardia* species and the organisms that cause coccidiosis.

These groups of parasites and their significance to veterinary parasitology are discussed in detail in the upcoming chapters.

Chapter Two Test

MATCHING—Match the term in the left hand column with the correct definitions in the right hand column.

A. Platyhelminthes	1. Thorny-headed worms
B. Protists	2. Pseudotapeworms
C. Eucestodes	3. Leeches
D. Cotyloda	4. True tapeworms
E. Nematodes	5. Roundworms
F. Acanthocephalans	6. Animals with jointed appendages
G. Metazoans	7. Flukes
H. Hirudineans	8. Unicellular or single-celled organisms
I. Arthropods	9. Flatworms
J. Trematodes	10. Multicellular organisms

Questions for Thought and Discussion

1. Why is the Linnaean classification system so important in the study of veterinary parasitology? Can you think of a more efficient way to study, learn, and remember the various groups of parasites of domesticated, wild, exotic, and laboratory animals?
2. Based on the descriptions of the parasites to be studied in this textbook, what types of parasites have you observed in/on your pets or large animals? What parasite do you wish to know more about?

Chapter

3

Introduction to the Nematodes

OUTLINE

Nematodes of Importance in Veterinary Medicine 14

Key Morphologic Features 15
Life Cycle of the Nematode 18

LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Briefly discuss the importance of nematodes in veterinary practice.
- Describe the important external morphologic features for identifying nematodes.
- Name the important parts of the male nematode's reproductive system.
- Name the important parts of the female nematode's reproductive system.
- Determine which reproductive system (male or female) is more important in veterinary parasitology (diagnostically speaking).
- Describe the four types of nematode eggs.
- Determine the differences among these reproductive terms: oviparous, ovoviviparous, and larviparous.
- Describe the "typical life cycle" of a representative nematode.
- Explain the difference between a direct life cycle and an indirect life cycle.
- Integrate these terms with the nematode parasites covered in [Chapter 4](#).

KEY TERMS

Ascaroid- or ascarid-type egg	Cloaca
Body cavity	Copulatory bursa
Bursal rays	Dioecious
Cervical alae	Direct life cycle
	Hypodermis

Indirect life cycle
Infective third-stage larva
Larviparous
Leaf crown
Molts
Morula stage
Oviduct
Oviparous
Ovoviviparous
Papillae
Pseudocoelom
Pseudocoelomic membrane

Rectum
Seminal receptacle
Somatic muscular layer
Spicule pouch
Spicules
Spiruroid-type egg
Trichinelloid- or trichuroid-type egg
Trichostrongyle- or strongyle-type egg
Tubular ovaries
Tubular testes
Vas deferens

Members of the phylum Nematoda, the nematodes, or roundworms, are the most numerous and most diverse group of animals on Earth. Approximately 10,000 species thrive in very diverse habitats. There are three basic types of nematodes: (1) the free-living nematodes residing in marine water, freshwater, and soil environments; (2) the nematodes that parasitize plants; and (3) the nematodes that parasitize domesticated and wild animals and humans.

Note



Nematodes are collectively referred to as *roundworms* and are the most numerous and diverse group of animals on Earth.

Nematodes of Importance in Veterinary Medicine

Nematodes in domesticated farm animals in the United States alone cause the loss of billions of dollars in animal

agriculture, resulting from veterinary bills and death. Plant nematodes cause approximately 10% of cultivated crops to be lost each year. It is impossible to determine similar monetary losses in the pet or companion animal “industry.”

Key Morphologic Features

Protozoans, discussed in [Chapters 10 and 11](#), are unicellular organisms; nematodes, however, are multicellular organisms. Whereas trematodes (leaf-like in form) and cestodes (chain-like or boxcar-like in form) are dorsoventrally flattened in cross section, nematodes are unsegmented, elongate, rounded on both ends, circular in cross section, and bilaterally symmetric ([Fig. 3.1](#)); thus they are often referred to as *roundworms*. Nematodes come in a variety of sizes, from *Strongyloides stercoralis*, a tiny parasitic female worm only 2 mm in length and about 35 μm wide ([Fig. 3.2](#)), to *Diectophyma renale*, “the giant kidney worm,” measuring 100 cm (1 m) in length and 1.2 cm wide ([Fig. 3.3](#)). As mentioned previously, most nematodes are cylindric and rounded on both ends; however, nematodes come in a wide variety of shapes, from spherical (definitely not cylindric), such as *Tetrameres* species, parasites of the gizzard of domesticated and wild birds ([Fig. 3.4](#)), to the whip-like *Trichuris* species, which parasitize every domesticated animal except the horse ([Fig. 3.5](#)).

Technician’s Note

Nematodes are referred to as *roundworms* because they are circular in cross section, rounded at both ends, unsegmented, elongate, and bilaterally symmetric.

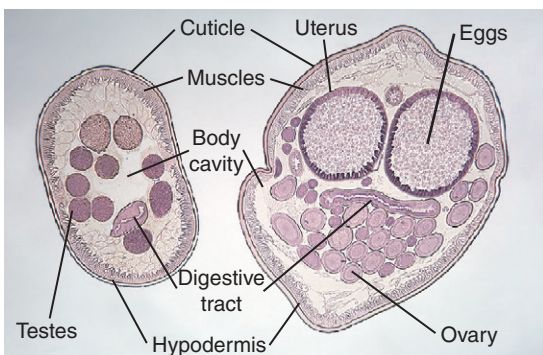


Fig. 3.1 Cross section of male (*left*) and female (*right*) *Ascaris suum*, the pig roundworm. Whereas flukes and tapeworms are dorsoventrally flattened, roundworms are usually round in cross section.

External Morphologic Features

Nematodes are covered by a thin cuticle (see [Fig. 3.1](#)). This cuticle covers the exterior body surface of the nematode and extends into all its body openings, that is, the mouth, esophagus, and rectal and genital openings. On the external surface, the cuticle has a variety of modifications. There may be lateral flattened expansions of the cuticle in the region of the anterior end; these expansions are called **cervical alae** ([Fig. 3.6](#)). There also may be lateral flattened expansions of the cuticle in the region of the posterior end of some male nematodes; this posterior lateral expansion is called the **copulatory bursa** and serves to hold on to or to grasp the female nematode during the mating process ([Fig. 3.7](#)). The copulatory bursa is composed of finger-like



Fig. 3.2 Numerous parasitic female *Strongyloides stercoralis* (approximately 2 mm in length and about 35 μm wide) recovered from mucosal scrapings from a canine small intestine.



Fig. 3.3 The largest nematode known to parasitize domesticated animals, *Diectophyma renale*, the “giant kidney worm” of dogs. This largest of parasites measures 100 cm (1 m) in length and is approximately 1.2 cm wide.



Fig. 3.4 Nematodes come in a variety of shapes. Some are spherical, such as *Tetrameres* species, which parasitize the gizzard of domesticated and wild birds.



Fig. 3.5 Whip-like *Trichuris* species parasitize every domesticated animal except the horse.

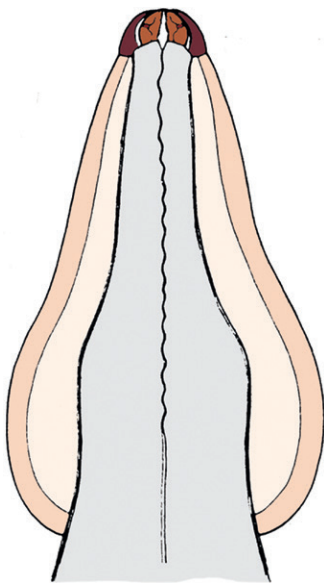


Fig. 3.6 Diagrammatic representation of lateral flattened expansion of the cuticle on the anterior end of *Toxocara cati*, the feline ascarid. These expansions are called *cervical alae*.

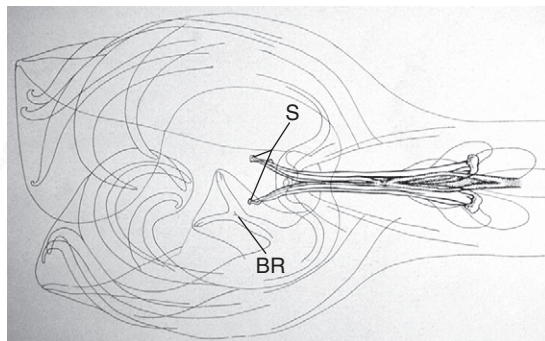


Fig. 3.7 Diagrammatic representation of lateral flattened expansion of the cuticle on the posterior end of male *Haemonchus contortus*, the “barberpole worm” of ruminants. This expansion is called the *copulatory bursa* and serves or grasp the female nematode during the mating process. The copulatory bursa is composed of finger-like projections called *bursal rays*. Between each adjacent bursal ray are thin membranes. Male spicules (or intromittent organs) are associated with the copulatory bursa.

projections called **bursal rays**. Between each adjacent bursal ray are thin membranes. The male’s highly chitinous and pigmented **spicules** (see Fig. 3.7) (the intromittent organs, or “penis”) are associated with the copulatory bursa. The cervical alae and the copulatory bursa are only two of the many modifications of the external cuticle of nematodes. The nematode’s cuticle is secreted, or formed, by the thin layer directly beneath it, the **hypodermis** (see Fig. 3.1).

Just beneath the hypodermis lies the **somatic muscular layer**, the layer of muscles that enables the nematode to move about (see Fig. 3.1, *muscles*). These muscle fibers are spindle shaped and lie along the edge of the hypodermis. Nematodes also possess specialized muscles that aid in feeding and reproductive activities. The muscles line the nematode’s **body cavity** (see Fig. 3.1). Unlike trematodes (flukes) and cestodes (tapeworms), which lack a body cavity, nematodes (roundworms) do have a body cavity.

The body cavity of a typical nematode is not considered a true coelom; it is a **pseudocoelom** lined by a **pseudo-coelomic membrane**.

Internal Morphologic Features

The most important of the nematode's organ systems are the digestive and reproductive systems.

The digestive tract of the typical nematode is a long, straight tube that extends from the mouth to the anus. On cross section, the digestive tract resembles a tube within a tube (see Fig. 3.1, *digestive tract*).

The mouth may be surrounded by lips, numbering two to eight. In some nematodes, the lips are replaced by finger-like projections, or bumps, called **papillae**. Collectively, these papillae may number as many as 40 and are referred to as the **leaf crown** (Fig. 3.8). The mouth connects to a buccal cavity, which connects to the esophagus, which connects to a long, winding intestine. The intestine ends with an opening to the outside. Female nematodes have a **rectum**, and male nematodes have a **cloaca**. Remember that the cloaca and the rectum are lined with cuticle and open to the outside through an anus. The part of the nematode's body posterior to the anus is the tail.

Note

The most important organ systems of the nematode are the reproductive system and the digestive system.



Whereas trematodes (flukes) and cestodes (tapeworms) are hermaphroditic (or monoecious), nematodes are **dioecious**; that is, they have separate sexes. There are both male nematodes and female nematodes.

The male reproductive organs consist of one or two **tubular testes** (see Fig. 3.1). Usually, a **vas deferens** leads from the testes to the cloaca. There may be a **spicule pouch**, which contains two spicules. Remember that the male nematode's spicules (or intromittent organs) are associated with the copulatory bursa and serve to open the female nematode's vulva during copulation to allow sperm to enter the vagina.

The female reproductive organs consist of one or two **tubular ovaries** (see Fig. 3.1, *ovary*). Usually an **oviduct** leads from the ovary to the uterus. A **seminal receptacle** for sperm storage may be present. The uterus leads to the vagina, which opens to the outside through the vulva. The uterus may contain thousands of eggs or larvae (see Fig. 3.1, *uterus* and eggs). Parasitic nematodes are very prolific; a

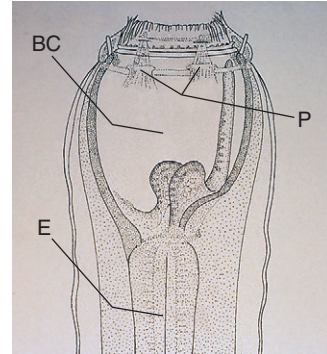


Fig. 3.8 Tiny finger-like projections, or bumps, called *papillae* on the anterior end of *Strongylus vulgaris*. Collectively, these papillae may number as many as 40 and are referred to as the *leaf crown*. The mouth connects to a buccal cavity, which connects to the esophagus, which eventually connects to the long, winding intestine.

single female nematode may produce several thousand eggs (or larvae) each day. The reproductive system is important because it allows for the production of eggs (and eventually offspring). A veterinary diagnostician confronted with an unrecognized type of nematode can dissect it, and if the nematode is a female, characteristic eggs (or larvae) may be released. When examined microscopically, these eggs or larvae provide a valuable clue as to the type (or species) of nematode.

Note

A female nematode can produce thousands of eggs or larvae each day; however, whipworms tend to produce fewer eggs and release them at irregular intervals.



Female nematodes produce several egg types commonly used for diagnosis in feces or vomitus: (1) the **ascaroid**, or **ascarid**, type (e.g., *Toxocara canis*) (Fig. 3.9); (2) the **trichostrongyle** or **strongyle** type (e.g., *Haemonchus contortus* of ruminants, *Strongylus vulgaris* of horses, *Ancylostoma caninum* of dogs) (Fig. 3.10); (3) the **spiruroid**, or spirurid, type (e.g., *Spirocerca lupi* of dogs, *Physaloptera* spp. of dogs and cats) (Fig. 3.11); and (4) the **trichinelloid** or **trichuroid** type (e.g., *Trichuris vulpis*, the whipworm of dogs, *Capillaria* spp.) (Fig. 3.12). In addition, some adult female nematodes produce characteristic larval stages: (1) the microfilaria, or prelarval, stage (e.g., *Dirofilaria immitis* of dogs) (Fig. 3.13); (2) the lungworm, or kinked-tail, larvae (e.g., *Aelurostrongylus abstrusus* of cats, *Filaroides osleri* of dogs) (Fig. 3.14); and (3) the dracunculoid, or long-tailed, larvae



Fig. 3.9 The ascaroid, or ascarid, type of nematode egg is best represented by that of *Toxocara canis*, the canine roundworm. The adult female nematode producing this egg type is oviparous. This nematode egg contains a single-cell stage within the eggshell.



Fig. 3.11 The spiruroid, or spirurid, type of nematode egg is best represented by that of *Spirocerca lupi*, the esophageal worm of dogs. The adult female nematode producing this egg type is ovoviviparous. This nematode egg contains a first-stage larva within the eggshell.

(e.g., *Dracunculus insignis* of dogs) (Fig. 3.15). Nematode eggs (and larvae) vary greatly in size and composition. This fact is very important when attempting to render a diagnosis.

Some female nematodes are **oviparous**; that is, the eggs produced by these nematodes contain a single-cell stage (see Figs. 3.9 and 3.12) or a **morula stage** within the eggshell (see Fig. 3.10). Some female nematodes are **ovoviviparous**; that is, the eggs produced by these nematodes contain a first-stage larva within the eggshell (see Fig. 3.11). Finally, some female nematodes are **larviparous**; that

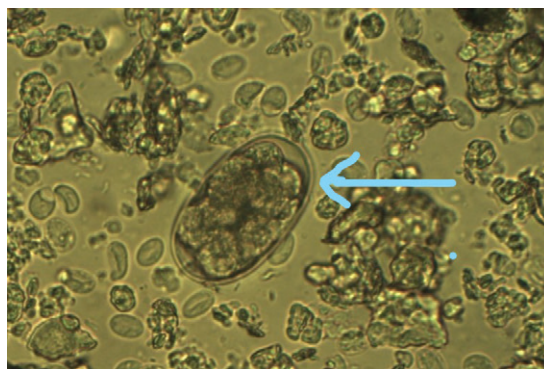


Fig. 3.10 The trichostrongyle or strongyle, or hookworm, type of nematode egg is best represented by that of *Ancylostoma caninum*, the hookworm of dogs. The adult female nematode producing this egg type is oviparous. This nematode egg contains a morula stage within the eggshell.



Fig. 3.12 The trichinelloid type of nematode egg is best represented by that of *Trichuris vulpis*, the whipworm of dogs. The adult female nematode producing this egg type is oviparous. This nematode egg contains a single-cell stage within the eggshell. This egg has a polar plug on either end.

is, they retain their eggs within the uterus and incubate them, then give birth to live larvae (see Figs. 3.13, 3.14, and 3.15).

Life Cycle of the Nematode

Compared with the complex life cycles of trematodes (flukes) and cestodes (tapeworms), the typical nematode life cycle is quite simple (Fig. 3.16). The adult female nematode produces an egg, which is a single-cell stage within

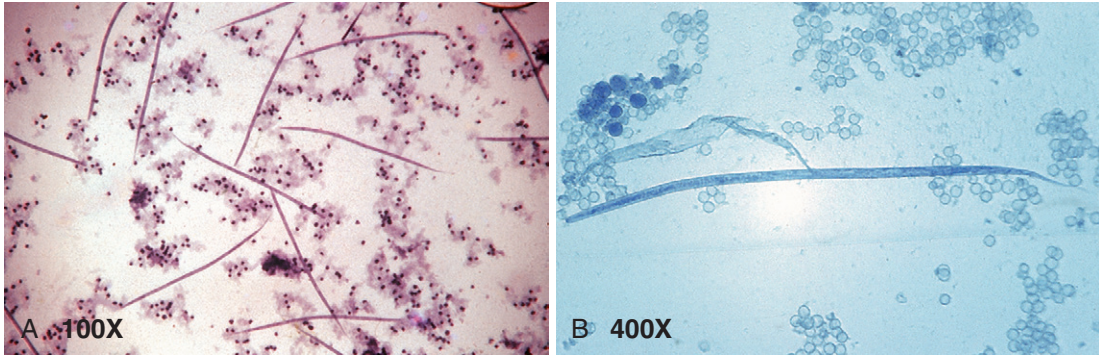


Fig. 3.13 Some adult female nematodes produce characteristic larval stages. Microfilariae, or prelarval, stages of *Dirofilaria immitis*, the heartworm of dogs and cats, are characteristic of filarial parasites. The adult female nematode producing this larval type is larviparous. She produces live offspring.



Fig. 3.14 The first-stage, kinked-tail larvae of *Aelurostrongylus abstrusus*, the lungworm of cats, are characteristic of lungworm larvae. The adult female nematode producing this larval type is larviparous. She produces live offspring.



Fig. 3.15 Long-tailed larvae of *Dracunculus insignis*, the guinea worm of dogs, are also characteristic larvae. The adult female nematode producing this larval type is larviparous. She produces live offspring.

the eggshell. The original cell divides into two cells, two cells divide into four, four cells divide into eight, and so on. The original single-cell stage eventually develops into a morula stage, which in turn develops into a tadpole stage. The tadpole stage develops into a fully formed first-stage larva within the eggshell. This first-stage larva is ready to hatch. The larva emerges from the eggshell, **molts** (sheds its external cuticle), and develops into a second-stage larva. The second-stage larva eventually molts into the third-stage larva. This stage is often referred to as the **infective third-stage larva** because it is infective for the definitive host.

The first three larval stages can develop in the external environment or within the intermediate host. The intermediate host serves as the means of transmission to the definitive host. Once the infective third larval stage has been reached, it must return to the definitive host to survive. It infects the host either by direct penetration or by intervention of the intermediate host. The intermediate host serves as a means of transmission to the definitive host. Once within the definitive host, the third larval stage molts to the fourth larval stage, which subsequently molts to the fifth larval stage. The fifth larval stage is actually the immature, or preadult, nematode. This stage eventually migrates to its organ or system predilection site and develops into the sexually mature adult stage. The male and female nematodes breed, and the cycle begins again.

Note

The general nematode life cycle is a simple life cycle compared with the trematode and cestode life cycles.

Nematodes may or may not use an intermediate host. If there is no intermediate host, the life cycle is said to be a

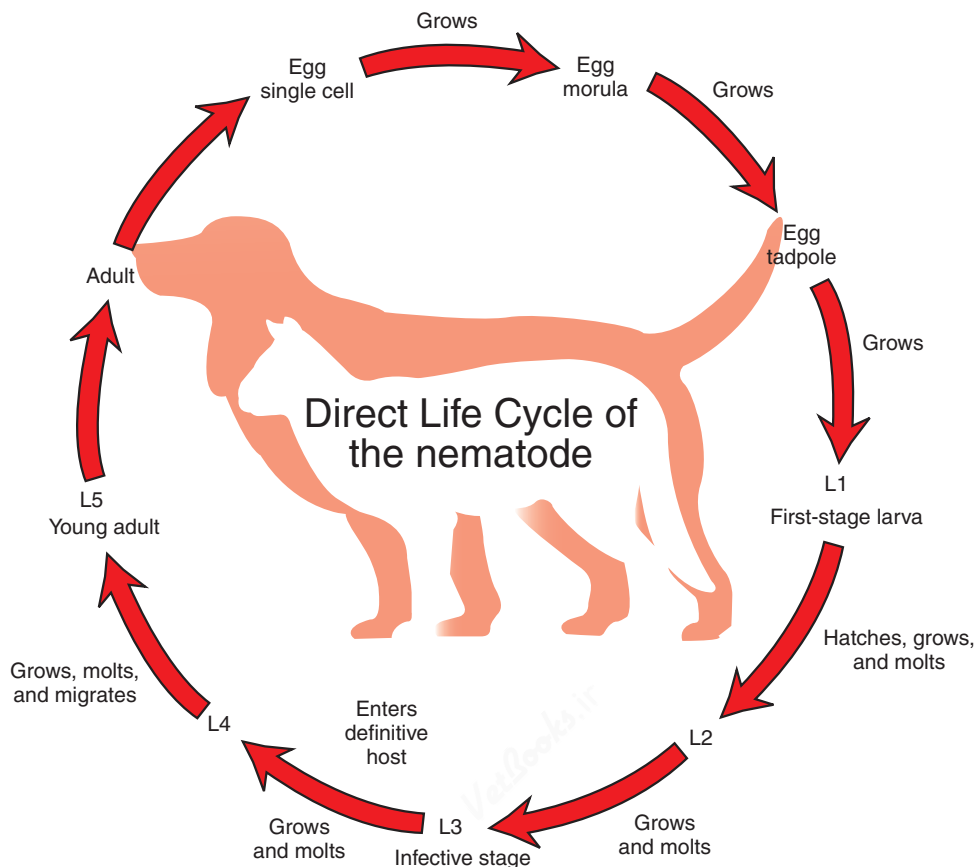


Fig. 3.16 Life cycle of the nematode.

direct life cycle (see Fig. 3.16). For example, canine hookworms (*Ancylostoma* spp.) develop to the infective third stage in the external environment (see Fig. 4.13). They penetrate the dog's skin and migrate to the small intestine, where they mature to adults. The canine hookworm's life cycle is said to be "direct."

If the nematode uses an intermediate host, the life cycle is said to be an **indirect life cycle** (see Fig. 4.24). For example, a female mosquito ingests microfilariae of the canine heartworm, *D. immitis*, along with her blood meal. The mosquito incubates the microfilariae, and they eventually develop into infective third-stage larvae within the proboscis (mouthparts) of the mosquito. When the mosquito takes a blood meal from an uninfected dog, the infective third-stage larvae emerge from the mouthparts and migrate into the puncture wound made by the mosquito. Within the dog, the third-stage larvae molt to fourth-stage larvae and then molt again to fifth-stage larvae (immature, or preadult, heartworms). These larvae

migrate to the right ventricle and pulmonary artery of the dog's heart, where they mature to adults. The adults breed, and the females produce microfilariae. The life cycle begins again (see Fig. 1.9). The canine heartworm's life cycle is said to be *indirect*.

Note



The nematode can develop by a direct life cycle with no intermediate host, or it can develop through an indirect life cycle where an intermediate host is necessary to complete the nematode's development.

A few nematodes produce eggs that do not hatch in the external environment. Within this egg, the larva develops to the second stage but does not hatch from the egg. It remains within the egg; the infective stage for these nematodes is the egg containing the second-stage larva.

It is important to remember that there are many variations for this typical nematode life cycle. For every nematode,

there is a distinct life cycle, and the detailed life cycles of the most commonly seen nematodes are typified in [Chapter 4](#).

Chapter Three Test

MATCHING—Match the term with the correct phrase or term.

A. Direct life cycle	1. Finger-like projections of a copulatory bursa
B. Indirect life cycle	2. The infective stage for many nematodes
C. Spicules	3. Intromittant organs that serve as the “penis” of male nematode
D. Cervical alae	4. A nematode life cycle that does not use an intermediate host
E. Copulatory bursa	5. A female nematode that gives “birth” to live larvae
F. Bursal rays	6. Having separate sexes—both male and female nematodes
G. Larviparous	7. The shedding of the cuticle (“skin”) of a nematode
H. Third-stage larva	8. Morphologic feature on the anterior end of an adult nematode
I. Molt	9. Morphologic feature on the posterior end of a male nematode
J. Dioecious	10. A nematode life cycle that uses an intermediate host

Questions for Thought and Discussion

1. Diagnostically speaking, which reproductive system (male or female) is more important in veterinary practice? Would you rather use a male nematode for diagnosis or a female nematode for diagnosis of a parasite problem? Why?
2. Compare and contrast the following types of nematode eggs. You may use drawings with labels to illustrate the differences. Give examples of nematodes that typify these egg types (see [Chapter 4](#) for examples).
 - Ascaroid- or ascarid-type egg
 - Trichostrongyle or strongyle-type egg
 - Spiruroid-type egg
 - Trichinelloid- or trichuroid-type egg
3. Define the terms *direct life cycle* and *indirect life cycle*. Give an example of a genus of nematode that uses each type of life cycle.
4. What are some external morphologic features used to identify intact adult nematodes?
5. Describe the “typical nematode life cycle.”
6. Define the following terms that are commonly used in veterinary practice:
 - Infective third-stage larva
 - Trichinelloid- or trichuroid-type egg
 - Oviparous nematode
7. Of the terms listed in the previous matching exercise (items A through J), which are terms that are used to describe the morphology of a nematode? Why are they important in veterinary parasitology?
8. Of the terms listed in the previous matching exercise (items A through J), which are terms that are used to describe the life cycle of a nematode?

Chapter

4

Nematodes That Infect Domestic Animals

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LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Remember the scientific names and corresponding common names for major parasites affecting domestic and laboratory animals.
- Recognize the pathology produced by nematodes of domesticated and laboratory animals.
- Recognize ova and distinctive larval stages of major parasites affecting domestic and laboratory animals.
- Understand the life cycles of the following parasites:
 - Canine roundworm (*Toxocara canis*)
 - Canine hookworm (*Ancylostoma caninum*)
 - Canine whipworm (*Trichuris vulpis*)
 - Canine heartworm (*Dirofilaria immitis*)
 - Feline heartworm (*Dirofilaria immitis*)
 - Ruminant lungworm (*Dictyocaulus viviparus*)
 - Equine roundworm (*Parascaris equorum*)
 - Equine large and small strongyles (*Strongylus vulgaris*)

KEY TERMS

Adulticides	Facultative parasites
Ascarids	L2 larvae
Asymptomatic	Microfilariae
Benzimidazoles	Microfilaricide
Cutaneous draschiasis	Neotenic
Cutaneous habronemiasis	Oxyurids
Cutaneous onchocerciasis	Parthenogenesis

Prepatent period	Summer sores
Probenzimidazoles	Thumps
Rhabditiform esophagus	Vermicide
Strongyles	Vermifuge

This chapter includes brief descriptions of many of the common nematode parasites of domesticated (and wild) animals in the United States. The discussions include information on the tissue, organ, or organ system parasitized in the host. Where appropriate, information is also provided on the **prepatent period** (time from the point of infection until a specific diagnostic stage can be recovered), the diagnostic stage (life-cycle stage) most often identified, a morphologic description of this diagnostic stage (e.g., eggs, larvae, or adult), and treatment for the most common parasites.

In this and subsequent chapters, the symbol ♦ prior to a parasite name will denote that the parasite is zoonotic.

Nematodes of Dogs and Cats

Gastrointestinal Tract

Parasite: *Spirocerca lupi*

Host: Canines and felines

Location of Adult: Esophageal wall

Distribution: Tropical and subtropical regions

Derivation of Genus: Coiled tail

Transmission Route: Ingestion of eggs

Common Name: Esophageal worm

Zoonotic: No

Spirocerca lupi, the esophageal worm, is a nematode usually associated with the formation of nodules in the esophageal wall of dogs and cats. Occasionally, this roundworm may be found in granulomas or nodules in the stomach wall of both dogs and cats (Fig. 4.1). Adult worms reside in tunnels deep within these nodules and expel their eggs through the fistulous (tract-like) openings in the nodules. These nodules can cause obstruction of the gastrointestinal tract, esophagus, or stomach. Eggs are passed down the esophagus and out in the feces. The thick-shelled eggs of *S. lupi* are 30 to 37 μm $\times$ 11 to 15 μm and contain a larva when laid. These eggs have a unique “paper-clip” shape (Fig. 4.2). An animal is infected by ingesting the eggs of this parasite. Eggs usually can be observed on fecal flotation but may also be recovered from vomitus that has been subjected to standard fecal flotation procedures. Radiographic or endoscopic examination may reveal a characteristic nodule or granuloma within the esophagus or stomach. The prepatent period for this roundworm is 6 months.

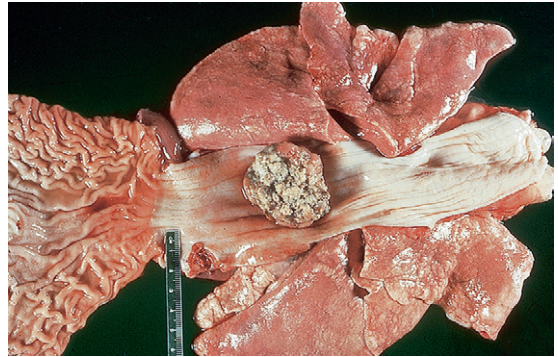


Fig. 4.1 *Spirocerca lupi*, the esophageal worm, is a nematode usually associated with formation of nodules in the esophageal wall of dogs and cats.



Fig. 4.2 Characteristic thick-shelled eggs of *Spirocerca lupi* with a unique paper-clip shape.

Technician's Note

Adult *Spirocerca lupi* reside inside nodules, which can cause esophageal obstruction.

Parasite: ♦ *Physaloptera* species

Host: Canines and felines

Location of Adult: Lumen of the stomach or small intestine, more commonly attached to the stomach mucosa

Distribution: Worldwide

Derivation of Genus: Bladder wing

Transmission Route: Ingestion of a paratenic host or intermediate host insect

Common Name: Canine and feline stomach worms

Zoonotic: Yes, however, rarely seen in humans per the American Association of Veterinary Parasitologists (AAVP)

Physaloptera species are stomach worms of both the dog and the cat. Although occasionally found in the lumen of the stomach or small intestine, *Physaloptera* species are usually firmly attached to the mucosal surface of the stomach, where they suck blood. When an endoscope is used, these nematodes can be observed in their attachment sites (Fig. 4.3). Their diet consists of blood and tissue derived from the host's gastric mucosa. The feeding habits of these worms may expose their attachment sites, which often continue to bleed after the parasite has detached. Vomiting, anorexia, and dark and tarry stools are often observed in infected animals. The adults are creamy white, sometimes tightly coiled, and 1.3 to 4.8 cm long (Fig. 4.4). They may also be recovered in the pet's vomitus; when this happens, *Physaloptera* species can easily be confused with ascarids. A quick way to differentiate the two parasites is to break open an adult specimen and (if the specimen is female) examine the eggs microscopically.

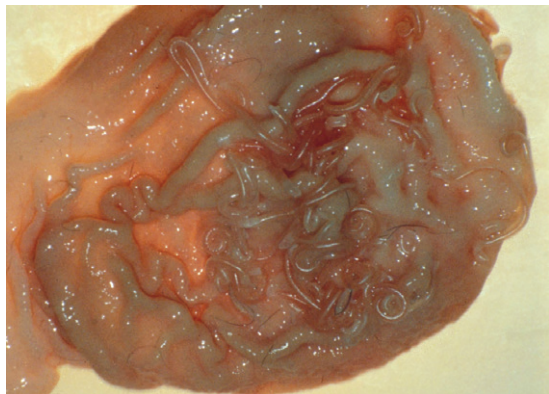


Fig. 4.3 *Physaloptera praeputialis* in the stomach of a cat. (From Bowman DD: *Georgis' parasitology for veterinarians*, ed 10, St Louis, 2013, Elsevier.)



Fig. 4.4 Adult of *Physaloptera* is creamy white, sometimes tightly coiled, and 1.3 to 4.8 cm long.

The eggs of *Physaloptera* species are small, smooth, thick shelled, and embryonated (larvated) when passed in the feces. These eggs are quite similar in appearance to the eggs of *S. lupi*. They are 30 to 34 μm $\times$ 49 to 59 μm and contain a larva when laid. (See Fig. 4.5 for the characteristic egg of *Physaloptera* species.) This parasite infects animals that ingest the intermediate host insect (cockroaches, beetles, or crickets) or a paratenic host that has ingested an infective intermediate host. Eggs can usually be recovered on standard fecal flotation of either feces or vomitus using solutions with a specific gravity greater than 1.25. The prepatent period for this nematode is 56 to 83 days.

Technician's Note



The eggs of *Physaloptera* species can be confused with the eggs of ascarids.

Parasite: *Aonchotheca putorii*

Host: Felines and minks

Location of Adult: Small intestine

Distribution: Tropic and temperate countries, worldwide

Derivation of Genus: Sheath diminished in bulk

Transmission Route: Ingestion of eggs

Common Name: Gastric capillarid of cats

Zoonotic: No

Aonchotheca putorii is commonly referred to as the *gastric capillarid of cats*. This nematode was once known by another scientific name, *Capillaria putorii*. This capillarid frequently parasitizes minks but has also been reported in cats. *A. putorii* is rarely reported in North America. The adult parasites can be found in the small intestine, where they suck blood. The eggs of *A. putorii* are easily confused



Fig. 4.5 Characteristic smooth, thick-shelled, embryonated (larvated) eggs of *Physaloptera* species. Eggs usually can be recovered on standard fecal flotation using solutions with a specific gravity greater than 1.25.

with those of other trichuroid nematodes. (See the following section on identification of feline whipworms.) The eggs of *A. putorii* are 53 to 70 $\mu\text{m} \times 20$ to 30 μm and exhibit a net-like surface similar to the eggs of *Eucoleus aerophilus*, another capillarid found in the upper respiratory system. The eggs of *A. putorii* are dense and less delicate than those of *E. aerophilus*; they have flattened sides and contain a one- or two-cell embryo that fills the egg. This parasite is passed to new hosts by ingestion of the embryonated egg. The eggs can be detected on fecal flotation.

Parasite: *Ollulanus tricuspis*

Host: Felines

Location of Adult: Stomach

Distribution: Worldwide

Derivation of Genus: Small feline hair

Transmission Route: Ingestion of larvae from vomitus

Common Name: Feline trichostrongyle

Zoonotic: No

Ollulanus tricuspis is the feline trichostrongyle. As a group, the trichostrongyles are considered to be parasites of the gastrointestinal tract of ruminants such as cattle, sheep, and goats; it is quite unusual for the cat to serve as a host for a trichostrongyle. *O. tricuspis* is often diagnosed in cats that exhibit chronic vomiting. These nematodes are usually identified by examining the cat's vomitus under a dissecting or compound microscope. Feline vomitus can also be examined with a standard fecal flotation procedure. The best flotation solution for identification is a modified Sheather flotation solution. Adult female *O. tricuspis* are tiny; are only 0.8 to 1 mm long; and possess three major tail cusps, or tooth-like processes, on the tip of the tail (thus the specific epithet *tricuspis*). Adult male nematodes are 0.7 to 0.8 mm long and possess a copulatory bursa. The female worms are larviparous and release infective third-stage larvae (500 $\times$ 22 μm), which mature to adults in the cat's stomach. This feline trichostrongyle also is unusual in that these third-stage larvae are immediately infective for any cat that may ingest vomitus containing them. Free-living stages in the external environment are not required for completion of the life cycle.

Technician's Note

Ollulanus tricuspis females release third-stage infective larvae that are immediately infective to cats.

Parasites: ♦ *Toxocara canis*, *Toxocara cati*, and *Toxascaris leonina*

Host: Canines and felines

Location of Adults: Small intestine

Distribution: Worldwide

Derivation of Genus: *Toxocara*—arrowhead; *Toxascaris*—arrow ascaris

Transmission Route: Ingestion of egg with infective larva

Common Name: Canine and feline roundworms

Zoonotic: *T. canis* and *T. cati*: Yes; *T. leonina*: No

Toxocara canis, *Toxocara cati*, and *Toxascaris leonina* are the **ascarids**, or large roundworms, of dogs and cats. These roundworms may be found in the small intestine of dogs and cats in most areas of the world. All young puppies and kittens presenting to a veterinary clinic should be examined for the presence of these large, robust nematodes. Adult ascarids may vary in length from 3 to 18 cm and, when passed in the feces, are usually tightly coiled, similar to a coiled bedspring (Fig. 4.6). Ascarids in young puppies and kittens may produce vomiting, diarrhea, constipation, and other nonspecific clinical signs. The adult worm does not attach to the host but rather uses an undulating motion to remain in the small intestine. Therefore adult worms may “swim” into the stomach and cause vomiting. The worm may then be present in the vomitus. Because of the presence of the adult worm in the vomitus, the owner may describe the vomitus as having “spaghetti” in it. An accumulation of adults can cause gastrointestinal obstruction.

The eggs of *Toxocara* species are unembryonated and spherical and have a deeply pigmented center and rough, pitted outer shell. The eggs of *T. canis* are 75 to 90 μm in diameter (Fig. 4.7), whereas those of *T. cati* are smaller, 65 to 75 μm in diameter (Fig. 4.8). The eggs of *T. leonina* are spherical to ovoid, with dimensions of 75 $\times$ 85 μm . In contrast to the eggs of *Toxocara* species, the eggs of *T. leonina* have a smooth outer shell and a hyaline, or “ground-glass,” central portion (Fig. 4.9). The prepatent period for *T. canis* is 21 to 35 days, whereas that of *T. leonina* is 74 days. Ascarids are among the most frequently diagnosed nematodes in young puppies and kittens.



Fig. 4.6 Adult ascarids may vary in length from 3 to 18 cm and when passed in feces are usually tightly coiled.

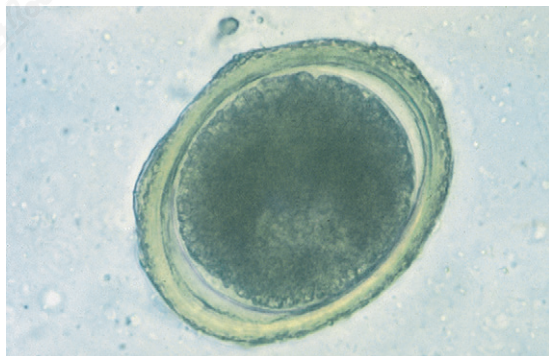


Fig. 4.7 Egg of *Toxocara canis* with unembryonated, spherical form with deeply pigmented center and rough, pitted outer shell.

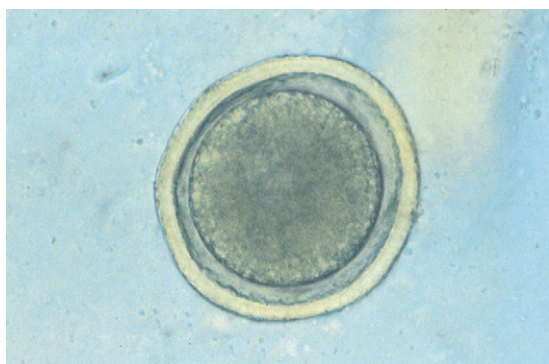


Fig. 4.8 Characteristic egg of *Toxocara cati* is similar in structure to that of *Toxocara canis* but smaller in diameter.

Technician's Note



Adult ascarids are commonly seen in vomitus and may be described by pet owners as freshly cooked "spaghetti-like" worms.

Adult roundworms are present in the small intestine, where they mate. The female produces unembryonated eggs that are passed in the host's feces. The eggs embryonate on the ground to the point that they contain **L2 larvae**. They are ingested by a host, and the L2 larvae are released from the eggs. The L2 larvae may go into dormancy in an adult host, but they grow and migrate to various tissues in the young host. Finally, the L2 larvae migrate to the young host's lungs, where they are coughed up and swallowed by the host. They grow to adulthood in the host's small intestine and begin a new life cycle (Fig. 4.10).

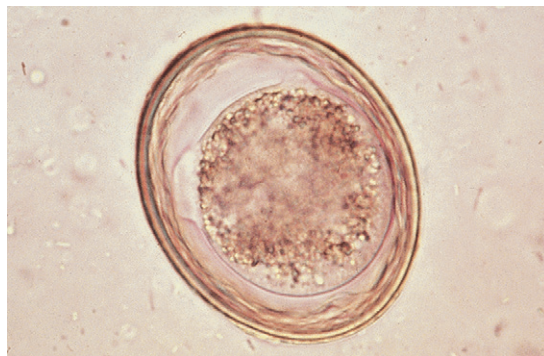


Fig. 4.9 The eggs of *Toxascaris leonina* are spherical to ovoid, with dimensions of $75 \times 85 \mu\text{m}$. In contrast to the eggs of *Toxocara* species, these eggs have a smooth outer shell and hyaline, or ground-glass, central portion.

In the adult female host, the infective larvae remain dormant until the female host mates and produces hormones during pregnancy. At this time, the larvae become active once more and migrate through the female host's body. The larvae (with the exception of *T. cati*) can cross the placental barrier to infect the host's offspring. The most common symptoms of a roundworm infection are diarrhea, vomiting, and a potbellied appearance.

The most common way of identifying an infection by *T. canis*, *T. cati*, or *T. leonina* is through the fecal flotation technique. Usually, the pregnant female will have feces tested for these parasites to determine the chances of her puppies or kittens becoming infected. Puppies and kittens are routinely dewormed during their first few visits to the veterinary office.

Several types of anthelmintics can be used to treat a roundworm infection. A **vermifuge** (anthelmintic that paralyzes the parasite so that it passes out in the feces) such as piperazine or pyrantel is often used to treat this type of parasite. A **vermicide** (anthelmintic that kills the parasite and allows the parasite to be broken down by the body) such as thiabendazole or mebendazole can also be used to treat a roundworm infection.

Technician's Note



The best way to identify a roundworm infection is through the fecal flotation technique.

T. canis, although primarily a parasite of the dog, can also infect humans (visceral larva migrans), as discussed in Chapter 16. The best way to prevent infection of humans and other animals is to clean up feces in the yard daily. Also, children should be prevented from playing in the yard and placing their contaminated hands in their mouths.

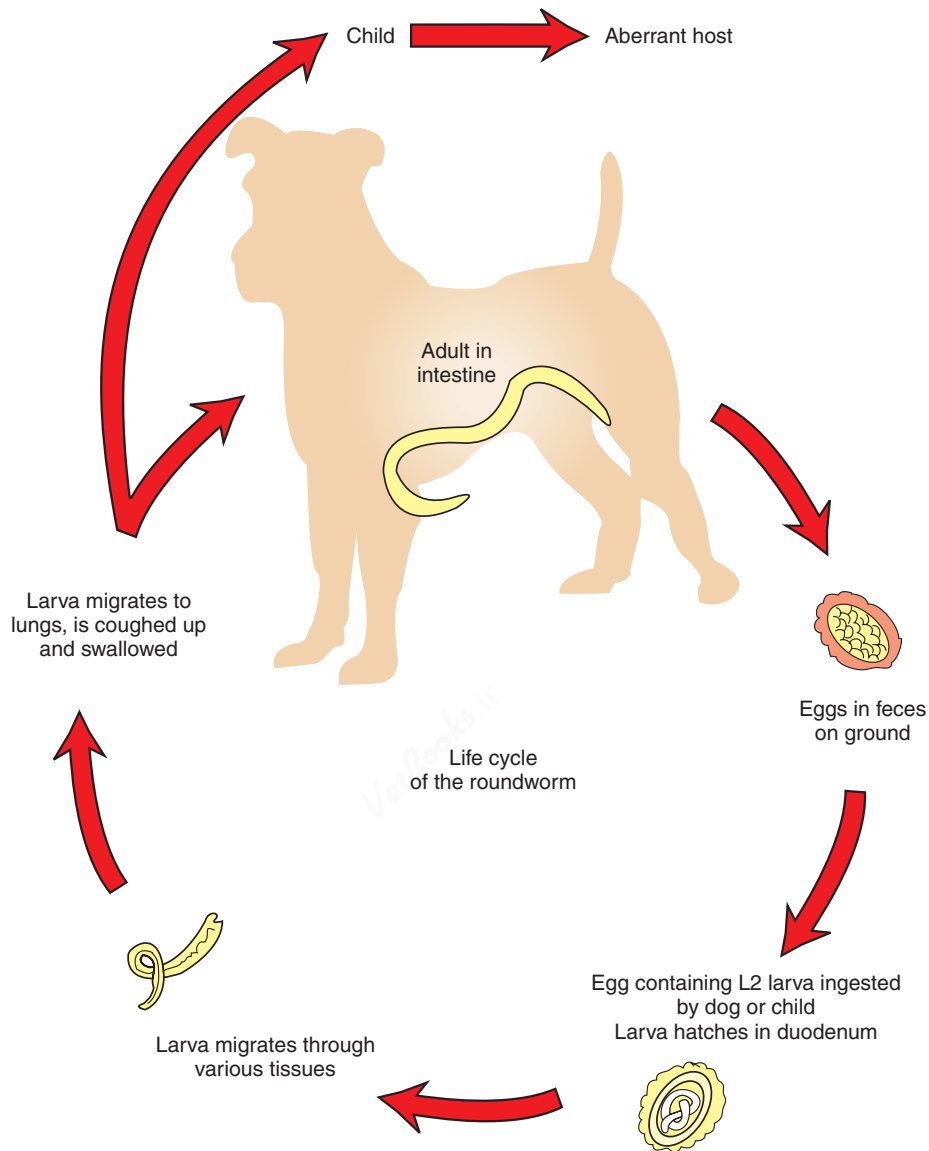


Fig. 4.10 Life cycle of the roundworm.

Parasite: ♦ *Baylisascaris procyonis*

Host: Raccoon but also seen in many species

Location of Adult: Small intestine

Distribution: North America (Mississippi-Ohio River basin)

Derivation of Genus: Named after a renowned parasitologist, Dr. H. A. Baylis

Transmission Route: Ingestion of eggs

Common Name: Raccoon roundworm

Zoonotic: Yes

Baylisascaris procyonis is the roundworm of the raccoon. *B. procyonis* is common in North America and is a zoonotic parasite. The adult resides in the small intestine of the raccoon. The ova are found in the feces. The ova are unembryonated and spherical with a deeply pigmented center and a rough/pitted outer shell. They are slightly smaller than the ova of *T. canis* (Fig. 4.11). An accumulation of adults in the small intestine can cause a gastrointestinal obstruction in the natural host.

CASE PRESENTATION 4-1

Setting Up the Scenario

Ms. Eliot presented Julius, a 3-month-old male Labrador, for a first puppy visit. Ms. Eliot also noted that Julius had diarrhea. A fecal centrifugation was performed, and *T. canis* was found. Dr. Wright informed Ms. Eliot that Julius had roundworms and would be treated with three doses of pyrantel pamoate. The technician then educated Ms. Eliot on *T. canis*.

What Information Must the Veterinary Technician Convey to Ms. Eliot?

Technician: "Ms. Eliot, because Julius has been diagnosed as having roundworms, let me give you some information on that intestinal parasite. Roundworms are commonly found in puppies because they are passed from the mother through her milk when the puppies are nursing. The adult worms produce eggs that are released with the puppy's stool. Although these eggs can infect other dogs, it is also

important to know that they can cause a disease in humans called *visceral larva migrans*, which means the baby worms can travel through the organs of the human body and cause problems. It is important to clean up the puppy's stools from the yard. In addition to cleaning up the stools, you and any family member or guest should wash your hands thoroughly after handling the puppy. If you experience any abnormalities, please see your family physician and let him or her know that Julius was diagnosed as having roundworms. Dr. Wright has given a first deworming to Julius, and you will give another dose in 2 weeks and again 2 weeks later. You may see long, white "spaghetti-like" worms in Julius's stool or in some vomit after the deworming. This is normal and should not worry you. Do you have any questions for me at this point?"

The technician also noted in the patient record that Ms. Eliot was given education on the zoonotic parasite diagnosed in Julius.



Fig. 4.11 Egg of *Baylisascaris procyonis* and two eggs of *Trichuris vulpis*. (From Bowman DD: *Georgis' parasitology for veterinarians*, ed 10, St Louis, 2013, Elsevier.)

B. procyonis is diagnosed by finding the ova on fecal flotation. The ova can be found anywhere that raccoons defecate and in naturally infected canines. Although the raccoon is the natural host, *B. procyonis* can cause zoonotic disease in many species. Because the larvae migrate to the central nervous system, this is a very pathogenic parasite in the incidental host, producing a zoonotic condition known as *neurologic larva migrans*.

Technician's Note



Baylisascaris procyonis is a very pathogenic zoonotic parasite that can infect the central nervous system of humans.

Parasites: ♦ *Ancylostoma caninum*, *Ancylostoma tubaeforme*, *Ancylostoma braziliense*, and *Uncinaria stenocephala*

Host: *A. caninum*, canine; *A. tubaeforme*, feline; *A. braziliense*, canine and feline; and *U. stenocephala*, canine

Location of Adult: Small intestine

Distribution: *Ancylostoma* species (worldwide), *U. stenocephala* (northern regions of North America)

Derivation of Genus: *Ancylostoma*—curved mouth and straight trumpet shape; *Uncinaria*—hooked nose and narrow head

Transmission Route: Ingestion of L3 stage larvae, through the skin, across the placenta, and through mammary milk

Common Name: Canine and feline hookworm

Zoonotic: Yes, *Ancylostoma caninum*

Ancylostoma caninum, the canine hookworm; *Ancylostoma tubaeforme*, the feline hookworm; *Ancylostoma braziliense*, the canine and feline hookworm; and *Uncinaria stenocephala*, the northern canine hookworm, are nematodes that infect the small intestine. Hookworms are found throughout the world but are most often found in tropical and subtropical areas of North America. Hookworms attach to the small intestinal mucosa. *A. caninum* demonstrates a frightful buccal cavity—it has three pairs of ventral teeth with



Fig. 4.12 *Ancylostoma caninum* demonstrates a frightful buccal cavity with three pairs of ventral teeth, with which it attaches to the mucosa of the small intestine of dogs.

which it attaches to the mucosa of the small intestine (Fig. 4.12). These parasites may change feeding sites and reattach elsewhere in the small intestine. Because this hookworm feeds on blood, it secretes an anticoagulant from its mouth, which causes the former attachment sites to continue to bleed. Thus the hookworm's voracious feeding activity and the secondary hemorrhage produced can cause significant anemia. Because this bleeding occurs within the small intestine, the blood is often digested by the host and often appears as black, tarry stool. The resulting anemia can be quite severe in young kittens and puppies. Hookworms often produce serious problems in kennels and catteries. The prepatent period depends on the species of hookworm. Animals are usually infected through percutaneous, prenatal, and transmammary routes.

The male and female worms attach to adjacent villi of the intestinal wall. The male and female mate continuously, and therefore the female continually produces eggs that are laid in the feces. The egg contains the morula stage as it is passed out of the host's body in the feces. These eggs embryonate into L1 larvae in the external environment. The L1 larvae hatch, feed, grow, and molt to L2 larvae. The L2 larvae feed, grow, and molt to L3 larvae but do not release the cuticle of the L2 larvae. They are ensheathed L3 larvae that do not feed and are the infective-stage larvae. The L3 larvae can be ingested, or they can penetrate the host's intact skin and migrate through the tissues of the body until they reach the lungs. Once in the lungs, the larvae are coughed up and swallowed by the host (Fig. 4.13).

Technician's Note

Hookworms can cause black, tarry stool in the host as a result of the attachment and reattachment of the parasite and the digestion of free blood in the intestinal tract.

The larvae of this parasite are able to cross the placenta and also can be passed from mother to offspring through the colostrum. Therefore the pregnant host should be checked several times during pregnancy for the presence of these parasites. Because these parasites can penetrate intact skin, they can also enter the skin of humans (*cutaneous larva migrans*), as discussed in Chapter 16.

The eggs of all hookworm species are oval or ellipsoidal and thin walled and contain an 8- to 16-cell morula when passed in feces. Because these eggs embryonate, or larvate, rapidly in the external environment (as early as 48 hours), fresh feces are needed for diagnosing hookworm infections. Eggs of *A. caninum* are 56 to 75 μm $\times$ 34 to 47 μm ; those of *A. tubaeforme* are 55 to 75 μm $\times$ 34.4 to 44.7 μm ; those of *A. braziliense* are 75 $\times$ 45 μm ; and those of *U. stenocephala* are 65 to 80 μm $\times$ 40 to 50 μm . These eggs can be easily recovered on standard fecal flotation (Fig. 4.14).

Technician's Note

Hookworms are easily recovered and identified using a standard fecal flotation technique.

Treatment for the hookworm species can take two forms. The first is prevention with the use of once-a-month heartworm preventive agents; Interceptor and Heartgard Plus are the most common brands, although other brands of heartworm preventatives also work against hookworms. Many of these preventive medications are also labeled for the prevention of hookworms. If the parasite eggs are found on fecal flotation or other techniques, the veterinarian may choose a vermicide such as mebendazole or fenbendazole.

Recent research has been published in veterinary and parasitology journals indicating the resistance of hookworms to the benzimidazoles and macrocyclic lactones. These are the most common dewormer groups used for hookworms. Although the studies have shown this in Greyhounds, it is reported in other breeds as well.

The best way to prevent hookworm species from infecting animals or humans is to remove the feces after defecation by the host. Removal during warm weather should take place immediately after defecation, whereas removal during cold months can take place every other day.

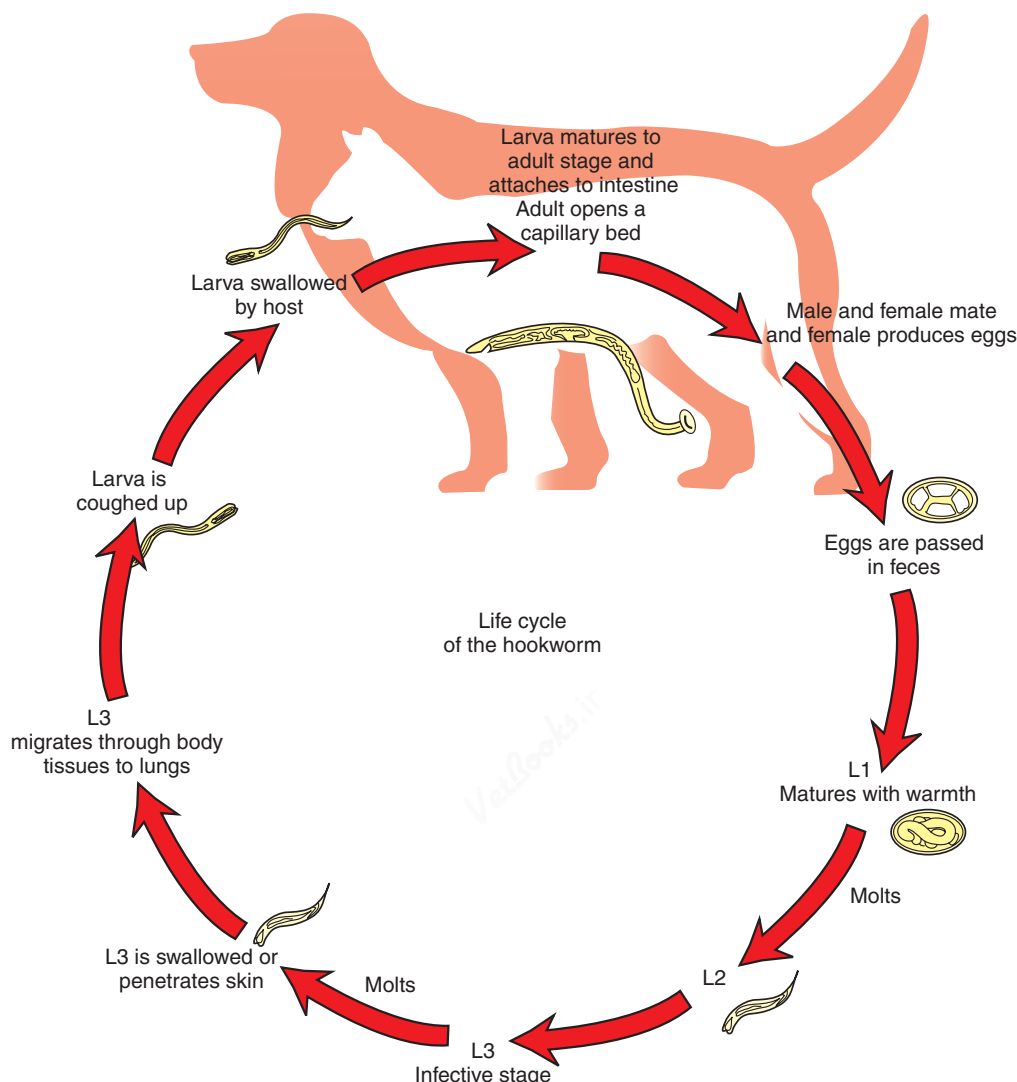


Fig. 4.13 Life cycle of the hookworm.

Technician's Note



The best way to prevent hookworm infections is to remove feces from the yard on a daily basis before the larvae hatch from the ova and develop to infective third stage larvae.

Parasites: ♦ *Strongyloides stercoralis* and *Strongyloides tumefaciens*

Host: Dogs, cats, and humans

Location of Adult: Small intestine

Distribution: Worldwide

Derivation of Genus: Round-like shape

Transmission Route: Through the skin and in mammary milk

Common Name: Intestinal threadworms

Zoonotic: *S. stercoralis*: yes; *S. tumefaciens*: no

Because parasitic males do not exist, the female worms are capable of producing viable ova without fertilization from a male worm. This process is called **parthenogenesis**.

Strongyloides stercoralis and *Strongyloides tumefaciens* are often referred to as *intestinal threadworms*. These nematodes are unique in that only a parthenogenetic female is parasitic in the host and resides in the small intestine. The female has

CASE PRESENTATION 4-2

Setting Up the Scenario

Mr. Watson presented Cleo, a 6-year-old female spayed dog, who has been vomiting and has had diarrhea for 3 days. A fecal centrifugation was run, and *A. caninum* was found. Dr. Whitney informed Mr. Watson that his dog had hookworms. A course of fenbendazole was prescribed for Cleo. The technician then educated Mr. Watson on *A. caninum*.

What Information Must the Veterinary Technician Convey to Mr. Watson?

Technician: “Mr. Watson, Cleo has been diagnosed as having hookworms. This adult intestinal parasite produces eggs that are passed in Cleo’s stool. When the eggs hatch, they produce a baby worm called a *larva* that can enter your dog and even humans through the skin. In humans, this parasite causes a disease called *cutaneous larva migrans*, which means the infective larvae travel through the skin. In your dog, they will travel through the skin and end up in the intestines, where they will grow to adults. In humans, they tend to die in most cases; however, in rare cases they can reach the intestines and become adults. Because humans can be infected, it is important to clean up Cleo’s stool after defecation no less than once a day to prevent reinfection to Cleo and to prevent infection of you and your family. Dr. Whitney has prescribed a dewormer that you need to mix with Cleo’s food once a day for 3 days. If you have any itching with worm-like lesions, you should see your physician.”

The technician also noted in the patient record that the owner was educated on this zoonotic parasite.



Fig. 4.14 The eggs of all hookworm species are oval or ellipsoidal and thin walled and contain an 8- to 16-cell morula when passed in feces. These eggs may represent one of several genera that parasitize dogs and cats: *Ancylostoma caninum*, *Ancylostoma tubaeforme*, *Ancylostoma braziliense*, and *Uncinaria stenocephala*.



Fig. 4.15 Parasitic adult females, eggs, and first-stage larvae of *Strongyloides stercoralis*, intestinal threadworms.

an approximately cylindric esophagus that is one-quarter the length of the parasite’s body. These females produce embryonated or larvated eggs, but in dogs, the eggs hatch in the intestine, releasing first-stage larvae that may be observed in fresh feces. (Fig. 4.15 shows the parasitic adult females, eggs, and first-stage larvae of *Strongyloides* species.) The larval *Strongyloides* species are 280 to 310 μm long and possess a rhabditiform esophagus with a club shaped anterior corpus, a narrow median isthmus, and a caudal bulb. The larvae go through a free-living stage in the environment before becoming infective third-stage larvae that can penetrate the skin and cause migratory damage in the host. In the dog, the major method of transmission is from mother to pups through the mammary glands. The prepatent period is 8 to 14 days. These nematodes are frequently associated with moderate to severe diarrhea in young puppies, particularly in kennel environments during the summer months. Because humans can also be infected with *S. stercoralis*, there is the potential of zoonosis called *strongyloidiasis*.

Technician’s Note

In fresh dog feces one may observe the larvae (rather than the ova) of *Strongyloides* species.

Parasites: *Trichuris vulpis*, *Trichuris campanula*, and *Trichuris serrata*

Host: *T. vulpis*, canine; *T. campanula* and *T. serrata*, feline

Location of Adult: Cecum and colon

Distribution: Worldwide, but *T. campanula* and *T. serrata* are rare in North America

Derivation of Genus: Hair tail

Transmission Route: Ingestion of eggs

Common Name: Whipworm

Zoonotic: No

Trichuris vulpis, the canine whipworm, and *Trichuris campanula* and *Trichuris serrata*, the feline whipworms, reside in the cecum and colon of their respective definitive hosts. Whipworms are a common clinical occurrence in dogs; however, it is important to remember that feline whipworms are quite rare in North America and have been diagnosed only sporadically throughout the world. Whipworms derive their name from the fact that the adults have a thin, filamentous anterior end (the “lash” of the whip) and a thick posterior end (the “handle” of the whip) (Fig. 4.16). The thin end of the whipworm was once thought to be the tail of the parasite. The egg of the whipworm is described as *trichuroid* or *trichinelloid*; it has a thick, yellow-brown, symmetric shell with prominent polar plugs at both ends. The eggs are unembryonated (not larvated) when laid. The eggs of *T. vulpis* are 70 to

89 $\mu\text{m} \times 37$ to 40 μm . (Fig. 4.17 shows the characteristic egg of *T. vulpis*.) The prepatent period for *T. vulpis* is 70 to 90 days.

Adult *Trichuris* species are attached to the wall of the cecum or colon, where they suck blood and produce eggs. The eggs are passed out in the feces intermittently. Once in the environment, the eggs go through a period of development to become an L1 (infective) larva within the egg. Unlike the hookworm species, the whipworm species must be ingested by the host. The L1 larva hatches from the egg once in the host’s small intestine. The larva molts several times in the small and large intestines before becoming an adult. The new adult migrates back through the colon to the cecum and attaches to the intestinal wall (Fig. 4.18). The most common symptoms seen in infected animals are diarrhea, anemia, and mucus-coated stool.

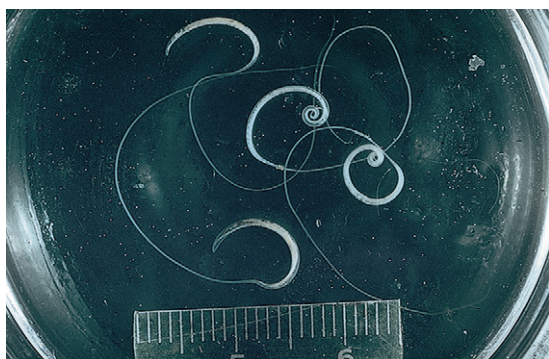


Fig. 4.16 *Trichuris vulpis*, the canine whipworm, derives its common name from the fact that adults possess a thin, filamentous anterior end (“lash” of the whip) and a thick posterior end (“handle” of the whip).



Fig. 4.17 Characteristic egg of *Trichuris vulpis* is described as *trichinelloid* or *trichuroid*; it has a thick, yellow-brown, symmetric shell with polar plugs at both ends. Eggs are unembryonated (not larvated) when laid.

Technician’s Note



The eggs of *Trichuris* species are passed in the stool only sporadically rather than every day, as in the case of most other nematodes.

The eggs of *T. campanula* and *T. serrata*, the feline whipworms, may be easily confused with those of *A. putorii*, *E. aerophilus*, and *Pearsonema feliscati*, parasites of the feline stomach, respiratory tract, and urinary system, respectively. The eggs of *T. campanula* average 63 to 85 $\mu\text{m} \times 34$ to 39 μm (Fig. 4.19). When examining a cat’s feces for trichurids, the diagnostician must remember that pseudoparasites, that is, the eggs of trichurids or capillarids, may parasitize nonfeline hosts such as mice, rabbits, or birds (an outdoor cat’s prey). The eggs of trichurids or capillarids from a cat’s prey may pass undigested and unaltered through the cat’s gastrointestinal system, remaining intact and unembryonated.

Fecal flotation is the most common way of identifying the eggs of this parasite; however, whipworm eggs do not float well in most common fecal flotation media. Therefore it is imperative that the eggs be allowed to float for a minimum of 15 minutes before viewing under the microscope. Once identified, the veterinarian will most often use the vermicides mebendazole or fenbendazole for treatment of these worms. Prevention involves daily feces removal to remove the uninfected eggs from the host’s environment.

Parasite: *Enterobius vermicularis*

Host: Humans

Distribution: Worldwide

Derivation of Genus: Intestinal life

Transmission Route: Ingestion of eggs

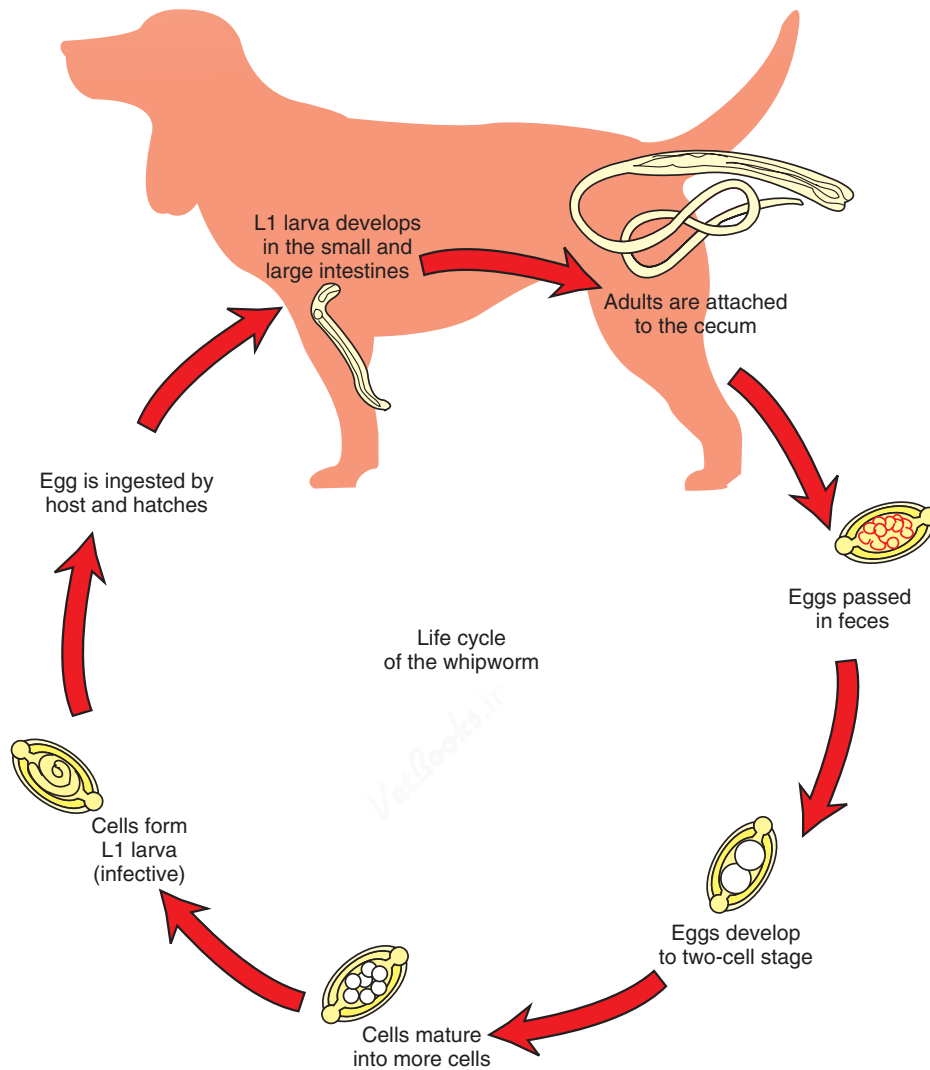


Fig. 4.18 Life cycle of the whipworm.

Common Name: Human pinworm
Zoonotic: No

Dogs and cats may often be blamed for serving as hosts for certain parasites of humans. *Enterobius vermicularis* is the pinworm found in humans, often in young children. This pinworm *does not* parasitize dogs or cats. Nevertheless, the family pet is often falsely incriminated by physicians, family practitioners, and pediatricians as a source of pinworm infection in young children. The veterinary diagnostician should remember this rule: Pinworms are parasites of omnivores (mice, rats, monkeys, and

humans) and herbivores (rabbits and horses) but *never* carnivores (dogs and cats).

Technician's Note

Because whipworm ova are heavy and hard to float, they require at least 15 minutes with a standard fecal flotation technique before they can be observed under a microscope. Ideally, centrifugal flotation should be used to facilitate flotation of whipworm ova.

CASE PRESENTATION 4-3

Setting Up the Scenario

Ms. Swanson presented Bruno, a 2-year-old male -neutered Corgi, with mucus-coated stool and diarrhea. A fecal centrifugation was performed, and *T. vulpis* was found. Dr. Williams told Ms. Swanson that Bruno had whipworms. Dr. Williams prescribed fenbendazole for 3 days, to be repeated in 3 weeks and 3 months.

What Information Must the Veterinary Technician Convey to Ms. Swanson?

Technician: "Ms. Swanson, Bruno has been diagnosed as having whipworms. Dr. Williams is sending you home with three sets of deworming medication. You will give one dose on 3 consecutive days, then repeat the dosing 3 weeks after finishing the first 3 days and again 3 months after finishing the first three doses. Repeated doses are necessary because whipworm eggs are hard to kill in the environment and the adults are slow in developing, so we need to make sure all of the adults are treated. You will also need to keep your yard clean of stools to prevent Bruno from being reinfected. Although Bruno can be reinfected, humans do not get infected with canine whipworms, so you do not have to worry about an infection."

The technician also noted in the patient record that the owner was educated on this parasite.

CASE PRESENTATION 4-4

Ms. Peterson phoned the clinic asking about a treatment for Scruffles, her 5-year-old spayed Yorkshire Terrier. Ms. Peterson had taken her son, Jeremy, to the family physician because of a pruritic rectum. The physician diagnosed Jeremy as having *E. vermicularis*, the human pinworm. The physician intimated that Jeremy was infected by the family dog.

Upon taking Ms. Peterson's call, the technician educated her on pinworms: "Ms. Peterson, there are two important things you need to know about pinworms. The first is that dogs and cats are two species of animals that do not get infected with pinworms; therefore Scruffles could not have infected Jeremy with pinworms. The second important fact is that pinworms are species specific, so a family pet with pinworms could infect only another of its own species. This means that Jeremy could be infected only by another human with pinworms. If you need me to discuss this further with your family physician, please have her call me."

The technician noted the discussion in the patient record.

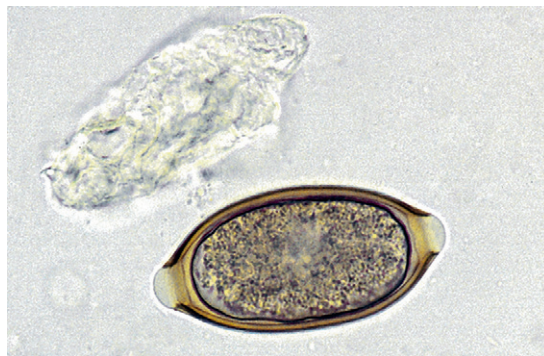


Fig. 4.19 The eggs of *Trichuris campanula* (pictured) and *Trichuris serrata*, the feline whipworms, may be easily confused with those of *Aonchotheca putorii*, *Eucoleus aerophilus*, and *Pearsonema feliscati*, parasites of the feline stomach, respiratory tract, and urinary system, respectively. The eggs of *T. campanula* average 63 to $85\ \mu\text{m} \times 34$ to $39\ \mu\text{m}$.

Circulatory System

Parasite: ♦ *Dirofilaria immitis*

Host: Canine, feline, and ferret; has been observed in humans as an incidental parasite

Intermediate Host: Female mosquito

Location of Adult: Right ventricle and pulmonary arteries of the heart

Distribution: Warm to temperate climates around the world

Derivation of Name: Dread thread and inexorable

Transmission Route: Bite of infective mosquito

Common Name: Heartworm

Zoonotic: Yes (incidental host)

Dirofilaria immitis is often referred to as the *canine heartworm* (Fig. 4.20); however, this nematode has been known to parasitize cats and ferrets as well (Fig. 4.21). The definitive host for *D. immitis* is the canine. Although cats and ferrets have been parasitized by this parasite, they rarely serve as a source for transmission. Heartworms are long, slender parasites (Fig. 4.22). As adults, these parasites are found within the right ventricle and the preferred pulmonary arteries and its fine branches. The offspring of filarial worms such as *D. immitis* are known as *microfilariae*.

Among the nematodes of small animals, *D. immitis* is perhaps the one nematode that may be found in sites other than its normal predilection sites. This parasite is often recovered in a variety of aberrant sites, such as the brain, anterior chamber of the eye (Fig. 4.23), and subcutaneous sites. The prepatent period in dogs is approximately 6 months.

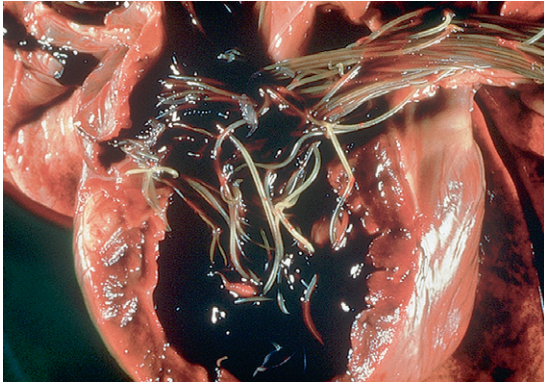


Fig. 4.20 Adults of *Dirofilaria immitis*, the canine heartworm, are found within the right ventricle and pulmonary artery and its fine branches.



Fig. 4.21 Canine heartworms may be found in sites other than the heart and in hosts other than the dog. These heartworms were recovered from the brain of a ferret.

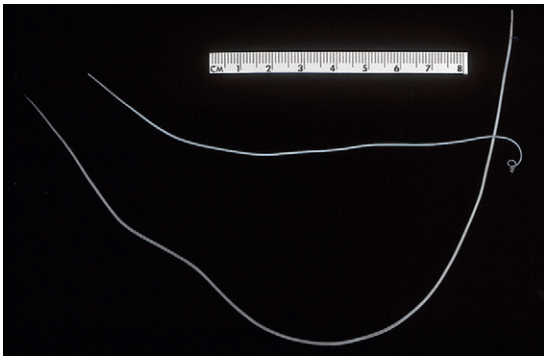


Fig. 4.22 Heartworms are long, slender parasites, evolved for fitting into the fine branches of pulmonary arteries.

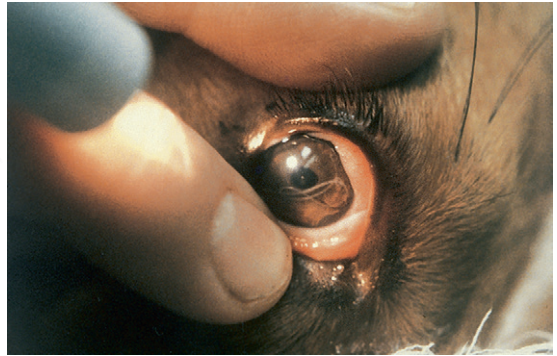


Fig. 4.23 *Dirofilaria immitis*, the canine heartworm, may also be recovered from a variety of aberrant sites, such as the anterior chamber of the eye.

Technician's Note



Dirofilaria immitis is the parasite that causes heartworm disease in dogs and cats. It has a prepatent period of 6 months before it can be diagnosed in the dog.

The life cycle of *D. immitis* requires the mosquito intermediate host to be transmitted from animal to animal. The adults live in the right ventricle and pulmonary arteries, where they can obstruct the blood vasculature. The male and female adults mate, and the female produces microfilariae. The microfilariae are released into the host's bloodstream, where they are ingested by feeding female mosquitoes. The microfilariae grow and molt in the mosquito until they reach the infective stage. Once

they become infective, they enter a new host the next time the mosquito feeds (Fig. 4.24). Once in the new host, the larvae migrate and molt through various body tissues on their way to the heart. It is at this time that the larvae may grow and molt to become adults in sites other than the heart.

Technician's Note



Dirofilaria immitis larvae must develop to the infective stage within a mosquito before they can be transferred to a new host.

In microfilaremic dogs, diagnosis is made by observing microfilariae in blood samples using the modified

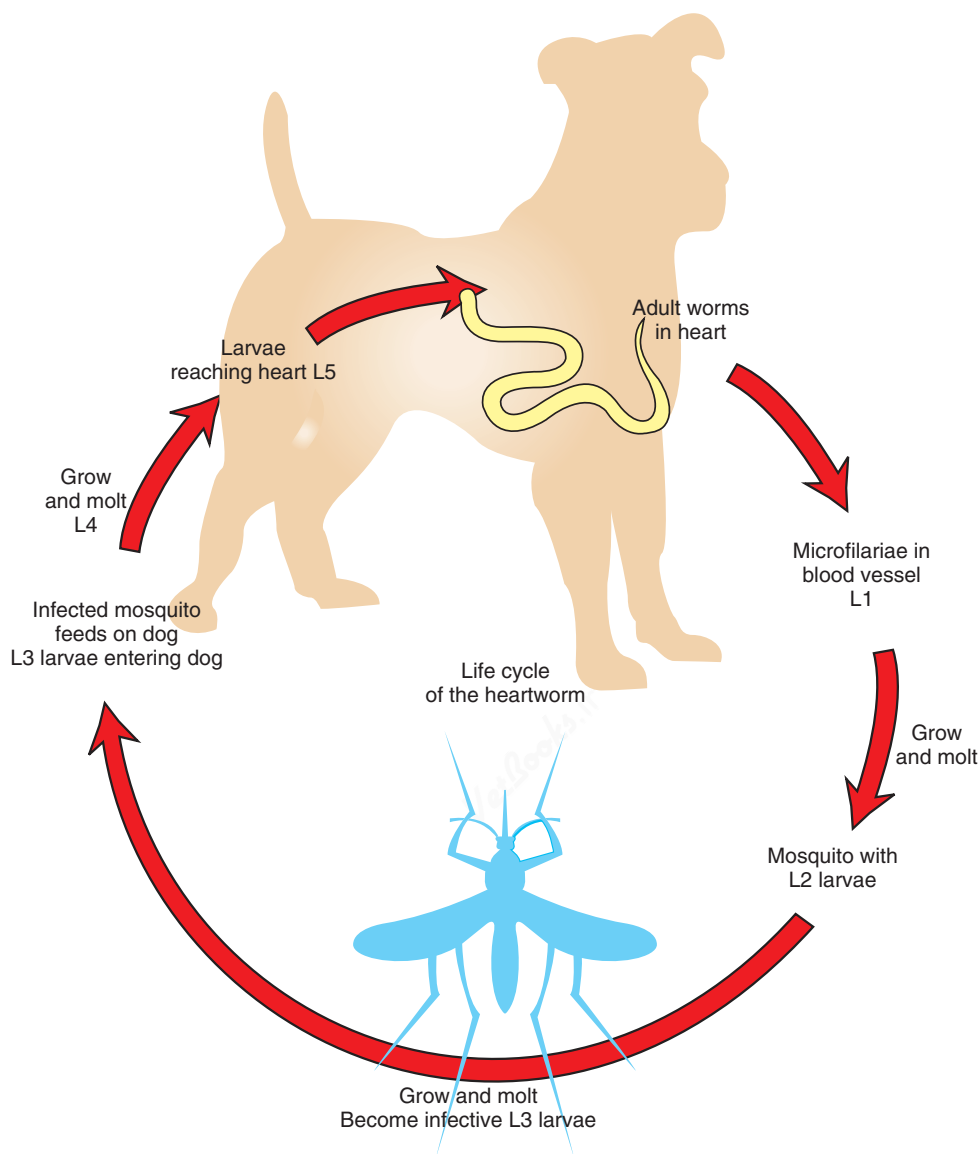


Fig. 4.24 Life cycle of the canine *Dirofilaria immitis*.

Knott test (Figs. 4.25 and 4.26) or commercially available filter techniques (Fig. 4.27). For dogs (amicrofilaremic or microfilaremic), infection can also be diagnosed using one of the commercially available enzyme-linked immunosorbent assay (ELISA) tests (Fig. 4.28). It is important to remember that *Acanthocheilonema* (formerly known as *Dipetalonema*) *reconditum*, a subcutaneous filariid of dogs, also produces microfilariae in the peripheral blood (Figs. 4.29 and 4.30). The microfilariae of this nonpathogenic nematode must be

differentiated from those of *D. immitis* (see Figs. 4.25 and 4.26).

The damage that *D. immitis* causes to the heart will result in the hallmark symptoms of heartworm disease in dogs. The symptoms are a decrease in exercise tolerance, right-sided heart enlargement, and abdominal ascites (fluid accumulation in the abdomen). These symptoms are caused by the parasite's location in the heart and pulmonary arteries, which reduces blood flow on the right side of the heart and causes inflammation to the lining of the blood vessels.

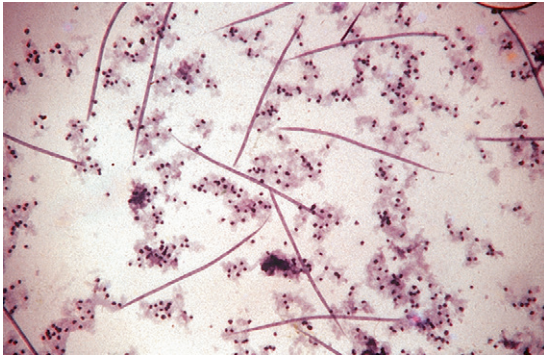


Fig. 4.25 Microfilariae of *Dirofilaria immitis* subjected to the modified Knott test. Microfilariae of this pathogenic nematode must be differentiated from those of *Acanthocheilonema reconditum*.

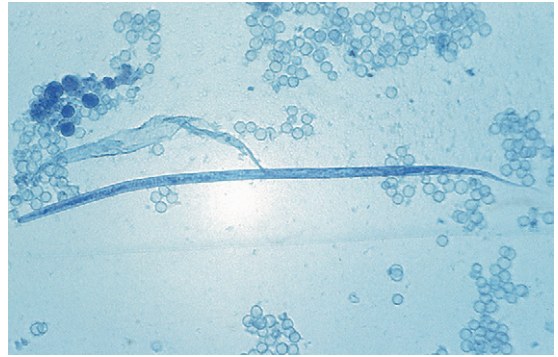


Fig. 4.26 Microfilaria of *Dirofilaria immitis* subjected to the modified Knott test. Note the tapering anterior end and straight tail. This microfilaria measures approximately 310 μm in length.

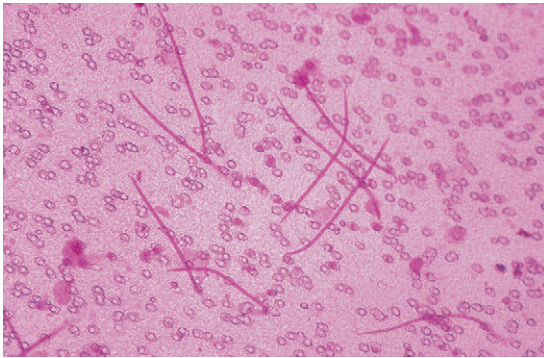


Fig. 4.27 Microfilariae of *Dirofilaria immitis* subjected to a commercially available filter technique.

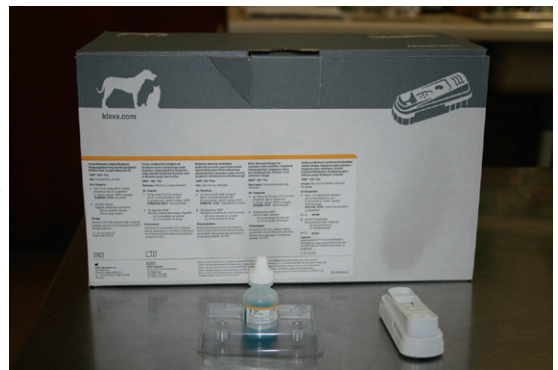


Fig. 4.28 Heartworm infection can also be diagnosed using commercially available enzyme-linked immunosorbent assay (ELISA) tests.

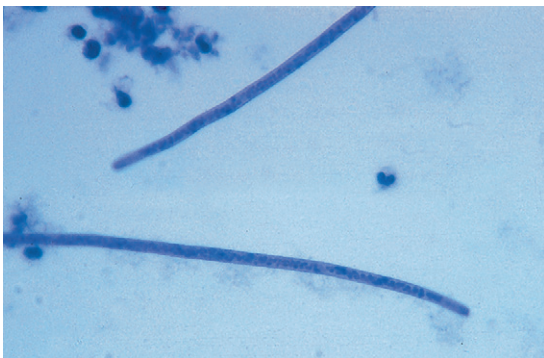


Fig. 4.29 Microfilariae of *Acanthocheilonema reconditum* subjected to the modified Knott test. Note the broom-handle anterior end. This microfilaria measures approximately 280 μm in length. Microfilariae of this nonpathogenic nematode must be differentiated from those of *Dirofilaria immitis*.

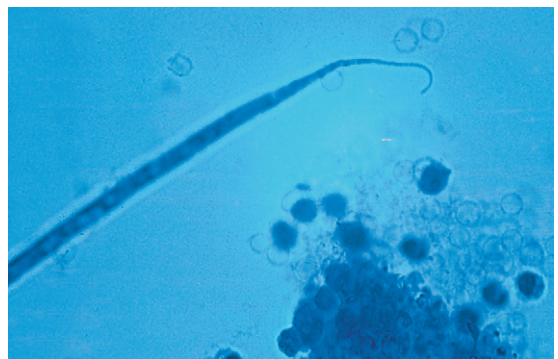


Fig. 4.30 Microfilaria of *Acanthocheilonema reconditum* subjected to the modified Knott test. Note the buttonhook posterior end, which is an artifact of formalin fixation used in the modified Knott procedure.

Technician's Note

The classic symptoms of heartworm disease are exercise intolerance, right-side heart enlargement, and abdominal ascites caused by reduced blood flow on the right side of the heart.

The treatment for heartworm disease involves pretreatment testing, treatment, and posttreatment rest. The first step in treatment involves determining the canine's ability to withstand the treatment by performing blood work; this determines the status of the internal organs. Radiographs are taken to determine the status of the heart and the stage of the disease. After testing, the canine is treated for adult heartworms. **Adulticides** (drugs that kill the adult stages of the parasite), such as Immiticide, Diroban, or melarsomine dihydrochloride, are used to kill adult heartworms. As the adults die, they move with the flow of blood toward the lungs. This could cause problems for the canine if it is allowed to exercise after the adulticide treatment. The canine must be kept quiet for several weeks post treatment while the body resorbs the dead adults. Once the adults have been treated and resorbed by the body, the canine is treated with a **microfilaricide** (usually ivermectin) to clear the blood of any microfilariae. The final part of the treatment is heartworm testing. This usually involves a microfilariae test and an ELISA test to confirm that the microfilariae and adults have been cleared from the canine's body. Current treatment protocols can be found on the American Heartworm Society website.

The treatment for canine heartworm disease can be very stressful on a dog's body. Therefore prevention is recommended so that the dog does not contract the parasite. The various preventive regimens include daily preventive medications, monthly medications, and an injection every 6 months. Recent studies have shown that there is resistance by *D. immitis* to the macrocyclic lactone (monthly) preventatives. The studies further showed that the preventatives have better efficacy with consistent use (monthly) rather than a single dose given infrequently. Only moxidectin has been shown to be 100% effective as a single-dose preventative.

Resistance has been seen in other preventatives, which may be attributed to client compliance. It is recommended that all dogs receive a preventative year-round; however, studies have shown that only about 50% of dogs are on year-round prevention.

Feline hosts for *D. immitis* occur in the same areas in which canines are infected. Cats are susceptible to the parasite but tend to be very resistant to infection. Therefore it takes a greater exposure to the microfilariae from the mosquito to infect a cat than it does to infect a dog. Whereas *D. immitis* causes enough damage to produce hallmark

symptoms in dogs, cats do not show specific symptoms of the infection. Cats tend to show signs similar to those seen with respiratory disease.

The life cycle of *D. immitis* in cats begins as it does in dogs. The adults live in the right ventricle and pulmonary arteries of the dog. The adults mate, and the female produces microfilariae, which are present in the vessels of the dog. Mosquitoes feed on the infected canine and ingest the microfilariae. The microfilariae grow and molt to infective L3 larvae. Once infective, the mosquito feeds on a cat, and the larvae are transferred to the cat. The larvae grow, molt, and migrate in the cat on their way to the heart (Fig. 4.31).

Technician's Note

Feline heartworm diseases do not produce the hallmark symptoms observed in canine heartworm disease. The symptoms are similar to those seen with respiratory disease.

Identification of the parasite in the cat is difficult. The adults do not produce many microfilariae in the cat, so the microfilarial tests produce negative results in most cases. Tests developed for dogs are not sensitive enough for the infection in cats, so ELISA tests have been developed for detection of *D. immitis* in cats. Two types of tests are available for in-clinic use: antigen tests and antibody tests. The antigen test is the definitive test, although a negative result does not rule out a heartworm infection. The antibody test can detect a reaction by the cat's body to the microfilariae, but the microfilariae may die before becoming adults. Therefore a positive antibody test result does not positively detect an active infection. A positive antigen or antibody test result in the presence of clinical respiratory symptoms indicates an active infection (see <https://www.heartwormsociety.org/images/pdf/2014-AHS-Feline-Guidelines.pdf>).

At this time, there are no approved treatments for feline heartworm disease. Therefore the best treatment is prevention. Preventive options available for cats include once-a-month pills or a single topical monthly application for the prevention of feline heartworm disease.

Technician's Note

The best way to test for feline heartworm disease is to use both an antigen test and an antibody test made for feline heartworm disease because those made for canines alone are not sensitive enough for feline heartworm disease.

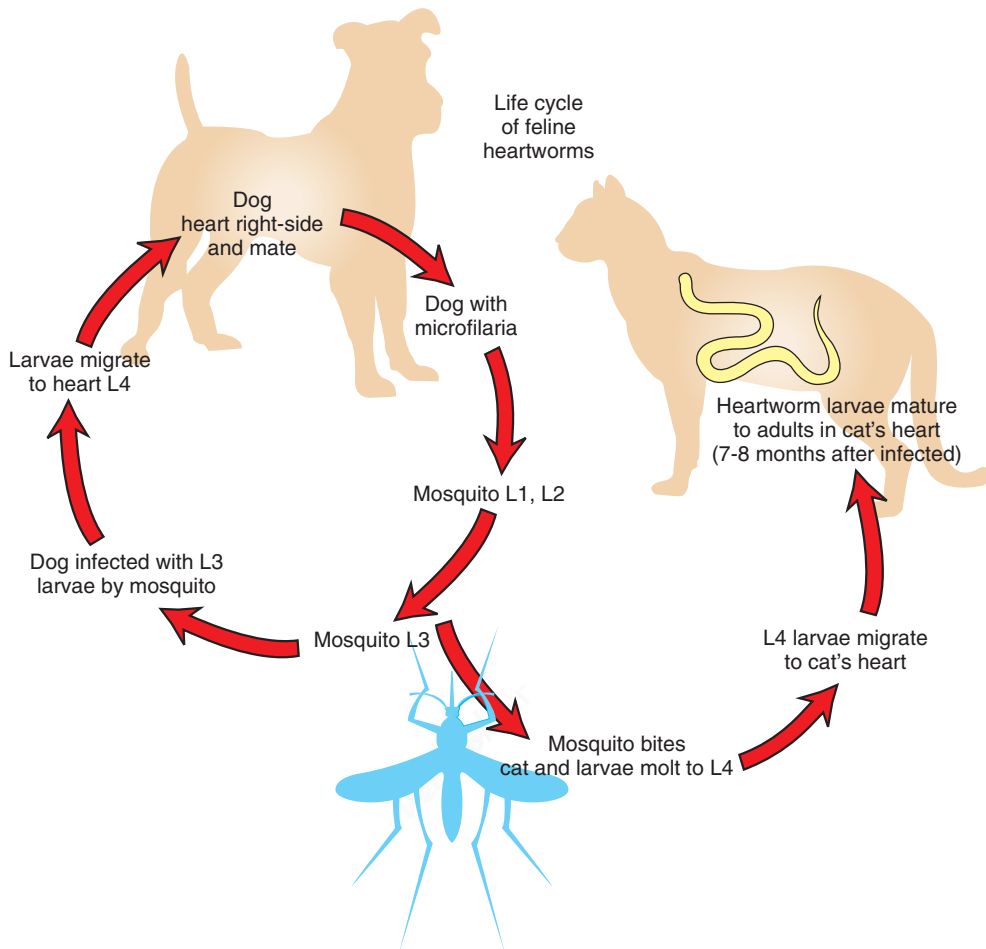


Fig. 4.31 Life cycle of the feline *Dirofilaria immitis*.

Respiratory System

Parasite: *Aelurostrongylus abstrusus*

Host: Feline

Location of Adult: Respiratory bronchioles and alveolar ducts

Distribution: Worldwide

Derivation of Genus: Cat strongyle

Transmission Route: Ingestion of larvae

Common Name: Feline lungworm

Zoonotic: No

Aelurostrongylus abstrusus is the feline lungworm. The adults live in the terminal respiratory bronchioles and alveolar ducts, where they form small egg nests or nodules where they can obstruct the bronchioles. Initially, this parasite lays embryonated (larvated) eggs. The eggs of this parasite

are forced into the lung tissue, where they hatch to form characteristic first-stage larvae, approximately 360 μ m long. These larvae are quite distinct; each has a tail with a unique S shaped bend with a dorsal spine (Fig. 4.32). These larvae are coughed up by the cat, swallowed, and passed out in the feces. Diagnosis is made by finding these characteristic larvae on fecal flotation or by the Baermann technique (see Chapter 17). It is also possible to recover the larvae using a tracheal wash (Fig. 4.33). The prepatent period for the feline lungworm is approximately 30 days.

Parasite: *Oslerus osleri*, *Oslerus hirthi*, and *Oslerus milksi* (*Oslerus* was formerly known as *Filaroides*)

Host: Canine

Location of Adult: Trachea, lung parenchyma, and bronchioles, respectively

Distribution: North America, Europe, and Japan

CASE PRESENTATION 4-5

Setting Up the Scenario

Mr. and Mrs. Milton presented Wilma, a 3-month-old female Boxer, for her first puppy visit. After getting a weight for Wilma, the technician asked Mr. and Mrs. Milton if they knew anything about canine heartworm disease. Mr. and Mrs. Milton replied, "No."

What Information Must the Veterinary Technician Convey to Mr. and Mrs. Milton?

The technician replied, "Let me give you some information on canine heartworm disease. Canine heartworm disease is caused by a parasite called *Dirofilaria immitis*. The adult worms reside in the right side of the heart, as you can see in this model. The adults produce babies called *microfilariae*. The microfilariae are found in the blood, where they are picked up by the mosquito when it bites a canine heartworm-infected dog. The microfilariae or babies then incubate an infective larva. At this stage, the mosquito bites Wilma and transfers the infective larvae to her. The microfilariae travel through Wilma's tissues to her heart. Once in the heart, they mature to adults. We have monthly heartworm preventatives to help keep Wilma from developing heartworm disease. The preventatives kill the larvae before they can reach the heart and become adults. We are going to give you a puppy kit for Wilma that includes the first dose of heartworm prevention. Our hospital recommends using the preventative year-round."

The technician noted in the patient record that heartworm disease and prevention were discussed.

Derivation of Genus: Thread-like shape

Transmission Route: Ingestion of infected L1 larvae

Common Name: Canine lungworm

Zoonotic: No

Oslerus osleri, *Oslerus hirathi*, and *Oslerus milksi*, the canine lungworms, are found in the trachea, lung parenchyma, and bronchioles, respectively. The larva is 232 to 266 μm in length and has a tail with a short S shaped appendage. *Oslerus* (formerly *Filaroides*) species are unique among nematodes in that their first-stage larvae are immediately infective for the canine definitive host. No period of development is required outside the host. These parasites are transmitted from the dam to her offspring as she licks and cleans her puppies. Diagnosis is made by finding these characteristic larvae on fecal flotation or by the Baermann technique. (Fig. 4.34 shows the unique infective larvae of *O. osleri*.) Nodules of *O. osleri* are usually found at the bifurcation of the trachea, where they can cause obstruction of the airway and be easily observed at necropsy (Fig. 4.35). The prepatent period for *O. osleri* is approximately 10 weeks.



Fig. 4.32 First-stage larva of *Aelurostrongylus abstrusus*, the feline lungworm. Each larva has a tail with an S shaped bend and a dorsal spine. Diagnosis is made by finding these characteristic larvae on fecal flotation or by the Baermann technique.

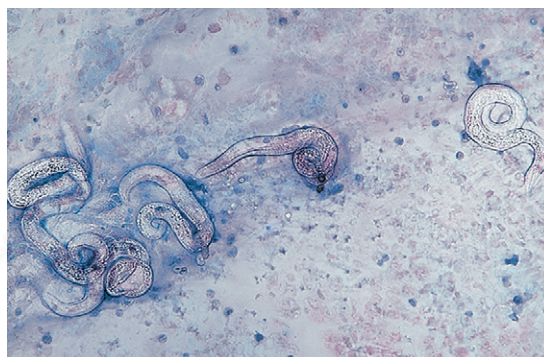


Fig. 4.33 First-stage larvae of *Aelurostrongylus abstrusus* recovered on tracheal wash.

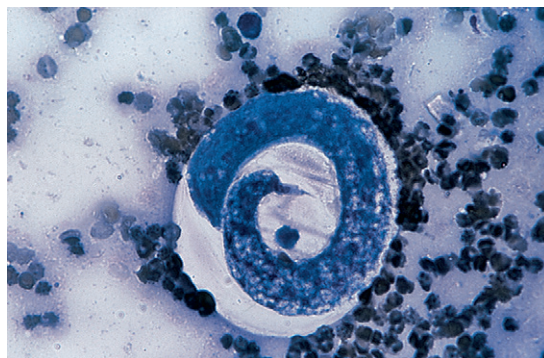


Fig. 4.34 Tracheal wash revealing the characteristic first-stage larva of *Oslerus* (formerly *Filaroides*) *osleri*, the canine lungworm, which has a tail with a short S shaped appendage. *Oslerus* species are unique among nematodes in that their first-stage larvae are immediately infective for the canine definitive host. No period of development is required outside the host.

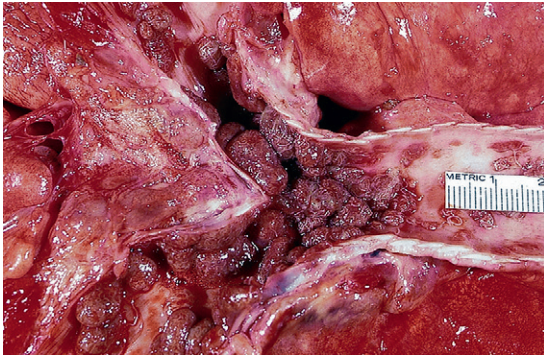


Fig. 4.35 Nodules of *Oslerus* (formerly *Filaroides*) *osleri* are usually found at the bifurcation of the trachea, where they can be easily observed at necropsy.

Parasite: ♦ *Eucoleus* (formerly *Capillaria*) *aerophilus* and *Eucoleus* (formerly *Capillaria*) *böehmi*
Host: Canines/felines and canines, respectively
Location of Adult: Bronchi and trachea, nasal cavity and frontal sinuses, respectively
Distribution: North America, South America, and Europe
Derivation of Genus: Good sheath
Transmission Route: Ingestion of ova from feces or mucoid discharge. Dogs may become infected by eating raw fish or frogs containing infective larvae.
Common Name: Respiratory capillarid
Zoonotic: *E. aerophilus*: yes (per AAVP); *E. böehmi*: no

Eucoleus aerophilus (*Capillaria aerophila*) is a capillarid nematode found in the trachea and bronchi of both dogs and cats, where it can cause an inflammatory response by the host. The prepatent period is approximately 40 days. The ova are passed through the feces or mucoid discharge from coughing them up in sputum. The ova are ingested by the host. During standard fecal flotation, eggs of *Eucoleus* species are often confused with those of *Trichuris* species (whipworms). Eggs of *E. aerophilus* are smaller (59 to $80\ \mu\text{m} \times 30$ to $40\ \mu\text{m}$), more broadly barrel shaped, and lighter in color than whipworm eggs. The egg has a rough outer surface with a netted appearance (Fig. 4.36). *E. böehmi* is found in the nasal cavity and frontal sinuses of dogs, where it can cause obstruction of the nasal cavity and sinuses. Its eggs are smaller and have a smoother outer surface than those of *E. aerophilus*. Its shell has a pitted appearance. *E. böehmi* can be diagnosed by standard fecal flotation.

Technician's Note

Eucoleus aerophilus and *Eucoleus böehmi* ova are easily confused with *Trichuris* ova on fecal flotation.

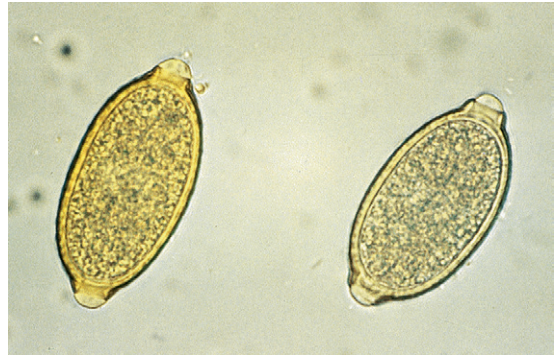


Fig. 4.36 Egg of *Eucoleus aerophilus* (*Capillaria aerophila*), a capillarid nematode found in the trachea and bronchi of dogs and cats. The eggs are smaller than whipworm eggs and more broadly barrel shaped and lighter in color. The eggs have a rough outer surface with a netted appearance.



Fig. 4.37 *Dioctophyma renale*, the giant kidney worm of dogs, is the largest of the parasitic nematodes that affect domestic animals.

Urinary Tract

Parasite: ♦ *Dioctophyma renale*
Host: Canine
Location of Adult: Right kidney
Distribution: Worldwide (but not Britain) and rare in the United States
Derivation of Genus: Distended growth
Transmission Route: Ingestion of infected larvae within an annelid, raw fish and frogs
Common Name: Canine giant kidney worm
Zoonotic: Yes but rare in humans (per *The Merck Veterinary Manual*)

Dioctophyma renale is the giant kidney worm of dogs. This largest of the parasitic nematodes that affect domestic animals (Fig. 4.37) frequently infects the right kidney of dogs

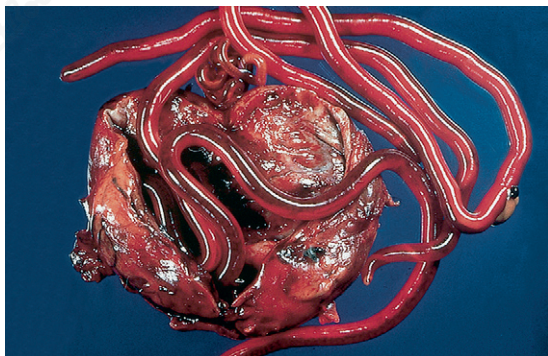


Fig. 4.38 *Dioctophyma renale* frequently infects the right kidney of dogs and ingests the entire parenchyma, leaving only the capsule of the kidney.

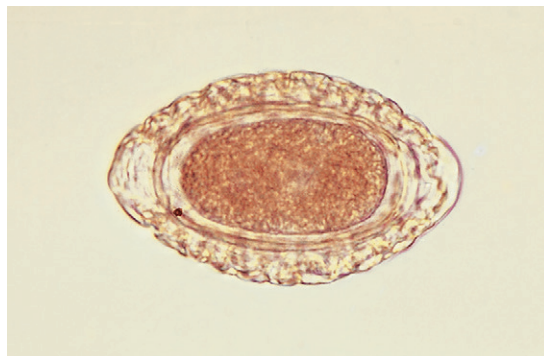


Fig. 4.39 Egg of *Dioctophyma renale*, with its characteristic barrel shaped, bipolar, yellow-brown appearance. The shell has a pitted appearance.

and ingests the parenchyma, leaving only the capsule of the kidney (Fig. 4.38). The eggs from the canine urine are ingested by an annelid worm and mature into an infective larva. Ingestion of the annelid worm with an infective larva spreads the parasite to a new canine host. Eggs may be recovered by centrifugation and examination of the urine sediment. They are characteristically barrel shaped, bipolar, and yellow-brown. The shell has a pitted appearance. Eggs measure 71 to 84 $\mu\text{m} \times 46$ to 52 μm . (Fig. 4.39 shows the characteristic egg of *D. renale*.) *D. renale* is also known for its wandering activity; it often “gets off course” during its migration to the kidney. This nematode also may occur freely within the peritoneal cavity. When the kidney worm is in an aberrant site, its eggs cannot be passed to the external environment. The prepatent period for this largest of nematodes is approximately 18 weeks.

Technician's Note



Dioctophyma renale is the largest parasitic nematode of domestic animals and can ingest the parenchyma of the right kidney.

Parasite: *Pearsonema* (formerly *Capillaria*) *plica* and

Pearsonema (formerly *Capillaria*) *feliscati*

Host: Canines and felines, respectively

Location of Adult: Urinary bladder

Distribution: Southeastern United States

Transmission Route: Ingestion of infective intermediate host, earthworm; ingestion of earthworm containing infected L3 larvae

Common Name: Bladder worm of canines and felines, respectively

Zoonotic: No



Fig. 4.40 Egg of *Pearsonema plica*, the urinary capillarid. The eggs are clear to yellow and have flattened bipolar end plugs and a rough outer surface. The eggs may be confused with those of respiratory and gastric capillarids and whipworms.

Pearsonema plica and *P. feliscati* are nematodes of the urinary bladder of dogs and cats, respectively. Their eggs may be found in urine or in feces contaminated with urine. Eggs are clear to yellow; measure 63 to 68 $\mu\text{m} \times 24$ to 27 μm ; and have flattened, bipolar end plugs. The outer surface of the shell is roughened (Fig. 4.40). These eggs may be confused with eggs of the respiratory and gastric capillarids and those of the whipworms. The eggs are ingested by an earthworm, where they mature to infective larvae. If the earthworm is ingested by a new host, the larvae will migrate to the urinary bladder.

Technician's Note



Pearsonema species can be found in urine sediment or in fecal samples contaminated with urine, but the eggs can be easily confused with other capillarid ova of the respiratory and intestinal tract and with *Trichuris* species ova.

Skin

Parasite: *Rhabditis* (formerly *Pelodera*) *strongyloides*

Host: Canine

Location of Adult: Superficial layers of the skin

Distribution: Worldwide

Derivation of Genus: Rod shaped

Transmission Route: First-stage larvae enter directly through the skin (percutaneous)

Common Name: Free-living soil nematodes

Zoonotic: No

Rhabditis *(formerly *Pelodera*) *strongyloides* are free-living saprophytic nematodes that normally live in moist soil. These roundworms are **facultative parasites**; that is, they are normally free living but under certain circumstances, invade mammalian skin and develop to a parasitic mode of existence. Male and female adult *R. strongyloides* are found in soil mixed with moist organic debris such as straw or hay. The females produce eggs that hatch into first-stage larvae. These larvae invade the superficial layers of damaged or scarified skin, producing a mild dermatitis. The skin may become reddened, denuded, and covered with a crusty material. Occasionally, a pustular dermatitis develops. Because dogs acquire the infection by lying on contaminated bedding or soil, these lesions are usually observed on the ventral, or inner, surface of the limbs. Larvae of *R. strongyloides* also can be recovered from the skin of almost any domesticated animal, particularly downer cattle, when these cows come in direct contact with soil containing larval *R. strongyloides*.

Larval (and adult) stages can be identified after superficial skin scrapings of the affected areas on the ventral, or inner, surface of the limbs, where the larvae have a distinctive esophagus (Fig. 4.41). Larvae of *P. strongyloides* are 596 to 600 µm long. These larvae must be differentiated from the microfilariae of the canine heartworm, *D. immitis* (see Figs. 4.25 and 4.26), the microfilariae of *A. reconditum* (see Figs. 4.29 and 4.30), and the first-stage larvae of *Dracunculus insignis* (Fig. 4.42).

As discussed earlier, *D. immitis*, the canine heartworm, normally resides in the right ventricle and pulmonary arteries of the canine definitive host. This parasite tends to wander aberrantly and may be found in a variety of extravascular sites, including cystic spaces in subcutaneous sites. Fig. 4.43 shows an aberrant adult *D. immitis* in a subcutaneous interdigital cyst. When heartworms are found aberrantly, they are usually single, immature, isolated worms that have become “lost” en route to the heart. If the worm within the cyst is female, she will not have been fertilized by a male heartworm. Therefore she will not be gravid and will not produce microfilariae.



Fig. 4.41 Larval and adult stages of *Rhabditis strongyloides* can be identified after the superficial skin scrapings of affected areas that have come in contact with infected soil.



Fig. 4.42 Unique first-stage larvae of *Dracunculus insignis* with the characteristic long, pointed tail.



Fig. 4.43 Aberrant adult *Dirofilaria immitis* in a subcutaneous interdigital cyst. Heartworms found aberrantly are usually single, immature, isolated worms lost en route to the heart.

Technician's Note

Although *Rhabditis strongyloides* can cause inflammation of the skin in animals, it is usually a free-living organism.

However, other adult male and female heartworms may be in their predilection sites, the right ventricle and pulmonary arteries. It is possible for these adult females to produce microfilariae. These microfilariae occasionally may be recovered in deep skin scrapings that draw blood.

Aberrant *D. immitis* within cystic spaces in the skin can be removed surgically. When subjected to the modified Knott procedure, the microfilariae of *D. immitis* are 310 to 320 μm long, with straight tails and tapering anterior ends. They must be differentiated from microfilariae of *A. reconditum* (see Figs. 4.29 and 4.30), the first-stage larvae of *R. strongyloides* (see Fig. 4.41), and the first-stage larvae of *D. insignis* (see Fig. 4.42).

Parasite: *Acanthocheilonema* (formerly *Dipetalonema*) *reconditum*

Host: Canine

Location of Adult: Subcutaneous tissues

Distribution: Tropical and subtropical regions

Derivation of Genus: Thorny-lipped worm

Transmission Route: Bite from infected flea

Common Name: Canine subcutaneous filarial worm

Zoonotic: No

The adult *A. reconditum*, the subcutaneous filarial worm, is a nonpathogenic nematode residing in the subcutaneous tissues of the dog. The adult filarial parasites are seldom found (Fig. 4.44). (See Figs. 4.29 and 4.30 for the



Fig. 4.44 Adults of *Acanthocheilonema reconditum*, the subcutaneous filarial worm, are nonpathogenic. They reside in subcutaneous tissues of the dog and are seldom recovered at necropsy.

frequently seen microfilariae.) These parasites may also be found within the body cavity. Occasionally, subcutaneous abscesses and ulcerated areas have been associated with *A. reconditum*. The intermediate host for this parasite is the cat flea, *Ctenocephalides felis*. Because this parasite is found in enzootic areas where *D. immitis* is present, it is necessary to differentiate the microfilariae of these two filarial parasites.

Technician's Note

Acanthocheilonema reconditum is transmitted to the dog by the bite of the cat flea, *Ctenocephalides felis*.

Adult *A. reconditum* are rarely recovered from subcutaneous sites. More often, their microfilariae are recovered in peripheral blood samples. These microfilariae may be rarely recovered in deep skin scrapings that draw blood. On examination of microfilaremic peripheral blood subjected to the modified Knott procedure, the microfilariae of *A. reconditum* average about 285 μm in length and have "buttonhook" tails and blunt (broom handle shaped) anterior ends (see Figs. 4.29 and 4.30). It is important to differentiate these microfilariae from the microfilariae of *D. immitis* (see Figs. 4.25 and 4.26), the first-stage larvae of *R. strongyloides* (see Fig. 4.41), and the first-stage larvae of *D. insignis* (see Fig. 4.42).

Technician's Note

Acanthocheilonema reconditum microfilariae are often confused with the microfilariae of *Dirofilaria immitis* in a Knott test or heartworm filter test.

Parasite: *Dracunculus insignis*

Host: Canine

Location of Adult: Subcutaneous tissues

Distribution: North America— eastern United States and Ontario

Derivation of Genus: Small dragon

Transmission Route: Ingestion of intermediate host, small aquatic crustaceans

Common Name: Guinea worm

Zoonotic: No

Dracunculus insignis, the guinea worm, is a nematode found in the subcutaneous tissues of the dog. The adult female nematode may be extremely long, up to 120 cm. In comparison, the male is quite short, only 2 to 3 cm in length; however, it is rarely seen. The female resides



Fig. 4.45 Adult female *Dracunculus insignis*, the guinea worm, is often found in subcutaneous tissues of the dog. The guinea worm causes a draining, ulcerous lesion in the skin, usually on the limb.

subcutaneously and produces a draining, ulcerous lesion in the skin, usually on the dog's limb (Fig. 4.45). The anterior end of the female worm extends from this ulcer. If the female worm within the lesion comes in contact with water, her uterus will prolapse through her anterior end and rupture, releasing a mass of first-stage larvae into the water. These larvae are 500 to 750 μm in length and have long tails that are quite distinct. (See Fig. 4.42 for the first-stage larvae of *D. insignis*.) Larvae are ingested by tiny crustaceans in the water; within the crustaceans, the larvae develop to the infective third stage. Dogs become infected with *D. insignis* by drinking water containing these infected crustaceans.

If *D. insignis* is observed in an ulcerous lesion, the ulcer, with its associated worm, should be dipped in cool water. The cool water is a stimulus for the female worm to expel her larvae. The water containing expelled larvae should be collected and centrifuged; the sediment must then be examined for the presence of the characteristic first-stage larvae. Larvae of *D. insignis* must be differentiated from the microfilariae of *D. immitis* (see Figs. 4.25 and 4.26), the microfilariae of *A. reconditum* (see Figs 4.29 and 4.30), and the first-stage larvae of *R. strongyloides* (see Fig. 4.41). Once diagnosed, the adult female worm must be surgically removed.

D. medinensis, the human guinea worm, has been reported in dogs and cats on occasion.

Technician's Note

Dracunculus insignis larvae can be observed on a deep skin scraping and therefore must be differentiated from larvae of *Dirofilaria immitis* and *Acanthocheilonema reconditum*.

Eye and Adnexa

Parasite: ♦ *Thelazia californiensis*

Host: Canine and feline

Location of Adults: Conjunctival sac and lacrimal duct of the eye

Distribution: North America

Derivation of Genus: Nipple saliva

Transmission Route: Infection by infective larvae from intermediate host, *Musca autumnalis*

Common Name: Eyeworm of canines and felines

Zoonotic: Yes, but rare in humans (per *The Merck Veterinary Manual*)

Thelazia californiensis is the eyeworm of dogs and cats. Adult parasites can be recovered from the conjunctival sac and lacrimal duct (Fig. 4.46). Examination of the lacrimal secretions may also reveal eggs or first-stage larvae. The cat or dog is infected with *T. californiensis* by L3 infective larvae passed to the animal by the face fly, *Musca autumnalis*. The prepatent period is 3 to 6 weeks.

As mentioned previously, *D. immitis* can be recovered from a variety of aberrant sites, including the anterior chamber of the eye (see Fig. 4.43). As with aberrant parasites that occur in the skin, those found in the eye are usually single, immature, isolated worms that have become lost en route to the heart. If the worm within the anterior chamber is female, she will not have been fertilized by a male heartworm. Therefore she will not be gravid and will not produce microfilariae. This nematode can be surgically removed from the eye.

Technician's Note

Thelazia californiensis adults are seen in the conjunctival sac and lacrimal ducts of the dog or cat, whereas ova can be recovered from lacrimal secretions.

Nematodes of Ruminants

Gastrointestinal Tract

Parasite: *Gongylonema pulchrum*

Host: Sheep, goats, cattle, and occasionally pigs and horses

Location of Adult: Submucosa and mucosa of the esophagus

Distribution: Worldwide

Intermediate Host: Dung beetle or cockroach

Derivation of Genus: Worms with bumps



Fig. 4.46 *Thelazia californiensis* is the eyeworm of dogs and cats. Adult parasites can be recovered from the conjunctival sac and lacrimal duct. Examination of lacrimal secretions may also reveal eggs or first-stage larvae.

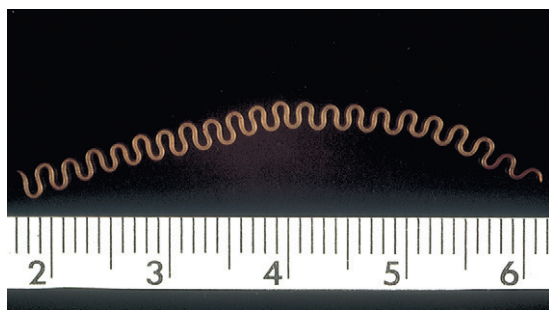


Fig. 4.47 *Gongylonema pulchrum* inhabits the esophagus of sheep, goats, cattle, and occasionally pigs and horses. The parasite lies embedded within the submucosa or mucosa of the esophagus; it has a unique appearance in that it lies in a zigzag fashion.

Transmission Route: Ingestion of infective intermediate host, dung beetle, or cockroach

Common Name: Esophageal worm of ruminants

Zoonotic: No

Gongylonema pulchrum inhabits the esophagus of sheep, goats, cattle, and occasionally pigs and horses. This parasite lies embedded within the submucosa or mucosa of the esophagus; it has a unique appearance in that it lies in a zigzag fashion within the tissues (Fig. 4.47). Its eggs are 50 to 70 μm $\times$ 25 to 37 μm . *G. pulchrum* requires an intermediate host in which to develop before it can be transmitted to the ruminant host. A dung beetle or cockroach is required as an intermediate host. The ova can be identified by standard fecal flotation.

Parasite: ♦ *Bunostomum* species, *Trichostrongylus* species, *Chabertia* species, *Cooperia* species, *Haemonchus* species, *Oesophagostomum* species, and *Ostertagia* species

Host: Cattle, sheep, and goats

Location of Adult: Abomasum, small and large intestines

Distribution: Worldwide

Derivation of Genus: Mound mouth—*Bunostomum*, blood spear—*Haemonchus*, esophagus mouth—*Oesophagostomum*, and hair round—*Trichostrongylus*

Transmission Route: Ingestion of infective larvae

Common Name: Trichostrongyles of cattle and sheep

Zoonotic: *Bunostomum* species and *Trichostrongylus* species: yes (per *The Merck Veterinary Manual*); *Chabertia* species, *Cooperia* species, *Haemonchus* species, *Oesophagostomum* species, and *Ostertagia* species: no

Technician's Note



Trichostrongyle type ova of any of the genera are too similar in appearance to accurately identify them by specific genus and species.

The bovine trichostrongyles comprise several genera of nematodes within the abomasum and the small and large intestines of cattle and other ruminants. The genera that can be classified as producing the trichostrongyle type of eggs are *Bunostomum*, *Chabertia*, *Cooperia*, *Haemonchus*, *Oesophagostomum*, *Ostertagia*, and *Trichostrongylus* species. These seven genera (there are many others) produce oval, thin-shelled eggs. The bovine trichostrongyles have a similar life cycle. The adults live in the abomasum and intestines, where they feed on blood from the host. The female passes eggs in the feces. The eggs have a morula that contains four or more cells and are 70 to 120 μm in length (Fig. 4.48). Some of these eggs can be identified to their respective genera; however, identification is usually difficult because mixed infections are quite common. On identification of the characteristic eggs, the veterinary diagnostician should record the identification as “trichostrongyle type of egg” and should not attempt to identify them to the individual genus names. Identification to genus and species is usually performed by fecal culture and larval identification. (Fig. 4.49 shows representative examples of trichostrongyle types of eggs.) The trichostrongyles are perhaps the most common nematodes diagnosed on fecal flotation of ruminants.

The most common dewormers used for the trichostrongyles are fenbendazole, levamisole, and ivermectin.

Technician's Note



The most common dewormers used for trichostrongyles are fenbendazole, levamisole, and ivermectin.

Parasite: *Nematodirus* species and *Marshallagia* species



Fig. 4.48 Oval, thin-shelled eggs that typify the eggs of ruminant trichostrongyles. The eggs contain a morula with four or more cells. Some eggs can be identified to their respective genera; however, identification is usually difficult because mixed infections are common. Identification of these should be recorded as “trichostrongyle types of eggs,” and no attempt should be made to identify them to individual genus names.

Host: Cattle, goats, and sheep

Location of Adult: Abomasum, small and large intestines

Distribution: Worldwide (*Nematodirus*) and tropical/subtropical regions (*Marshallagia*)

Derivation of Genus: Terrible nematode—*Nematodirus*, parasite studied by Dr. Marshall

Transmission Route: Ingestion of infective larvae

Common Name: Trichostrongyles with very large eggs

Zoonotic: No

Nematodirus species and *Marshallagia* species are also ruminant trichostrongyles; however, the eggs of these nematodes are much larger than those of the genera just mentioned and are the largest in the trichostrongyle family. The prepatent period is 15 to 26 days. Fig. 4.50 shows the eggs of *Nematodirus* species. In standard fecal flotation, the eggs of *Nematodirus* species are large, 150 to 230 $\mu\text{m} \times 80$ to 100 μm , and have tapering ends and a four- to eight-cell morula. The eggs of *Marshallagia* species are also large, 160 to 200 $\mu\text{m} \times 75$ to 100 μm , and have parallel sides and a rounded end and contain a 16- to 32-cell morula. Infected animals may have diarrhea, anorexia, dehydration, and a dull hair coat.

Technician's Note

Nematodirus species and *Marshallagia* species have ova similar to those of other trichostrongyle species, except the eggs of the species are the largest among the trichostrongyles.

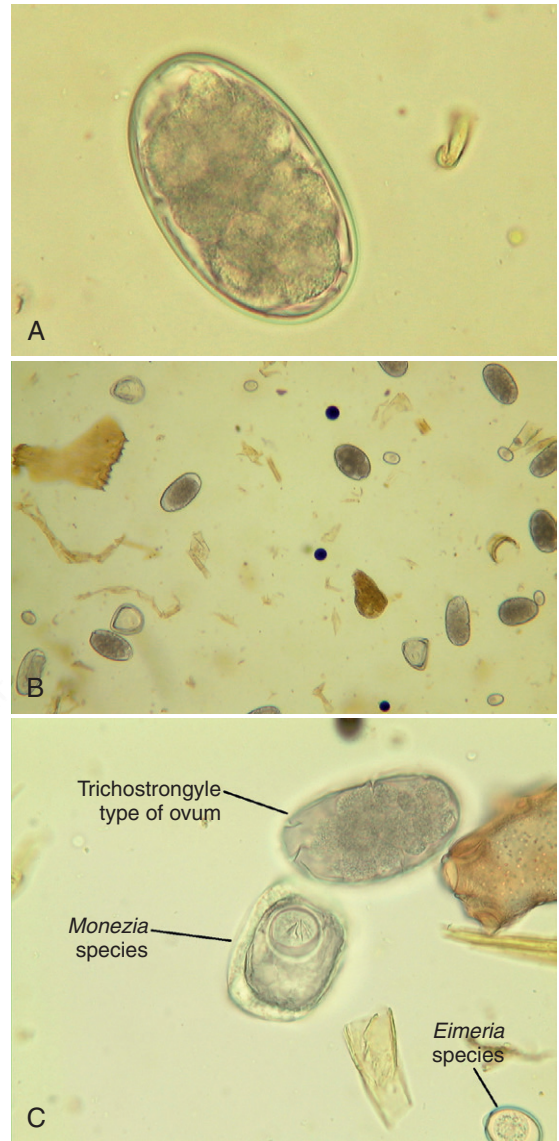


Fig. 4.49 Representative examples of the trichostrongyle types of eggs. Trichostrongyles are perhaps the most common nematodes diagnosed on fecal flotation of ruminants. **A**, 400 $\times$ close-up of a trichostrongyle type of egg. **B**, 100 $\times$ normal magnification. **C**, Trichostrongyle type of egg with other species of parasite eggs.

Parasite: *Strongyloides papillosus*

Host: Cattle

Location of Adult: Small intestine

Distribution: Worldwide

Derivation of Genus: Round-like shape

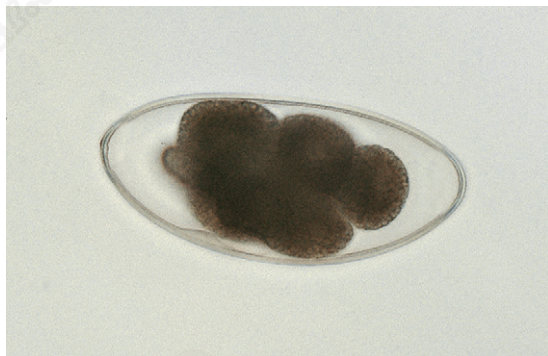


Fig. 4.50 Large eggs of *Nematodirus* species. The eggs are the largest of the ruminant trichostrongyle eggs and have tapering ends and a morula with four to eight cells.

Transmission Route: Ingestion of infective larvae or penetration of skin by infective larvae

Common Name: Bovine intestinal threadworm

Zoonotic: No

Strongyloides papillosus is the intestinal threadworm of cattle. These nematodes are unique in that only a parthenogenetic female is parasitic in the bovine host. Parasitic male *Strongyloides* do not exist. The female worms produce larvated eggs with a **rhabditiform esophagus** measuring 40 to 60 $\mu\text{m} \times 20$ to 25 μm . Eggs are usually recovered in the flotation of fresh feces. (See Fig. 4.15 for the parasitic adult females, eggs, and first-stage larvae of *Strongyloides* species.) The eggs grow and molt as they pass through the feces to the environment. Once the eggs hatch, the larvae become free-living adults or infective-stage female larvae. The infective-stage larvae can enter the host by penetration of the skin (usually between the hooves) or by ingestion. The larval *Strongyloides* species are 280 to 310 μm long and possess a rhabditiform esophagus with a club shaped anterior corpus, narrow median isthmus, and caudal bulb. The larvae migrate to the lungs through the circulatory system, are coughed up, and are swallowed. Once in the intestines, they mature to adults and feed on the host's blood. The larvae can be passed to the ruminant neonate through the colostrum. The prepatent period is 5 to 7 days. Light infections may be asymptomatic, but heavy infections produce diarrhea, anorexia, blood and mucus in the feces, and weight loss.

The most common anthelmintics for *S. papillosus* are the **benzimidazoles** (e.g., fenbendazole, oxfendazole, albendazole), the **probenzimidazoles** (e.g., thiophanate, febantel, netobimin), and ivermectin. Because most ruminants spend part or all of their lives in pasture, the animals are subject to constant reinfection. Treatment with dewormers is only part of the treatment for ruminant parasites.

Prevention plays a major role in the treatment procedure. Pasture rotation with nonruminant animals, such as horses, mules, and donkeys, reduces the infective larvae in the pasture.

Technician's Note



Only the parthenogenetic female *Strongyloides papillosus* is parasitic to the bovine host. Parasitic males do not exist. The parasitic female worm is commonly treated with benzimidazoles, probenzimidazoles, and ivermectin.

Parasite: *Trichuris ovis*

Host: Cattle, sheep, and goats

Location of Adult: Cecum and colon

Distribution: Worldwide

Derivation of Genus: Hair tail

Transmission Route: Ingestion of infective ova

Common Name: Whipworms

Zoonotic: No

Trichuris ovis parasites are commonly called *whipworms* and infect the cecum and colon of ruminants. (See Fig. 3.12 for the discussion of nematode parasites of the gastrointestinal tract of dogs and cats for details of gross morphology of adult whipworms.) The egg of the whipworm is described as trichinelloid or trichuroid; it has a thick, yellow-brown, symmetric shell with polar plugs at both ends. The eggs are unembryonated (not larvated) when laid. The eggs of bovine whipworms measure 50 to 60 $\mu\text{m} \times 21$ to 25 μm . (See Fig. 4.17 for the characteristic egg.) Symptoms are usually not apparent with *T. ovis* but can include dark feces, anorexia, and anemia. As with whipworms of dogs and cats, ruminant whipworms are diagnosed with the standard fecal flotation technique. The most common anthelmintics are the benzimidazoles, probenzimidazoles, and ivermectin.

Technician's Note



Trichurids of ruminants pass ova intermittently. Whipworm ova may be hard to find, so daily collection is recommended.

Circulatory System

Parasite: *Elaeophora schneideri*

Host: Sheep

Location of Adult: Common carotid artery

Distribution: Western and southwestern United States

Derivation of Genus: Bearing oil

Transmission Route: Bite of an infective horse fly, *Tabanus* species

Common Name: Arterial worms of sheep

Zoonotic: No

Elaeophora schneideri, the arterial worm, is found in the common carotid arteries of sheep in the western and south-western United States. Although the adults are found in these predilection sites, where they can cause obstruction of the arteries, their microfilariae are restricted to the skin. Microfilariae are 270 μm in length $\times$ 17 μm in thickness, bluntly rounded anteriorly, and tapering posteriorly. In the skin, the microfilariae usually reside in the capillaries of the forehead and face. In sheep, filarial dermatitis is seen on the face, poll region, and feet.

Diagnosis of *E. schneideri* is by observation of characteristic lesions and identification of microfilariae in the skin. The most satisfactory means of diagnosis is to macerate a piece of skin in warm saline and examine the fluid for microfilariae after about 2 hours. In sheep, microfilariae are rare and may not be found in the skin of affected animals. Postmortem examination may be necessary to confirm the diagnosis of adult parasites within the common carotid arteries. The prepatent period for *E. schneideri* is 4½ months or longer.

Technician's Note

Filarial dermatitis caused by *Elaeophora schneideri* is found on the face, poll region, and feet of sheep.

tail, and an anterior cuticular knob. These larvae are from 550 to 580 μm in length. Larvae of *D. viviparus* also have brown food granules in their intestinal cells, but they have straight tails. They are from 300 to 360 μm in length but lack the anterior cuticular knob. (Fig. 4.51 shows representative examples of eggs and larvae of *D. viviparus*.) The larvae pass out of the host through the feces to grow and molt from L2 to L3 larvae in the environment. The L3 infective larvae are ingested by the host and migrate through the tissues to the lymph vessels. The larvae grow and molt to L4 larvae and follow the lymph vessels to the heart. From the heart, the larvae follow the circulatory system to the lungs, where they mature into adults (Fig. 4.52). The adult worms are white with a small buccal cavity and short, dark, and granular spicules with the vulva in the center of the body. The most common symptom is coughing. The eggs can be found in mucus discharge or coughed-up sputum. Benzimidazoles, probenzimidazoles, and ivermectin are the most common anthelmintics used in ruminants.

Technician's Note

The ova of *Dictyocaulus* species hatch in the host's intestines, and the larvae are present in the feces. Therefore diagnosis is made by finding the larvae on standard fecal flotation or flotation of the sputum-mucus discharge, or by use of the Baermann technique. The Baermann technique is the preferred method for diagnosis of all lungworms in large animals.

Respiratory System

Parasite: *Dictyocaulus* species

Host: Cattle, sheep, and goats

Location of Adult: Bronchi

Distribution: Worldwide

Derivation of Genus: Net-like stalk

Transmission Route: Ingestion of infective larvae

Common Name: Lungworms of ruminants

Zoonotic: No

Dictyocaulus species are the lungworms of cattle (*Dictyocaulus viviparus*), sheep, and goats (*Dictyocaulus filaria*). Adult parasites are found in the bronchi of infected hosts. The prepatent period varies between the species but is approximately 28 days. The female worm lays her eggs in the lungs. The eggs are usually coughed up, swallowed, and hatch in the intestine, producing larvae that may be recovered in the feces. Larvae of *D. filaria* have brown food granules in their intestinal cells, a blunt



Fig. 4.51 Representative examples of the eggs and larvae of *Dictyocaulus viviparus*, the lungworms of cattle. Eggs are usually coughed up and swallowed and hatch in the intestine, producing larvae that may be recovered in feces. Larvae of *D. viviparus* have brown food granules in their intestinal cells, straight tails, and anterior cuticular knobs.

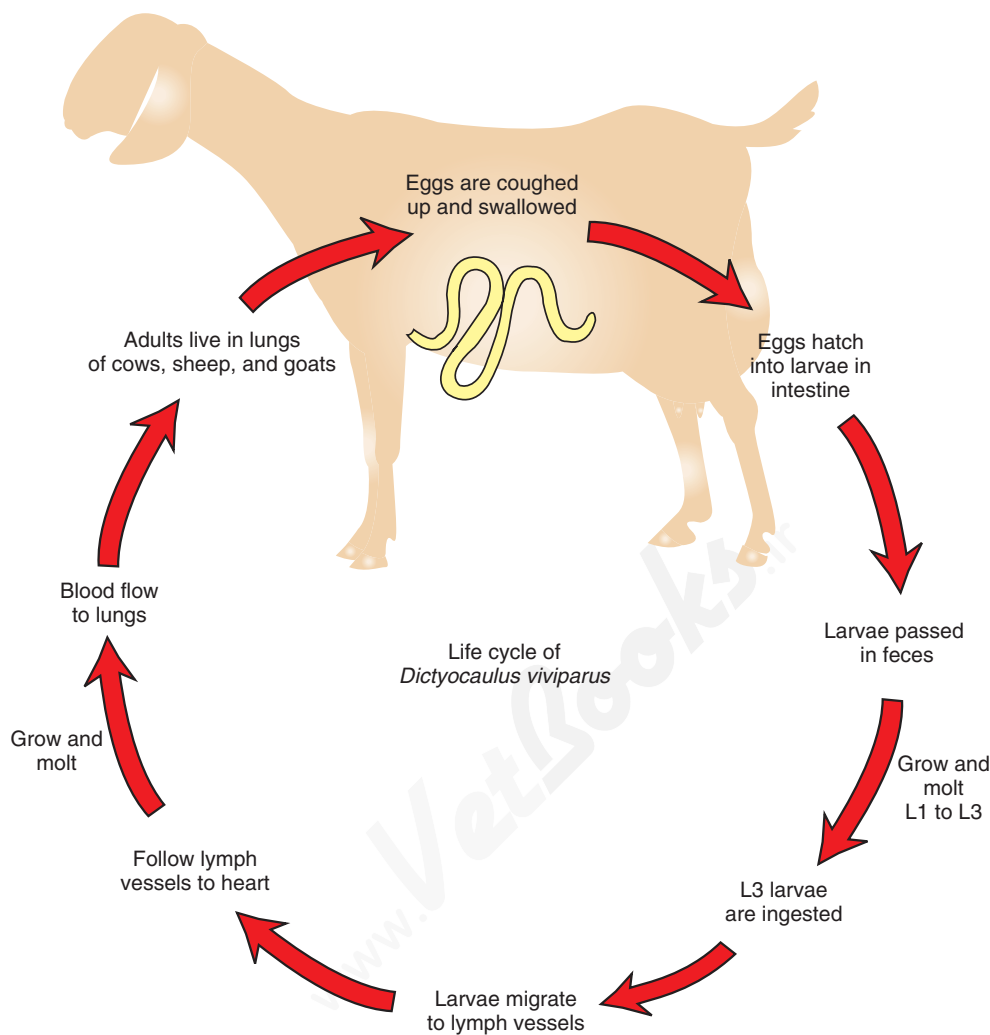


Fig. 4.52 Life cycle of *Dictyocaulus viviparus*.

Parasite: *Muellerius capillaris*

Host: Sheep and goats

Location of Adult: Bronchioles

Distribution: Worldwide

Derivation of Genus: A parasite named for Dr. Mueller

Transmission Route: Ingestion of infective larvae

Common Name: Hair lungworm of sheep and goats

Zoonotic: No

Muellerius capillaris is often called the *hair lungworm* of sheep and goats. Adults are found within the bronchioles, mostly in nodules in the lung parenchyma, where they can obstruct the bronchioles. The eggs develop in

the lungs of the definitive host, and first-stage larvae are coughed up, swallowed, and passed out with the feces. The larvae are from 230 to 300 μm long. The larval tail has an undulating tip and a dorsal spine. Fig. 4.53 shows representative examples of eggs and larvae of *M. capillaris*.

Technician's Note



Muelleris capillaris is best diagnosed by finding the first-stage larvae in the feces on a standard fecal flotation.



Fig. 4.53 Representative examples of the eggs and larvae of *Muellerius capillaris*, the hair lungworm of sheep and goats. Eggs develop in the lungs of the definitive host, and first-stage larvae are coughed up, swallowed, and passed out with feces. The larval tail has an undulating tip and dorsal spine.

Parasite: *Protostrongylus* species

Host: Sheep and goats

Location of Adult: Small bronchioles

Distribution: Worldwide

Derivation of Genus: First round

Transmission Route: Ingestion of infective larvae

Zoonotic: No

Adult *Protostrongylus* species occur in the small bronchioles of sheep and goats, where the adults can cause obstruction of the bronchioles. The eggs develop in the lungs of the definitive host. First-stage larvae are coughed up, swallowed, and passed out with the feces. These larvae are 250 to 320 μm long. This nematode's larval tail has an undulating tip but lacks the dorsal spine.

The Baermann technique is used to diagnose lungworm infection in ruminants (see Chapter 17).

Technician's Note



The ova of *Protostrongylus* species develop in the lungs of the host and larvae are passed in the feces, where they can be found by using the Baermann technique.

Skin

Parasite: *Stephanofilaria stilesi*

Host: Cattle, goats, buffalo, and wild ruminants

Location of Adult: Ventral midline skin

Distribution: United States

Derivation of Genus: Crown thread



Fig. 4.54 *Stephanofilaria stilesi* are small nematodes found in the skin of cattle, goats, buffalo, and other wild ruminants. They typically produce dermatitis, a plague-like lesion, along the ventral midline of cattle in the United States.

Transmission Route: Bite by the infective horn fly,

Haematobia irritans

Common Name: Skin worm of ruminants

Zoonotic: No

Stephanofilaria stilesi parasites are small nematodes found in the skin of cattle, goats, buffalo, and other wild ruminants. In the United States, they typically produce a dermatitis along the ventral midline of cattle (Fig. 4.54). The infective larvae are transmitted by the bite of the horn fly, *Haematobia irritans*. The skin lesions are thought to be caused by both adult and microfilarial stages of this parasite.

The lesions caused by *S. stilesi* are located at or near the umbilicus and consist initially of small red papules. Later, the lesions develop into large pruritic areas (up to 25 cm) of alopecia, with thick, moist crusts. Both the adults (6 mm) and microfilariae may be found in deep skin scrapings after the crusts have been removed from the lesions.

Technician's Note



Stephanofilaria stilesi adults and microfilariae cause skin lesions in the host that can be found on deep skin scraping. Remember that other parasite larvae can also be recovered from the skin of many other animals.

Although *E. schneideri*, the arterial worm, is found in the common carotid arteries of sheep in the western and southwestern United States, the microfilariae are restricted to the skin (see earlier discussion under Circulatory System).

It is important that the veterinary diagnostician remember that larvae of *R. strongyloides* also can be recovered from

the skin of almost any domesticated animal, particularly downer cattle that come in contact with moist soil containing larvae of the genus *Rhabditis*. The larvae actively penetrate the skin and can produce a severe dermatitis (see Fig. 4.41).

Eye and Adnexa

Parasite: *Thelazia rhodesii* and *Thelazia gulosa*

Host: Cattle, sheep, and goats

Location of Adult: Conjunctival sac and lacrimal duct

Intermediate Host: *Musca autumnalis*

Distribution: Worldwide

Derivation of Genus: Nipple saliva

Transmission Route: Infective larvae in face fly (*M. autumnalis*) feces around the eyes

Common Name: Eyeworms of cattle, sheep, and goats

Zoonotic: No

Thelazia rhodesii and *Thelazia gulosa* are the eyeworms of cattle, sheep, and goats. Adult parasites can be recovered from the conjunctival sac and lacrimal duct. Examination of lacrimal secretions may reveal eggs or first-stage larvae. The larvae require an intermediate host, *M. autumnalis*, the face fly, to develop into an infected larva. The infected larvae are deposited by the face fly when it feeds around the eyes of the definitive host. The larvae and adults can cause inflammation of the conjunctival sacs and lacrimal ducts. Microscopic evaluation of lacrimal secretions is used for diagnosis by finding ova or first-stage larvae.

Technician's Note



Thelazia rhodesii and *Thelazia gulosa* are diagnosed by finding the ova or first-stage larvae in lacrimal secretions.

Abdominal Cavity

Parasite: *Setaria cervi*

Host: Cattle

Location of Adult: Free within the peritoneal cavity

Intermediate Host: Female mosquito

Distribution: Worldwide

Derivation of Genus: Bristles

Transmission Route: Bite by an infective mosquito

Common Name: Abdominal worm of cattle

Zoonotic: No

Setaria cervi is the abdominal worm of cattle. Large white adults are usually observed on postmortem examination and are found free within the peritoneal

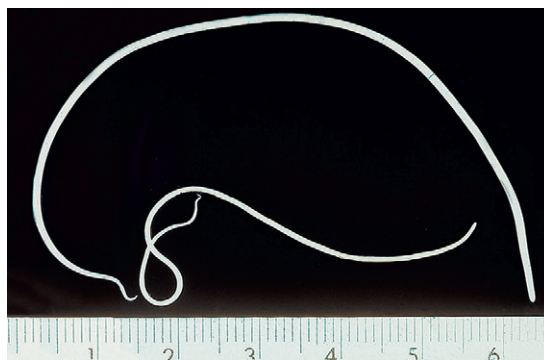


Fig. 4.55 *Setaria cervi* is the abdominal worm of cattle. Adults are usually observed on postmortem examination and are found free within the peritoneal cavity.

cavity (Fig. 4.55). The sheathed microfilariae are approximately $250 \times 7 \mu\text{m}$. Antemortem diagnosis is by demonstration of microfilariae in peripheral blood smears. Damage to the cow may occur because of the migration of the microfilariae to the peritoneal cavity through the tissues.

Technician's Note



Setaria cervi may be found free in the abdomen when performing abdominal surgery.

Nematodes of Equids

Gastrointestinal Tract

Parasite: *Habronema microstoma*, *Habronema muscae*, and *Draschia megastoma*

Host: Horses

Location of Adult: Stomach mucosa

Intermediate Host: Muscidae fly

Distribution: Worldwide

Derivation of Genus: Delicate thread—*Habronema*; worm named for Dr. Drasch

Transmission Route: Ingestion of infective Muscidae fly

Common Name: Stomach worms of horses

Zoonotic: No

Habronema microstoma, *Habronema muscae*, and *Draschia megastoma* are nematodes found in the stomach of horses. *H. microstoma* and *H. muscae* reside on the mucosa of the stomach, just beneath a thick layer of mucus. *D. megastoma*

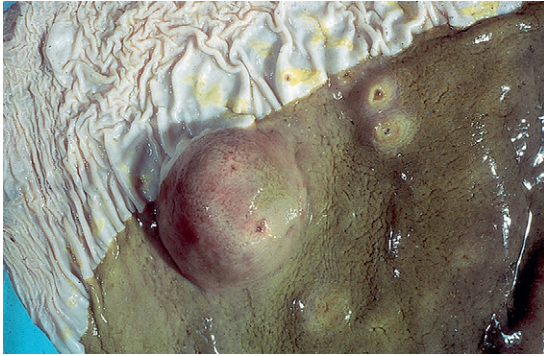


Fig. 4.56 *Draschia megastoma* is often associated with the formation of large, thickened, fibrous nodules within the stomach mucosa of horses.

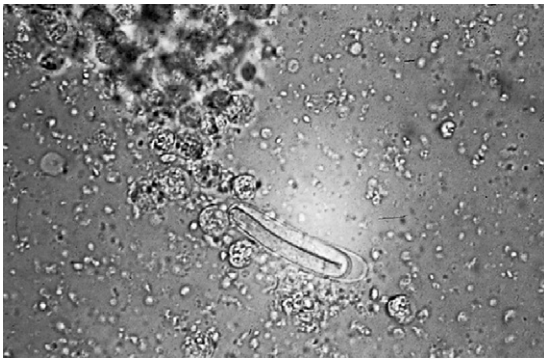


Fig. 4.57 Larvated eggs or larvae of *Habronema* and *Draschia* species may be recovered on standard fecal flotation. Eggs of both genera are elongate and thin walled and often contain first-stage larvae.

is often associated with the formation of large, thickened fibrous nodules within the stomach mucosa (Fig. 4.56). Larvae of both *Habronema* and *Draschia* species may also parasitize skin lesions, causing a skin condition of horses known as *summer sores* (see Fig. 4.68 and later discussion under Skin), or cutaneous habronemiasis/draschiiasis.

Larvated eggs or larvae may be recovered on standard fecal flotation. The eggs of both genera are elongate, thin walled, and measure 40 to 50 $\mu\text{m} \times 10$ to 12 μm (Fig. 4.57). These eggs (or hatched larvae) pass to the outside environment and are ingested by flies belonging to the family Muscidae. The larvae develop to the infective third stage within the fly, and if a horse accidentally ingests the fly, the larvae develop to the adult stage within the stomach of the horse. The prepatent period is approximately 60 days. Antemortem diagnosis of gastric habronemiasis is based on observation of eggs or larvae on fecal flotation.

Symptoms for *H. microstoma*, *H. muscae*, and *D. megastoma* occur with heavy infections and include gastritis, colic, and diarrhea caused by inflammation of the stomach tissues.

Technician's Note

Larval infections of *Habronema* and *Draschia* cause "summer sores" in horses when the larvae parasitize skin lesions.

Benzimidazoles and ivermectin are the most common anthelmintics used for these species in horses. As with ruminants, equines are pasture animals, so pasture management plays an important role in treatment and prevention. In addition, a good fly-control program will help reduce the infected flies in the horse's environment.

Parasite: ♦ *Trichostrongylus axei*

Host: Horses, cattle, sheep, and pigs

Location of Adult: Stomach

Distribution: Worldwide

Derivation of Genus: Hair round

Transmission Route: Ingestion of infective larvae

Common Name: Stomach worms of horses and pigs

Zoonotic: Yes but not common (per Centers for Disease Control and Prevention [CDC])

Trichostrongylus axei is another species of nematode that may reside in the stomach of horses, where they suck the host's blood. These unusual nematodes can cross species lines and can also infect cattle, sheep, and swine by ingesting the infective third-stage larvae. The egg of *T. axei* is classified as a strongyle or trichostrongyle type of egg and measures 79 to 92 $\mu\text{m} \times 31$ to 41 μm (see the following discussion on strongyles) when seen on standard fecal flotation.

Technician's Note

Trichostrongylus axei can cross species lines and infect cattle, sheep, and pigs.

Parasite: *Parascaris equorum*

Host: Horses

Location of Adult: Small intestine

Distribution: Worldwide

Derivation of Genus: Bearing worms

Transmission Route: Ingestion of ova

Common Name: Equine roundworm or equine ascarid

Zoonotic: No

Parascaris equorum is often called the *equine ascarid* or *equine roundworm*. These nematodes are found in the small intestine of young foals (Fig. 4.58). These robust nematodes are the largest of the equine nematodes. Sometimes young foals pass these nematodes in their feces (Fig. 4.59). The eggs are passed in the feces, which tend to be sticky, and the larvae grow and molt within the eggs. The egg containing an L2 larva is ingested by the young foal and hatches in the intestines. The larvae migrate to the liver through the hepatic portal vein, where they grow and molt to the next stage of larvae. The larvae are carried to the lungs through the circulatory system, where they are coughed up and swallowed. Once back in the intestines, the larvae mature into adults (Fig. 4.60) that ingest blood. The adult worms have large, distinctive lips (Fig. 4.61). The prepatent period for these ascarids is 75 to 80 days. The eggs are recovered from the feces of young horses and are round to oval and deeply pigmented. The shell is thickened, with a finely granular surface. These eggs measure 90 to 100 μm in diameter. The center of

the egg contains one or two cells (Fig. 4.62). Eggs can be easily recovered on standard fecal flotation.

The adult worms of *P. equorum* also may be passed in the feces of the young foal. This is one of the largest nematodes to infect horses and may grow to a length of 50 cm; however, such large specimens are the exception rather than the rule.

Technician's Note



Parascaris equorum is the largest of the equine nematodes.

Mild infections of *P. equorum* are usually asymptomatic, but heavy infections can cause unthriftiness, depression, a potbellied appearance, anorexia, colic, and a cough with nasal discharge. Treatment involves pasture management to reduce chances of reinfection and a sound deworming program with benzimidazoles, ivermectin, piperazine, moxidectin, or pyrantel. Prevention includes thoroughly washing the feeders and waterers to remove the contaminating eggs. In addition, pasture management involves rotating the pastures where the weanlings and foals graze.

Parasite: *Strongylus vulgaris*, *Strongylus edentatus*, and *Strongylus equinus*

Host: Horses

Location of Adult: Large intestines

Distribution: Worldwide

Derivation of Genus: Round and common

Transmission Route: Ingestion of infective larvae

Common Name: Strongyles of horses

Zoonotic: No

Strongyles are nematodes that parasitize the large intestine of horses and are typically divided into two types, large strongyles and small strongyles. The small strongyles comprise several genera that vary in pathogenicity. The large strongyles are the most pathogenic of the strongyles. *Strongylus vulgaris* is often associated with thrombi within the anterior mesenteric artery of horses (Fig. 4.63). *S. vulgaris*, *Strongylus edentatus*, and *Strongylus equinus* are the large strongyles (Fig. 4.64).

Technician's Note



Although horses are infected with large and small strongyles, the large strongyles are the more pathogenic of the two types.

Regardless of whether these endoparasites are a small strongyle or a large strongyle, their eggs are virtually



Fig. 4.58 *Parascaris equorum* nematodes are often called *equine ascarids* or *equine roundworms*. These nematodes are found in the small intestine of young foals.

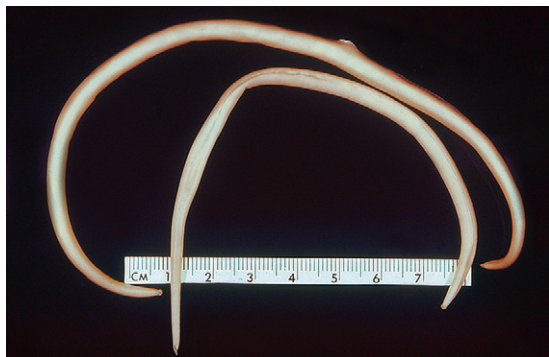


Fig. 4.59 *Parascaris equorum* is the largest of the equine nematodes. Young foals may pass these large parasites in the feces.

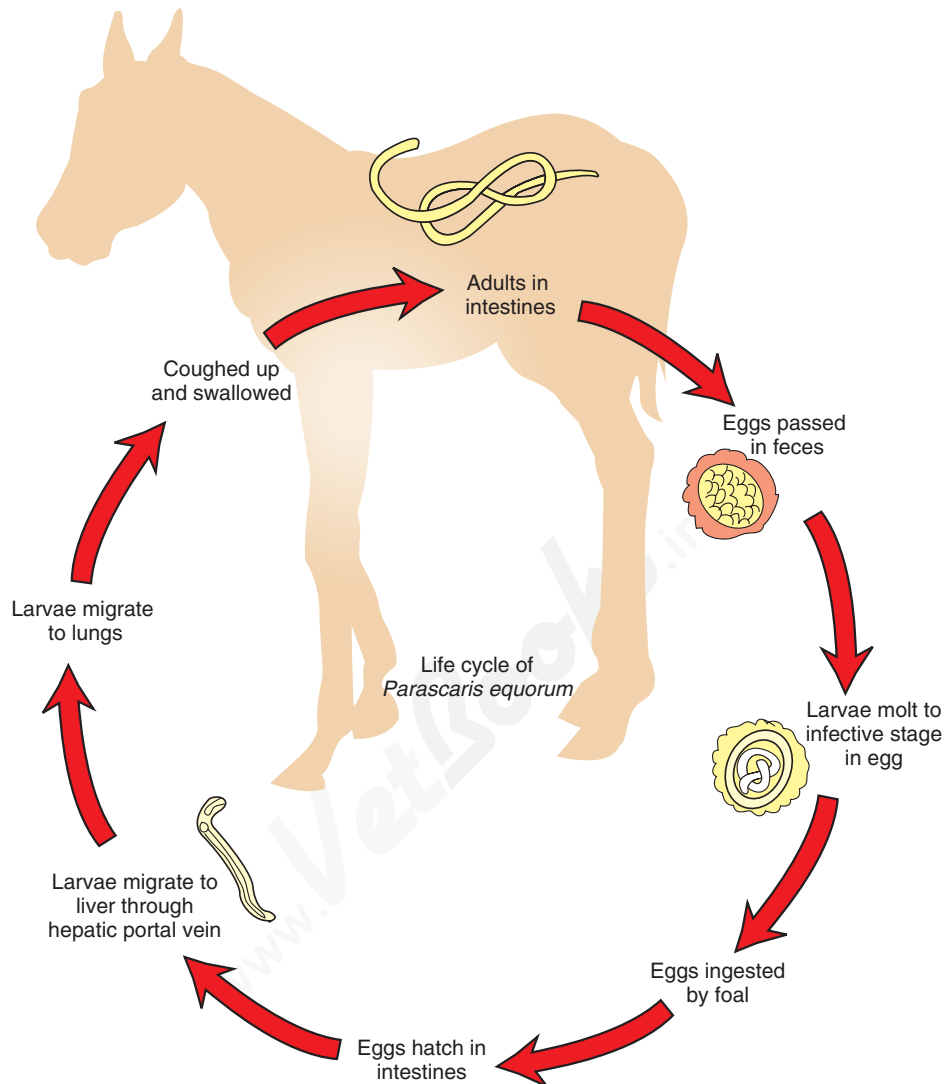


Fig. 4.60 Life cycle of *Parascaris equorum*.

identical. Identification to the species level is accomplished by fecal culture and identification of larvae. Strongyle eggs are most often observed during standard fecal flotation of horse feces. The eggs contain an 8- to 16-cell morula and measure approximately 70 to $90\ \mu\text{m} \times 40$ to $50\ \mu\text{m}$. In addition, the life cycles of the strongyles are very similar. The eggs are passed in the feces and hatch in the environment. The infective-stage larvae migrate up and down blades of grass until the equine host ingests the larvae. The larvae are swallowed and migrate through the intestines to the mesenteric arteries and the liver, where they grow and molt to the next larval stage. The larvae migrate back toward the

large intestine and grow and molt on their way. Once in the large intestine, the larvae enter the mucosa of the large intestine and mature to adults (Fig. 4.65, large strongyles, and Fig. 4.66, small strongyles). When these characteristic eggs are found on fecal flotation, the veterinary diagnostician should record their presence as a "strongyle type of egg" rather than trying to identify a particular species of large or small strongyles.

Clinical signs of a strongyle infection include colic, weight loss, lethargy, fever, and poor appetite. Most of the signs are related to the migration of the larvae through the mesenteric arteries and liver. The most common



Fig. 4.61 The distinctive lips of the adult *Parascaris equorum*. (From Bowman DD: *Georgis' parasitology for veterinarians*, ed 10, St Louis, 2013, Elsevier.)

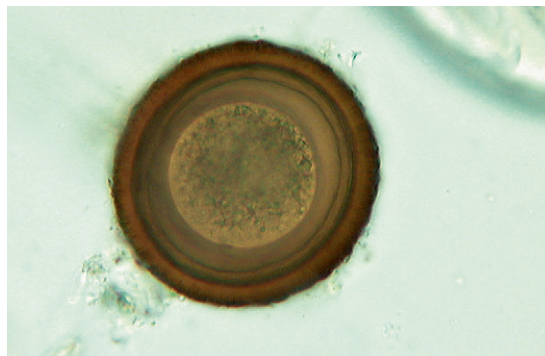


Fig. 4.62 Egg of *Parascaris equorum*. Eggs are recovered from the feces of young horses and are round to oval and deeply pigmented. The shell is thickened, with a finely granular surface.

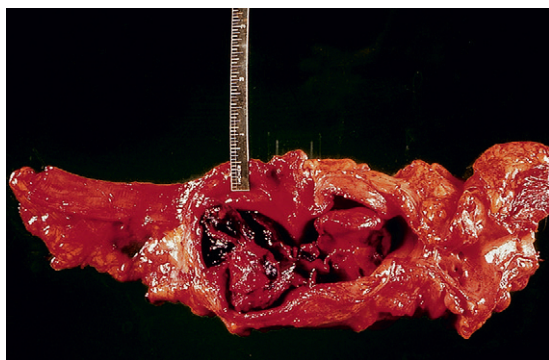


Fig. 4.63 *Strongylus vulgaris* is often associated with thrombi in the anterior mesenteric artery of horses.

anthelmintics include fenbendazole, oxfendazole, thiabendazole, and ivermectin. Preventive measures include pasture management, a good deworming program, and routine fecal examinations.

Technician's Note



Most of the damage associated with strongyle infections is caused by the migration of larvae through the mesenteric arteries and liver.

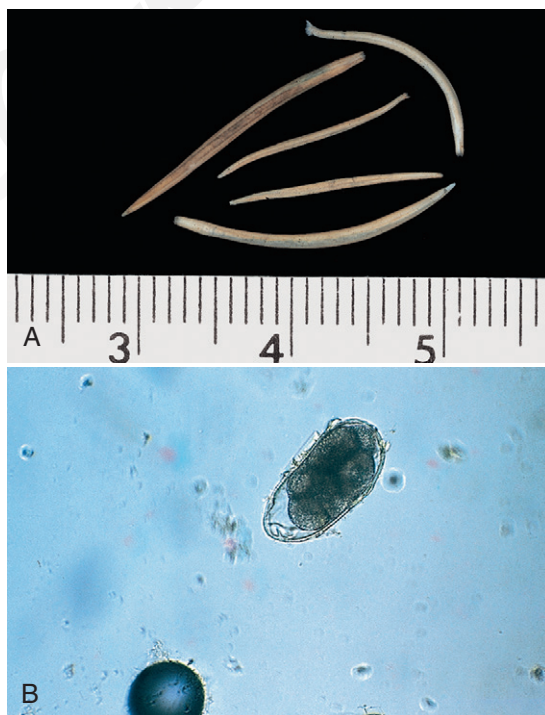


Fig. 4.64 Strongyles are nematodes that parasitize the large intestine of horses and are typically divided into two types, large strongyles and small strongyles. **A**, Small strongyles comprise several genera that vary in pathogenicity. **B**, Large strongyles are the most pathogenic. Both large and small strongyles produce the typical strongyle type of egg.

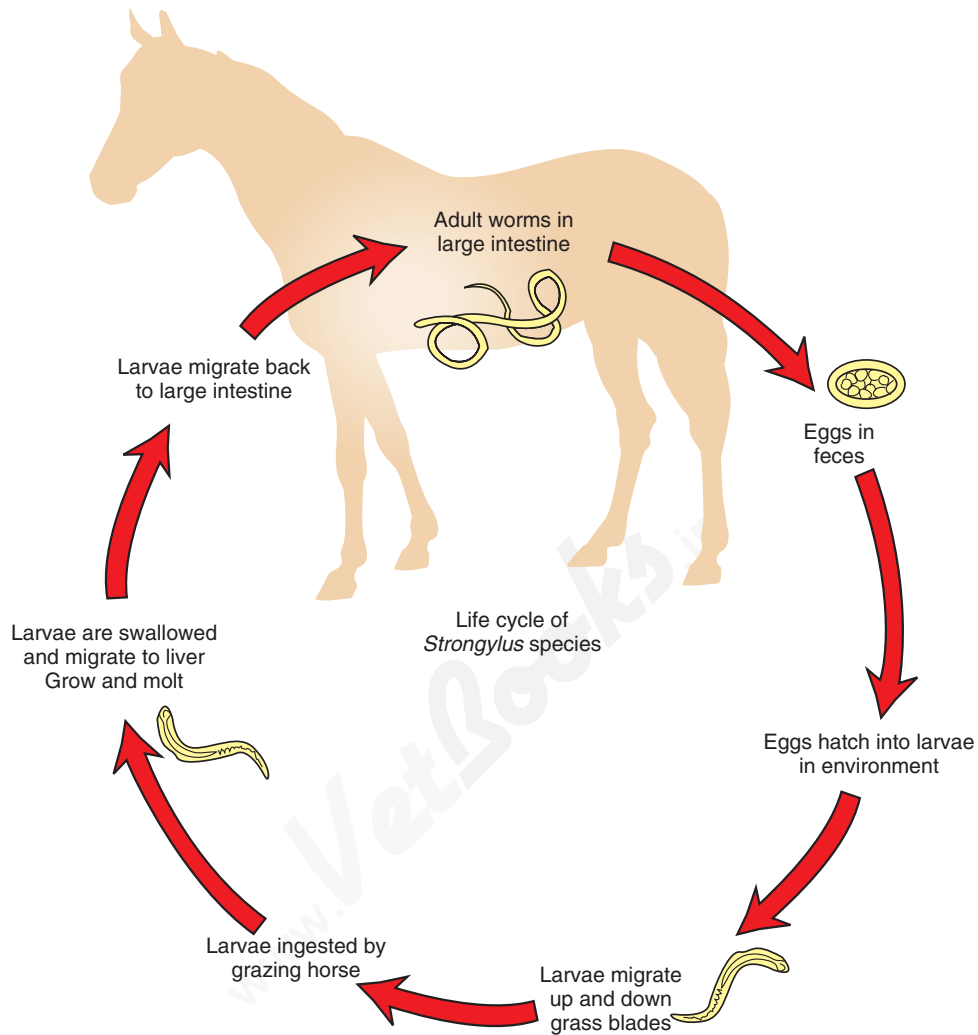


Fig. 4.65 Life cycle of the large strongyle species.

Parasite: *Strongyloides westeri*

Host: Horses

Location of Adult: Small intestine

Distribution: Worldwide

Derivation of Genus: Round-like shape

Transmission Route: Transmammary through colostrum and larval penetration through the skin

Common Name: Intestinal threadworm of horses

Zoonotic: No

Strongyloides westeri is the intestinal threadworm of horses, residing in the small intestine. These nematodes are unique in that only a parthenogenetic female is parasitic in

the host. Parasitic males do not exist. The female parasitic worm has a near-cylindric esophagus that is one-quarter the length of the body (see Fig. 4.15). *S. westeri* produces larvated eggs measuring 40 to $52\ \mu\text{m} \times 32$ to $40\ \mu\text{m}$. The mare can transmit the parasite to the foal through the colostrum. Larvae are able to enter the host through the skin or percutaneously. Eggs are usually recovered on flotation of fresh feces. The prepatent period is 5 to 7 days (see Fig. 4.15). The clinical symptoms include diarrhea, weight loss, anemia, and poor appetite related to the adult feeding on the host's blood. A good deworming program for the mare and foal with oxibendazole, thiabendazole, or ivermectin helps control the parasite.

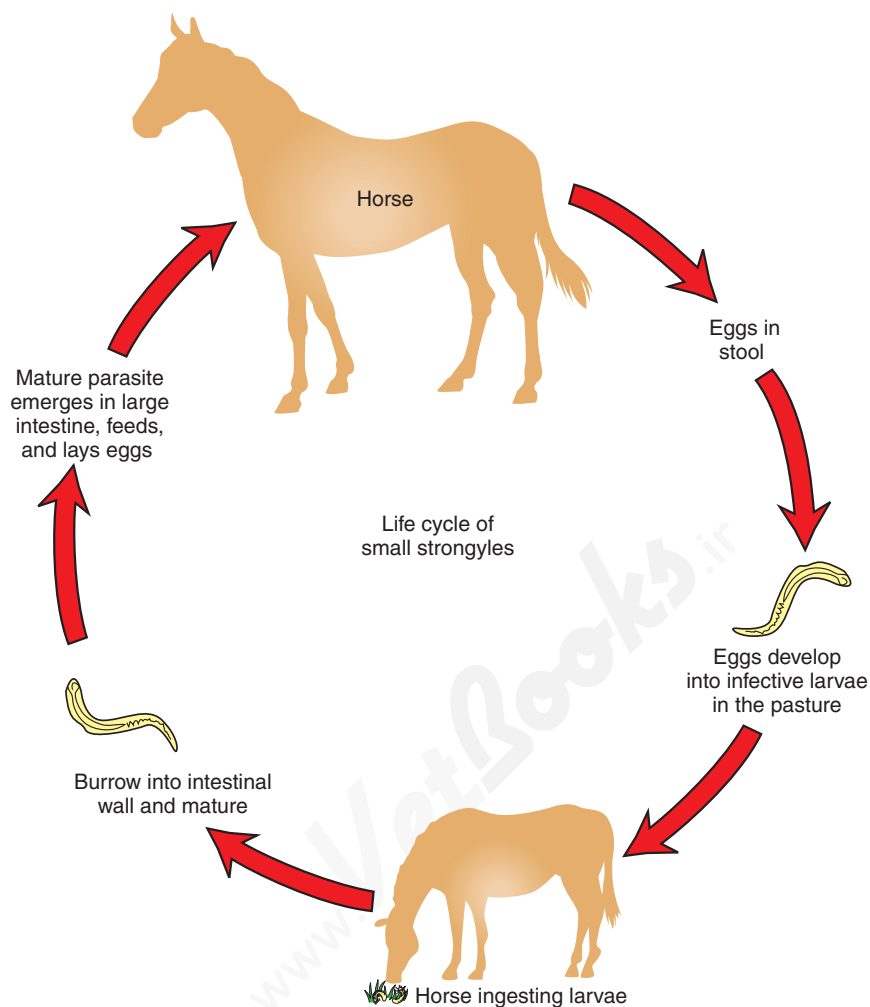


Fig. 4.66 Life cycle of the small strongyle species.

Technician's Note



The parthogenetic female is the only parasitic form of *Strongyloides westeri*. There are no parasitic males.

Parasite: *Oxyuris equi*

Host: Horses

Location of Adult: Cecum, colon, and rectum

Distribution: Worldwide

Derivation of Genus: Sharp tail

Transmission Route: Ingestion of infective ova

Common Name: Pinworm of horses

Zoonotic: No

Oxyuris equi is a pinworm of horses. The adult worms are found in the cecum, colon, and rectum. Adult worms are often observed protruding from the anus. Adult female worms attach their eggs to the exterior of the anus with a gelatinous, sticky material that produces inflammation and anal pruritus in infected horses. The eggs can be rubbed off the anus onto waterers, feeders, and fences, where the eggs can be ingested by the same host or a new host. Pinworm eggs can also be recovered from the feces; eggs are $90 \times 40 \mu\text{m}$ and have a smooth, thick shell. They are operculate and slightly flattened on one side. Pinworm eggs may be larvated (Fig. 4.67). The prepatent period is approximately 4 to 5 months.

Diagnosis of pinworms in horses is made by finding the characteristic eggs on microscopic examination of cellophane tape impressions or by scraping the surface of the



Fig. 4.67 Egg of *Oxyuris equi*, the equine pinworm. Eggs are operculate and slightly flattened on one side. Pinworm eggs may be larvated.

anus. The pruritus produced often causes the horse to rub its rump against solid objects to relieve the itching. As a result, hairs in the region of the tail head are often broken. A good deworming program with oxibendazole, thiabendazole, or ivermectin and thoroughly washing the anus of infected horses will help control the spread of *O. equi*.

Technician's Note

The female *Oxyuris equi* attaches her eggs to the anus of the horse rather than laying them within the intestine; thus it is rare to find ova on a fecal flotation test.

Respiratory System

Parasite: *Dictyocaulus arnfieldi*

Host: Donkeys (the preferred host), horses, and mules

Location of Adult: Bronchi and bronchioles

Distribution: Worldwide

Derivation of Genus: Net-like stalk

Transmission Route: Ingestion of larvae

Common Name: Equine lungworm

Zoonotic: No

Dictyocaulus arnfieldi, the equine lungworm, is found in the bronchi and bronchioles of horses, mules, and donkeys. The adults can cause obstruction of the bronchi and bronchioles. The eggs are ellipsoidal and embryonated and measure approximately 80 to 100 μm $\times$ 50 to 60 μm . Eggs can be recovered on fecal flotation of fresh feces (less than 24 hours old). Larvae hatch from the eggs within a few hours after feces are passed to the outside. The lungworm larvae become infective in the external environment; horses become infected by ingesting the larvae. The larvae migrate to the bronchi through lymphatic vessels. The prepatent period for

the equine lungworm is 42 to 56 days. The ova or larvae can be found on standard fecal flotation. The common anthelmintics (thiabendazole, fenbendazole, ivermectin) used in a good deworming program will also treat *D. arnfieldi*.

Technician's Note

The larvae of *Dictyocaulus arnfieldi* hatch from the ova within hours of being defecated.

Skin

Parasite: *Habronema microstoma*, *Habronema muscae*, and *Draschia megastoma*

Host: Horses

Location of Adult: Stomach mucosa

Distribution: Worldwide

Intermediate Host: Muscid flies

Derivation of Genus: Delicate thread (*Habronema*), worm named for Dr. Drasch

Transmission Route: Deposition of infected larvae into skin wounds by Muscid flies

Common Name: Cutaneous habronemiasis, cutaneous draschiasis, summer sores

Zoonotic: No

Adult *Habronema* species that occur in horses are gastrointestinal nematodes (see earlier discussion). The adults never parasitize the skin; however, the larval stages can be deposited by flies (*Musca domestica*) onto the skin wounds of horses. Here the larvae are aberrant, or "off course," and produce a condition known as **cutaneous habronemiasis**, **cutaneous draschiasis**, or **summer sores**. The lesions vary in size and have an uneven surface that consists of a soft, reddish-brown material and covers a mass of firmer granulation tissue. These lesions are seen on the parts of the body likely to be injured, such as the legs, withers, male genitalia, and medial canthus of the eye (Fig. 4.68). These wounds tend to increase in size and do not respond to usual treatment until the following winter, when they spontaneously heal.

Diagnosis of cutaneous habronemiasis is based on clinical signs and skin biopsies, which may reveal cross sections or longitudinal sections of these aberrant larvae.

Technician's Note

Summer sores are caused by *Habronema* species and by *Draschia* species becoming aberrant when the larvae are deposited in skin wounds by flies that carry the larval stage of the parasites.



Fig. 4.68 Lesions of cutaneous habronemiasis (cutaneous draschiasis, or summer sores) vary in size and have an uneven surface that consists of soft, reddish-brown material and covers a mass of firmer granulation tissue. Lesions are seen on body parts that are likely to be injured, such as the legs, withers, male genitalia, and medial canthus of the eye.

Parasite: *Onchocerca cervicalis*

Host: Horses

Location of Adult: Ligamentum nuchae; microfilariae are found in the dermis

Intermediate Host: Biting midges of the *Culicoides* species

Distribution: Worldwide

Derivation of Genus: Tumor tail

Transmission Route: Bite by infective *Culicoides* species, no-see-ums

Common Name: Equine filarial worm

Zoonotic: No

The microfilariae of *Onchocerca cervicalis*, the equine filarial parasite, produce recurrent dermatitis and periodic ophthalmia in horses. The adults live in the ligamentum nuchae of horses. The female worms produce microfilariae that migrate to the dermis through connective tissue. This parasite is spread by the biting midges of *Culicoides* species. The flies feed on host blood and ingest the microfilariae, which develop to the infective third stage within the fly. When the fly bites another horse, larvae are injected into the connective tissue and develop to adults during migration to the ligamentum nuchae.

The microfilariae produce the characteristic lesions of **cutaneous onchocerciasis** as a result of the inflammation they cause: patchy alopecia and scaling on the head, neck, shoulders, and ventral midline that may be accompanied by intense pruritus.

Many infected horses are asymptomatic. Microfilariae of *Onchocerca* concentrate in certain areas, most often along the ventral midline. Because more than 90% of normal hosts are probably infected with *O. cervicalis*, detection of microfilariae in the skin of the ventral

midline is not diagnostic for cutaneous onchocerciasis. However, the presence of microfilariae in diseased skin is highly indicative of, although not diagnostic of, cutaneous onchocerciasis.

Technician's Note



Cutaneous onchocerciasis is caused by the inflammation of the microfilariae within the skin. The inflammation causes patchy alopecia and scaling on the head, neck, shoulders, and ventral midline, which may be accompanied by intense pruritus.

Onchocerca microfilariae may be demonstrated by the following procedure. After clipping and a surgical scrub, a 6-mm punch biopsy specimen is obtained (see Chapter 17). With a single-edged razor blade or scalpel blade, half the tissue is minced in a small amount of preservative-free physiologic saline on a glass slide and allowed to stand for 5 to 10 minutes. Drying of the specimen is prevented by placing the slide in a covered chamber with a small amount of saline. The slide is then examined under a low-power (10×) objective on the microscope. Because the translucent microfilariae are difficult to observe, low-intensity light and high contrast (achieved by lowering the condenser) are essential. Live microfilariae are identified by the vigorous swimming activity at the edge of the tissue. *O. cervicalis* microfilariae are slender and 207 to 240 μm long. The other half of the biopsy should be submitted for routine histopathologic examination.

The unsheathed microfilariae of *O. cervicalis* have been incriminated in causing periodic ophthalmia and blindness in the eyes of horses. These may be detected by ophthalmic examination.

Technician's Note



Onchocerca cervicalis can be diagnosed by taking a biopsy of the infected skin lesion, mincing the biopsy tissue, and placing half of the sample in physiologic saline on a glass slide to identify the microfilariae.

Eye and Adnexa

Parasite: *Thelazia lacrymalis*

Host: Horse

Location of Adult: Conjunctival sac and lacrimal duct

Distribution: Worldwide

Intermediate Host: *Musca autumnalis*

Derivation of Genus: Nipple saliva

Transmission Route: Infective larvae deposited near the eyes when intermediate host, *M. autumnalis*, defecates after feeding on tears

Common Name: Eyeworm of the horse

Zoonotic: No

Thelazia lacrymalis is the eyeworm of horses throughout the world. Adult parasites can be recovered from the conjunctival sac and lacrimal duct, where they can cause obstruction of the lacrimal ducts. Examination of the lacrimal secretions may reveal eggs or first-stage larvae.

Abdominal Cavity

Parasite: *Setaria equina*

Host: Horses

Location of Adult: Free within the peritoneal cavity

Distribution: Europe and North America

Intermediate Host: Mosquito

Derivation of Genus: Bristle

Transmission Route: Bite by infective mosquito

Common Name: Abdominal worm of horses

Zoonotic: No

Setaria equina is the abdominal worm of horses. Adults are large white worms and are found free within the peritoneal cavity. The sheathed microfilariae are 240 to 256 μm long. Antemortem diagnosis is by demonstration of microfilariae in peripheral blood smears. Adults may be observed freely within the peritoneal cavity during postmortem examination. The primary cause of pathology is migration of the larvae from the insertion point to the abdominal cavity.

Technician's Note

Adults of *Setaria equina* may be found free within the peritoneal cavity during abdominal surgery.

Nematodes of Swine

Gastrointestinal Tract

Parasite: *Ascarops strongylina* and *Physocephalus sexalatus*

Host: Pigs

Location of Adult: Stomach

Distribution: Worldwide

Intermediate Host: Beetle

Derivation of Genus: *Ascarops*—late worm;

Physocephalus—air head

Transmission Route: Ingestion of infective beetle

Common Name: Stomach worms of pigs

Zoonotic: No

Ascarops strongylina and *Physocephalus sexalatus* are the thick worms of the porcine stomach, where the adults suck the host's blood. Both nematodes produce thick-walled, larvated eggs that can be recovered on fecal flotation. The eggs of both species are similar in appearance. The egg of *A. strongylina* is 34 to 39 μm $\times$ 20 μm and has a thick shell surrounded by a thin membrane, producing an irregular outline (Fig. 4.69). The egg of *P. sexalatus* is 34 to 39 μm $\times$ 15 to 17 μm . The larvated egg is ingested by a beetle and develops into an infective larva. The beetle is then ingested by the pig. The prepatent period for both species is approximately 42 days. Diagnosis is by observation of typical eggs on routine fecal flotation. Clinical signs include anemia, diarrhea, and weight loss. Anthelmintics used for treating *A. strongylina* and *P. sexalatus* are ivermectin, fenbendazole, thiabendazole, and oxfendazole.

Technician's Note

The stomach worms of the pig require a beetle as intermediate host.

Parasite: *Hyostrongylus rubidus*

Host: Pigs

Location of Adult: Stomach

Distribution: Worldwide

Derivation of Genus: U shaped and round

Transmission Route: Ingestion of infective ova

Common Name: Red stomach worm of pigs

Zoonotic: No



Fig. 4.69 Egg of *Ascarops strongylina* is 34 to 39 μm $\times$ 20 μm and has a thick shell surrounded by a thin membrane that produces an irregular outline.

Hyoststrongylus rubidus is the red stomach worm of swine. The egg is a trichostrongyle type of egg that is oval and thin shelled. It contains a morula with four or more cells and measures 71 to 78 μm $\times$ 35 to 42 μm . These eggs can be recovered on fecal flotation. As with the bovine trichostrongyles, definitive diagnosis can be made only by fecal culture and larval identification. The prepatent period is approximately 20 days. Clinical signs include dehydration, weight loss, diarrhea, and anemia related to the adult sucking the host's blood. Deworming with benzimidazoles (fenbendazole, thiabendazole, oxbendazole) and ivermectin controls the parasite.

Technician's Note



Hyoststrongylus rubidus, or the red stomach worm of pigs, produces a trichostrongyle type of egg that contains a morula with four or more cells. It can be found on fecal flotation, but only a fecal culture and larval identification can provide a definitive diagnosis of specific genus and species.

Parasite: ♦ *Trichostrongylus axei*

Host: Horses, sheep, cattle, and pigs

Location of Adult: Stomach

Distribution: Worldwide

Derivation of Genus: Hair round

Transmission Route: Ingestion of ova

Common Name: Stomach worm of horses, cattle, sheep, and pigs

Zoonotic: Yes but not common (per CDC)

Trichostrongylus axei is another species of nematode that may reside in the stomach of pigs and suck blood. It is important to remember that *T. axei* can cross species lines and also parasitize cattle, sheep, and horses. The eggs of *T. axei* are classified as the trichostrongyle type and measure 79 to 92 μm $\times$ 31 to 41 μm . As with bovine trichostrongyles, definitive diagnosis can be made only by fecal culture and larval identification. Benzimidazoles are the anthelmintics of choice. Diagnosis of trichostrongyle ova can be made with a standard fecal flotation technique.

Parasite: *Ascaris suum*

Host: Pigs

Location of Adult: Small intestine

Distribution: Worldwide

Derivation of Genus: Worm

Transmission Route: Ingestion of infective ova

Common Name: Swine ascarid or large intestinal roundworm of pigs

Zoonotic: No

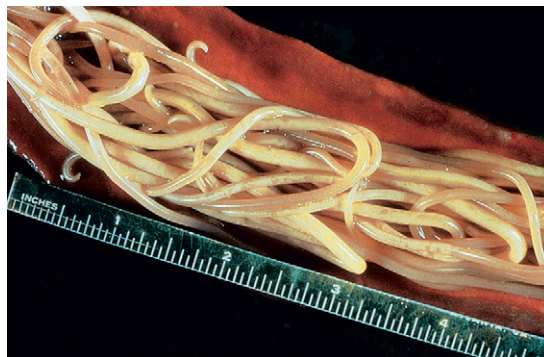


Fig. 4.70 *Ascaris suum*, the swine ascarid or large intestinal roundworm, is the largest nematode found within the small intestine of pigs.

Ascaris suum, the swine ascarid or large intestinal roundworm, is the largest nematode found in the small intestine of pigs (Fig. 4.70). It may attain a length of 41 cm and can be as wide as 5 mm. Large numbers of these worms can cause intestinal obstruction. These large, robust nematodes may also be passed in feces. They produce eggs that are passed in the feces and hatch in the environment. The larvae grow to infective larvae within the eggs, which are ingested by the pig. The larvae hatch and migrate to the liver, where they grow to the next larval stage. The larvae migrate through the circulatory system to the lungs and the bronchial tree, where they are swallowed. Once in the intestines, the larvae mature into adults.

Technician's Note



Ascaris suum is the largest nematode found in the pig; the ova can be found on standard fecal flotation.

Eggs of *A. suum* can be recovered on standard fecal flotation. They are oval and golden brown with a thick, albuminous shell bearing prominent projections that give a lumpy, bumpy appearance. The eggs measure 70 to 89 μm $\times$ 37 to 40 μm (Fig. 4.71). *A. suum* can cause a reduced growth rate, weight loss, unthriftiness, and respiratory symptoms (coughing, abdominal breathing, or **thumps**). Benzimidazoles, levamisole, ivermectin, pyrantel, piperazine, and hygroscopicin (a feed-additive dewormer) are the anthelmintics of choice.

Parasite: *Strongyloides ransomi*

Host: Pigs

Location of Adult: Small intestine

Distribution: Worldwide

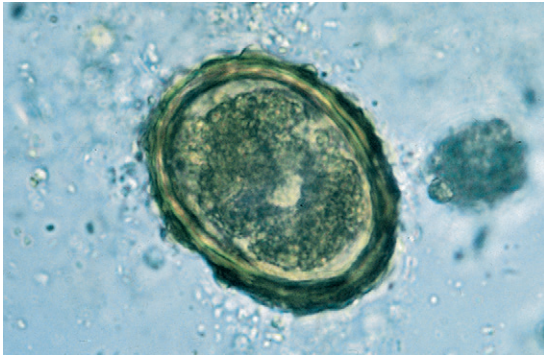


Fig. 4.71 Eggs of *Ascaris suum* can be recovered on standard fecal flotation. Eggs are oval and golden brown with a thick, aluminous shell bearing prominent projections that give a lumpy, bumpy appearance.

Derivation of Genus: Round-like

Transmission Route: Transmammary (through the colostrum), percutaneous

Common Name: Intestinal threadworm of pigs

Zoonotic: No

Strongyloides ransomi, the intestinal threadworm of pigs, is unique in that only a parthenogenetic female is parasitic in the host. Parasitic males do not exist. These females produce larvated eggs measuring 45 to $55\ \mu\text{m} \times 26$ to $35\ \mu\text{m}$. Eggs are usually recovered in the flotation of fresh feces. The life cycle of *S. ransomi* closely resembles that of *S. papillosus*. Transmission can occur through the colostrum. The prepatent period is 3 to 7 days (see Fig. 4.15). *S. ransomi* can produce diarrhea, anemia, and weight loss in the host as the parasite sucks its blood. Anthelmintics of choice are the benzimidazoles and ivermectin.

Technician's Note

Strongyloides ransomi is the intestinal threadworm of pigs; only the female is parasitic, and the larvae can enter a host through the skin or in the colostrum.

Parasite: *Oesophagostomum dentatum*

Host: Pigs

Location of Adult: Large intestine

Distribution: Worldwide

Derivation of Genus: Esophagus mouth; carry food mouth

Transmission Route: Ingestion of infective larvae

Common Name: Nodular worm of pigs

Zoonotic: No

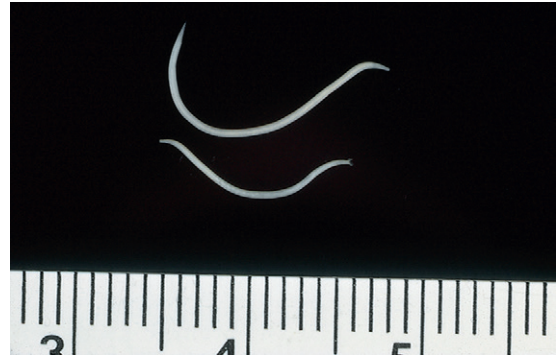


Fig. 4.72 *Oesophagostomum dentatum*, the nodular worm of swine, is found in the large intestine of swine.

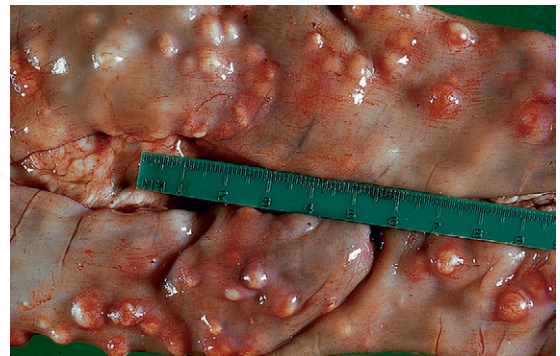


Fig. 4.73 *Oesophagostomum dentatum* is called the *nodular worm* of swine because its larval stages induce the formation of large nodules within the wall of the large intestine.

Oesophagostomum dentatum, the nodular worm of swine, is found in the large intestine of swine (Fig. 4.72). It is called the *nodular worm* because its larval stages induce the formation of large nodules within the wall of the large intestine, which can cause intestinal disturbance and obstruction (Fig. 4.73). The prepatent period is 50 days. The eggs of *O. dentatum* are of the trichostrongyle type, that is, oval, thin-shelled eggs. They contain 4 to 16 cells and measure $40 \times 70\ \mu\text{m}$. These eggs can be recovered on standard fecal flotation. As with the bovine trichostrongyles, definitive diagnosis can be made only by fecal culture and larval identification. The parasite can cause anorexia, diarrhea, weight loss, and gastrointestinal disturbances in the host. Benzimidazoles, ivermectin, levamisole, piperazine, and pyrantel are the anthelmintics of choice.

Technician's Note

The nodules formed by the third-stage larvae of *O. dentatum* in the large intestine cause intestinal disturbances and can cause a mechanical obstruction of the intestinal tract.

Parasite: *Trichuris suis*

Host: Pigs

Location of Adult: Cecum and colon

Distribution: Worldwide

Derivation of Genus: Hair tail

Transmission Route: Ingestion of infective ova

Common Name: Whipworm of pigs

Zoonotic: No

Trichuris suis, commonly called *whipworms*, infect the cecum and colon of swine. (See the previous discussion of nematodes of dogs and cats for gross morphology of adult worms and life cycle.) The egg of the whipworm is trichuroid or trichinelloid and has a thick, brown, barrel shaped shell with polar plugs at both ends (see Fig. 4.17). The eggs are unembryonated (not larvated) when laid. The eggs of porcine whipworms measure 50 to 60 μm $\times$ 21 to 25 μm . The prepatent period is 42 to 49 days. Common symptoms seen in the host are anemia, bloody diarrhea, anorexia, and stunted growth related to the adult attaching to the intestinal wall and sucking the host's blood. Levamisole, dichlorvos, and fenbendazole are the anthelmintics of choice.

Technician's Note

The life cycle and appearance of whipworms in pigs is similar to dogs and cats. The thin end of the adult was once thought to be the tail of the worm rather than the head.

Parasite: $\diamond$ *Trichinella spiralis*

Host: Pigs can serve as both definitive and intermediate hosts.

Location of Adult: Small intestine

Distribution: Worldwide but does not occur in Australia or Denmark

Derivation of Name: Small hair

Transmission Route: Ingestion of contaminated raw and undercooked meat, usually pork

Common Name: Trichina worm

Zoonotic: Yes

The adult *Trichinella spiralis*, the "trichina worm," is found in the small intestine of the porcine definitive host. The adult worm is very fine and slender. The female is very

tiny, only 4 mm in length; the male is even smaller. This stage is seldom recovered by the veterinarian. The egg is larvated and measures 30 $\times$ 40 μm . (See the discussion under musculoskeletal system for the larval stage in the porcine intermediate host.) *T. spiralis* is a very unusual parasite because the definitive host and the intermediate host may be the same animal. *T. spiralis* can be passed to humans in undercooked pork (see Chapter 16). Most animal hosts are **asymptomatic** (showing no symptoms); however, because larvae encyst in muscle tissue, they can cause damage to the muscle by their encysted presence.

Technician's Note

Although *Trichinella spiralis* $\diamond$ does not typically cause symptoms in the definitive host, it does cause problems in human muscles. The only test that can be used for diagnosis in the intermediate host is a biopsy of the muscle tissue for encysted larvae.

Respiratory Tract

Parasite: *Metastrongylus elongatus*

Host: Pigs

Location of Adult: Bronchi and bronchioles

Intermediate Host: Earthworm

Distribution: Worldwide

Derivation of Genus: After round

Transmission Route: Ingestion of infective earthworm

Common Name: Swine lungworm

Zoonotic: No

Metastrongylus elongatus, the swine lungworm, is found within the bronchi and bronchioles of pigs. The oval, thick-walled eggs measure 60 $\times$ 40 μm and contain larvae (Fig. 4.74). Eggs can be recovered on fecal flotation using a



Fig. 4.74 *Metastrongylus elongatus* (apri), the swine lungworm, is found in the bronchi and bronchioles of pigs. Oval, thick-walled eggs measure 60 $\times$ 40 μm and contain larvae.

flotation medium with a specific gravity greater than 1.25 or by using the fecal sedimentation technique. The prepatent period is approximately 24 days. *M. elongatus* uses the earthworm as an intermediate host. Therefore, control of earthworms in the pig's environment will help eliminate this parasite. Control may include keeping pigs on concrete rather than pasture or dirt. Infected pigs may have a persistent cough, reduced growth rate, and unthriftiness as a result of partial obstructions in the airways. Infected pigs can be treated with fenbendazole, ivermectin, or levamisole.

Technician's Note



Fecal flotation with a solution having a specific gravity greater than 1.25 and the fecal sedimentation technique are the best ways to diagnose swine lungworm using feces.

Urinary Tract

Parasite: *Stephanurus dentatus*

Host: Pigs

Location of Adult: Cystic spaces connected to the kidneys, ureters, and perirenal tissue

Intermediate Host: Earthworm

Distribution: Tropical and subtropical regions

Derivation of Genus: Encircling the urinary system

Transmission Route: Ingestion of infective intermediate host, earthworm, or percutaneous

Common Name: Swine kidney worm

Zoonotic: No

Stephanurus dentatus, the swine kidney worm, is found in cystic spaces that connect to the kidney, ureters, and perirenal tissues of pigs (Fig. 4.75). The eggs are the oval, thin-shelled strongyle type containing 4 to 16 cells and measuring 90 to 120 μm $\times$ 43 to 70 μm . Eggs can be recovered from the urine using sedimentation (Fig. 4.76). The prepatent period is extremely long, approximately 9 to 24 months. *S. dentatus* can use the earthworm as an intermediate host, or the infective larvae can enter the pig directly through the skin. Infected pigs may show signs of anorexia, decreased growth rate, and weight loss. Much of the damage caused by the parasite comes from the migration of larvae to the cystic spaces around the kidneys, ureters, and perirenal tissues. Anthelmintics of choice include fenbendazole, levamisole, and ivermectin.

Technician's Note



Stephanurus dentatus can have a direct life cycle by entering the host through the skin, or it can have an indirect life cycle by using an intermediate host, the earthworm.



Fig. 4.75 *Stephanurus dentatus*, the swine kidney worm, is found in cystic spaces that connect to the kidney, ureters, and perirenal tissues of pigs.



Fig. 4.76 Eggs of *Stephanurus dentatus* are of the strongyle type, that is, oval, thin-shelled eggs. They contain 4 to 16 cells and measure 90 to 120 μm $\times$ 43 to 70 μm . Eggs can be recovered from urine using sedimentation.

Musculoskeletal System

Parasite: ❖ *Trichinella spiralis*

Host: Pigs are the definitive host.

Location of Adult: Small intestine

Distribution: Worldwide but does not occur in Australia or Denmark

Derivation of Name: Small hairs

Transmission Route: Ingestion of contaminated raw and undercooked meat

Common Name: Trichina worm

Zoonotic: Yes

The larval form of *T. spiralis*, the trichina worm, is found in the musculature of the porcine intermediate host. The adult worm is very fine and slender and is found within the small intestine. The larval *T. spiralis* is found in striated muscle

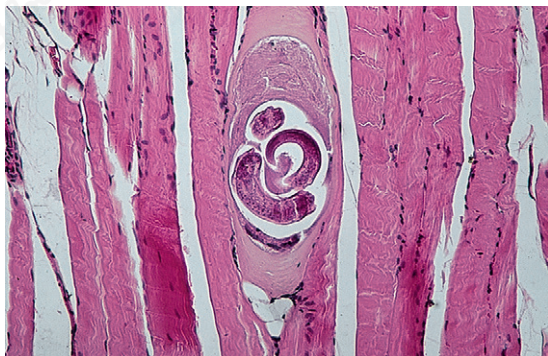


Fig. 4.77 Muscle biopsy specimen revealing the larval form of *Trichinella spiralis*, the trichina worm, found in the musculature of the porcine intermediate host. Larvae measure approximately 1 mm in length and are found in cystic spaces in the musculature.

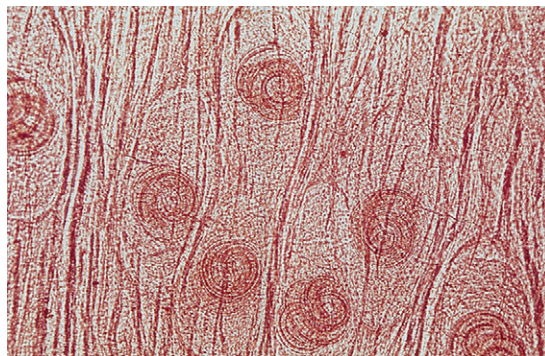


Fig. 4.78 Histopathologic section revealing the larval form of *Trichinella spiralis*, the trichina worm, found in the musculature of the porcine intermediate host.

fibers. It measures approximately 1 mm in length and is found in cystic spaces within the musculature (Figs. 4.77 and 4.78). The cyst measures 0.4 to 0.6 mm $\times$ 0.25 mm. In chronic cases, the cyst may become calcified. (See the discussion under Gastrointestinal Tract for the adult stage of this parasite in the definitive host.) Humans may become infected with *T. spiralis*.

Diagnosis of the larval stage of *T. spiralis* is made by performing a biopsy of muscle tissue and demonstrating encysted larvae within the skeletal musculature. As a result of the zoonotic potential for this parasite, pork should always be cooked thoroughly.

Technician's Note



Trichinella spiralis uses the pig as both the intermediate host and the definitive host. It can be passed to other hosts with the ingestion of raw or undercooked pork, thus using the pig as an intermediate host. However, it also uses the pig as the definitive host, reproducing within the pig to continue its life cycle.

Nematodes of Mice

Gastrointestinal Tract

Parasite: *Syphacia obvelata*, *Aspiculuris tetraptera*, and *Syphacia muris*

Host: Mice—*A. tetraptera*; mice, rats, hamsters, and gerbils—*Syphacia* species

Location of Adult: Cecum and rectum

Distribution: Worldwide

Derivation of Genus: *Syphacia*—love together;

Aspiculuris—toward a small tail

Transmission Route: Ingestion of infective ova and retrograde infection

Common Name: Pinworms

Zoonotic: No

Oxyurids, or pinworms, of mice include *Syphacia obvelata*, *Aspiculuris tetraptera*, and to a lesser extent *Syphacia muris*, the common pinworm of rats. Patent *Syphacia* infections can be detected both antemortem and postmortem with the perianal cellophane tape test. The adults of *Syphacia* reside in the cecum of the mouse until the gravid female migrates the length of the colon to deposit a large batch of eggs in the perianal region, at which time the female dies.

Eggs of *A. tetraptera* cannot be detected with the perianal cellophane tape test. *A. tetraptera* adults reside mainly in the proximal loop of the colon of the mouse and do not migrate to deposit eggs on the perianal area, as do *Syphacia* species. Eggs of *A. tetraptera* can be detected antemortem by fecal flotation and occasionally by direct smear examination of feces.

The banana shaped eggs of *S. obvelata* are elongated with pointed ends (Fig. 4.79). They are flat on one side and convex on the other, measuring 118 to 153 μm $\times$ 33 to 55 μm . *S. muris* is found less frequently and in smaller numbers in mice than *S. obvelata*. The more symmetric, football shaped eggs of *S. muris* are smaller than those of *S. obvelata*, measuring only 72 to 82 μm $\times$ 25 to 36 μm , and are blunted or rounded on the ends (Fig. 4.80). When observed on fecal flotation, the eggs of *A. tetraptera* have a thinner shell than the eggs of the *Syphacia* species and do not have a flattened side. *A. tetraptera* eggs are 89 to 93 μm $\times$ 33 to 42 μm , symmetrically ellipsoid, and midway in size between the eggs of the two *Syphacia* species.

Technician's Note

Aspiculuris tetraptera females do not deposit ova on the perianal area as other pinworms do. Therefore the cellophane tape method cannot be used for diagnosis. Instead, standard fecal flotation or direct fecal smear is used to diagnose this species of pinworm.

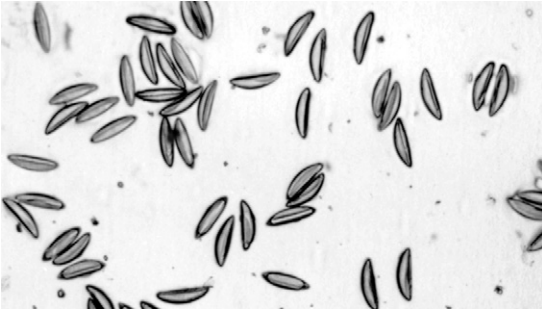


Fig. 4.79 Eggs of *Syphacia obvelata*, the mouse cecal pinworm, as they appear on cellophane tape presentation.

On postmortem examination, pinworms of mice may be detected by placing a small piece of the cecum and proximal loop of the colon in a Petri dish with a small amount of normal saline. Within a few minutes, pinworms may be observed in the saline grossly or with the aid of a handheld magnifying lens or a dissecting microscope (**Fig. 4.81**). The adult pinworms can be collected with a bulb and pipette, applied to a glass slide with a coverslip, and examined microscopically at low magnification (4× objective). *A. tetraptera* is usually recovered from the proximal colon and is easily distinguished from *Syphacia* species by its oval esophageal bulb and prominent cervical ala (**Fig. 4.82, A**). *S. obvelata* and *S. muris* are usually recovered from the cecum. *Syphacia* species have a rounded esophageal bulb and a small cervical ala (see **Fig. 4.82, B**). Additionally, the vulva is in the cranial one-sixth of the body of *S. obvelata* females (see **Fig. 4.82, C**), whereas the vulva of *S. muris* is in the cranial one-fourth of the body (see **Fig. 4.82, B**). Adult males of the two *Syphacia* species can be differentiated by the position of the three ventral mamelons. In males of *S. obvelata*, the middle mamelon is located centrally on the length of the body (see **Fig. 4.86, A**). The first mamelon is at the center of the male in *S. muris* (see **Fig. 4.86, B**). Although differentiation of the adults of the two *Syphacia* species may be

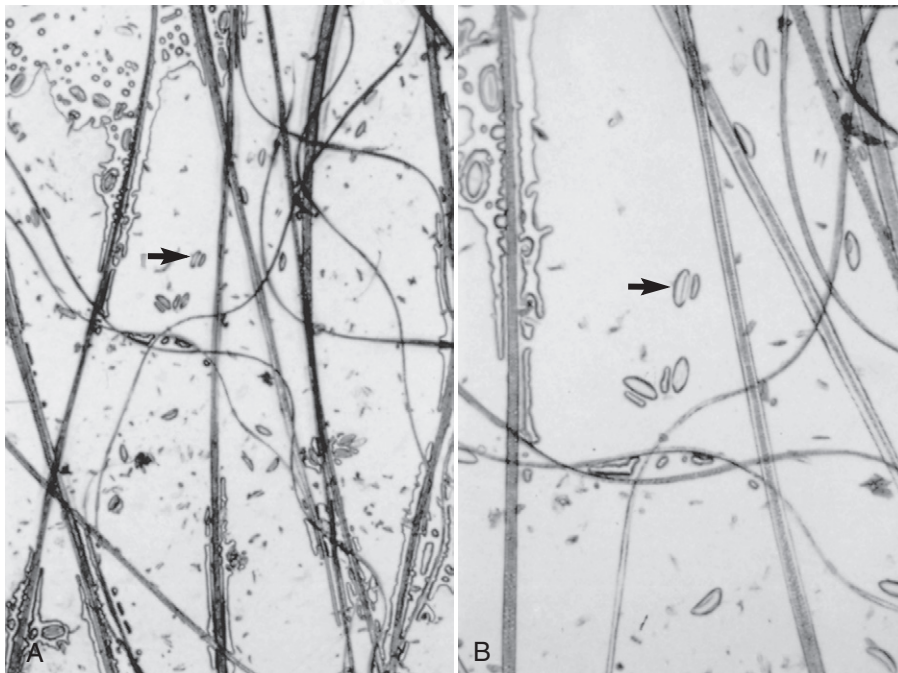


Fig. 4.80 Cellophane tape presentation of *Syphacia muris* eggs viewed at **A**, low magnification, and **B**, medium magnification. The arrow points to the same egg at each magnification. The smaller object to the right of the egg is an artifact.

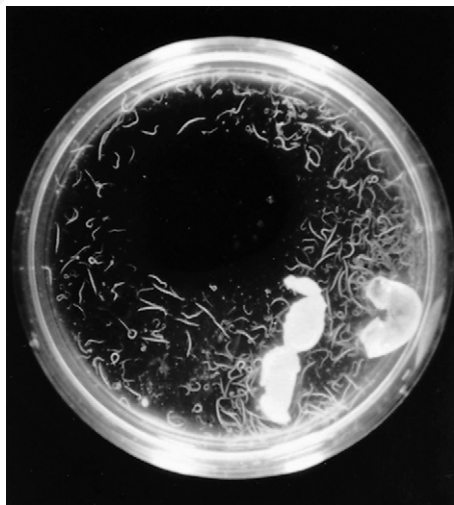


Fig. 4.81 A 2-inch Petri dish containing saline and proximal loops of colon from three mice. White, hair-like objects are *Aspiculuris tetraptera* roundworms that have moved into the saline from colon sections.

difficult and time consuming for veterinary technicians, experienced diagnosticians can easily differentiate the eggs on cellophane tape preparations by size and shape (see Figs 4.79 and 4.80).

In general, mice carry light to medium loads of pinworms without demonstrating clinical signs of infection. However, large numbers of pinworms may lead to rectal prolapse, enteritis, sticky stools, and pruritus, which result in biting at the base of the tail. Symptoms are caused by inflammation related to the female and eggs at the perianal region of the animal.

Pinworms are transmitted by the ingestion of the eggs. The eggs are hardy, resistant to environmental extremes, and light enough to aerosolize, making control difficult. Retrograde infection is also possible with *Syphacia* species. The multispecies owner should be instructed that *Syphacia* species can be easily transmitted among mice, rats, hamsters, and gerbils. *A. tetraptera* has also been diagnosed in rats. Rodent pinworms are not of zoonotic significance.

Technician's Note



Although pinworms are species specific, *Syphacia* species are able to survive and replicate in mice, rats, hamsters, and gerbils because they are all rodent species and are closely related.

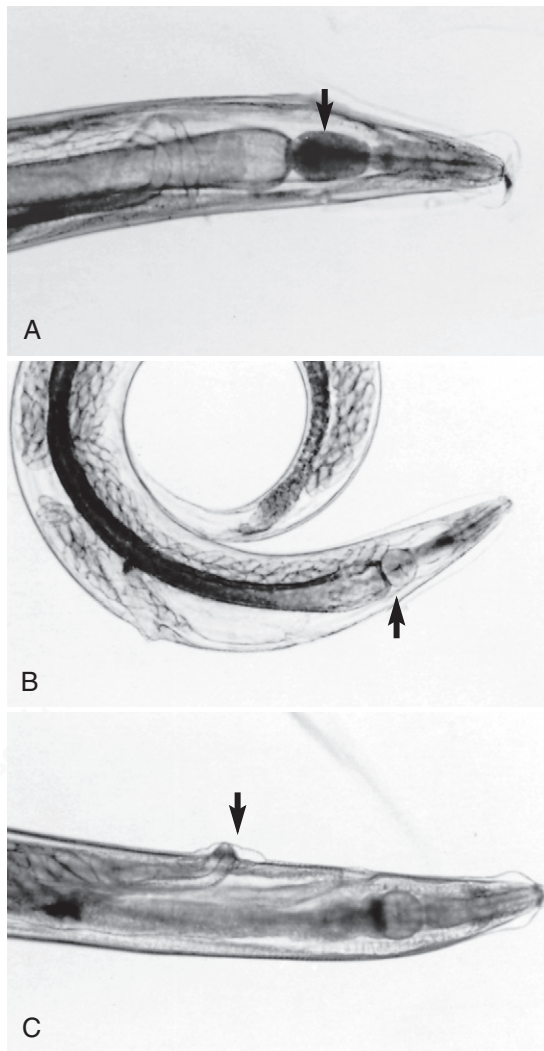


Fig. 4.82 **A**, Cranial end of *Aspiculuris tetraptera* female, showing the oval esophageal bulb (arrow). **B**, *Syphacia muris*, showing the round esophageal bulb (arrow). **C**, Cranial end of *Syphacia obvelata* female (arrow indicates the vulva).

Nematodes of Rats

Gastrointestinal Tract

The three oxyurids, or pinworms, discussed in the previous section (i.e., *S. muris*, *S. obvelata*, and *A. tetraptera*) may also infect rats. *S. muris* is by far the most common pinworm and is often referred to as the *rat pinworm*.

Parasite: *Trichosomoides crassicauda*

Host: Rats

Location of Adult: Urinary bladder

Distribution: Worldwide

Derivation of Genus: Body shaped like a hair

Transmission Route: Ingestion of ova from urine (urinary-oral route)

Common Name: Bladder worm of the rat

Zoonotic: No

Trichosomoides crassicauda is a nematode found in the urinary bladder of rats. The adult female *T. crassicauda* is approximately 10 mm long; it is a thin worm and is grossly visible in the wall of the urinary bladder. This parasite is unique in that the male is **neotenic**. This means that he is very small and resides in the vagina of the immature female and the uterus of the mature female, *T. crassicauda*. The eggs are double operculate and approximately $65 \times 33 \mu\text{m}$ and resemble whipworm eggs, especially those of *Trichuris* species. The main difference between them is that the eggs of *T. crassicauda* are lighter in color, are slightly smaller, and contain a single larva. This parasite has been associated with bladder tumors in rats; however, few clinical signs are associated with infection by *T. crassicauda*, with most damage coming from the presence of the parasite in the bladder wall. Transmission is by the urinary-oral route. This parasite can be a significant problem in rat colonies but can be eliminated by cesarean delivery of neonates. This is a species-specific nematode and is not of zoonotic significance.

Technician's Note

The male urinary bladder worm of rats resides inside the vagina of the immature female or the uterus of the mature female.

Infections with *T. crassicauda* may be diagnosed in three ways: antemortem or postmortem observation of eggs in the urine; gross observation at postmortem of adult worms in the wall or lumen of the urinary bladder; and microscopic observation of the adult worms in histopathologic sections of the urinary bladder, ureters, or renal pelvis.

Nematodes of Hamsters

Gastrointestinal Tract

Hamsters are susceptible to infection with the mouse and rat pinworms *S. obvelata* and *S. muris*, although it is unlikely that hamsters will develop clinically apparent infections (see previous discussion of nematodes of mice).

Nematodes of Gerbils

Gastrointestinal Tract

Parasite: *Dentostomella translucida*

Host: Gerbil

Location of Adult: Stomach and proximal one-third of the small intestine

Distribution: Worldwide

Derivation of Genus: Little tooth in mouth

Transmission Route: Ingestion of infective ova

Common Name: Pinworm of gerbils

Zoonotic: No

Technician's Note

Pinworms are not reported as commonly in gerbils as they are reported in other rodent species.

Dentostomella translucida, the gerbil pinworm, is not reported as frequently as other rodent pinworms (*Syphacia* species and *A. tetraaptera*). This may be the result of a lack of information on its life cycle. Adult male and female nematodes have a short, muscular esophagus. The vulva of the female is located just cranial to the midbody (Fig. 4.83). Males are distinguished by a cuticular inflation just cranial to the cloaca (Fig. 4.84). Adults are 6 to 31 mm long, with the female generally larger than the male, as is true of other rodent pinworms. The eggs of *D. translucida* are asymmetric and oval, measuring 120 to $140 \mu\text{m} \times 30$ to $60 \mu\text{m}$ (Fig. 4.85). They resemble those of *A. tetraaptera*, which are smaller, measuring 89 to $93 \mu\text{m} \times 36$ to $42 \mu\text{m}$.

Fecal flotation may be used to detect eggs of *D. translucida*, but this method is unreliable because of the poorly



Fig. 4.83 Adult female *Dentostomella translucida*.

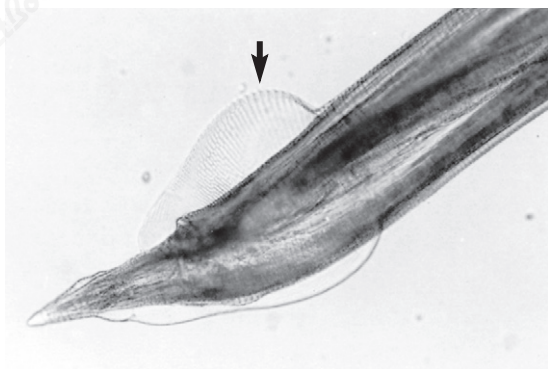


Fig. 4.84 Cuticular inflation (arrow) on the tail of a male *Dentostomella translucida*.



Fig. 4.85 Egg of *Dentostomella translucida* in fecal flotation.

understood life cycle (intermittent shedding of eggs). On postmortem examination, *D. translucida* may be found in the stomach and the proximal one-third of the small intestine.

D. translucida has a direct life cycle and is transmitted by ingestion of infective eggs from feces of infected animals. The parasite has been found in the golden hamster and the gerbil. This parasite has no zoonotic significance.

As with hamsters, gerbils are susceptible to infection with the mouse and rat pinworms *S. obvelata* and *S. muris* (Fig. 4.86; see also Figs. 4.79, 4.80, and 4.81 and previous discussion of nematodes of mice).

Technician's Note



As with other pinworm species, the damage done by *Dentostomella translucida* is most commonly caused by inflammation and irritation.

Nematodes of Guinea Pigs

Gastrointestinal Tract

Parasite: *Paraspidodera uncinata*

Host: Guinea pig

Location of Adult: Cecum and colon

Distribution: Worldwide

Derivation of Genus: Bears a peculiar neck

Transmission Route: Ingestion of infective ova

Common Name: Ascarid of guinea pigs

Zoonotic: No

Paraspidodera uncinata is generally a nonpathogenic nematode of guinea pigs that can be found in cecal contents or

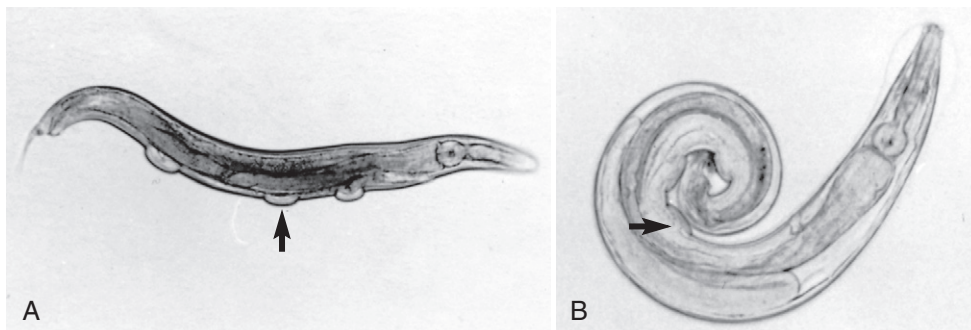


Fig. 4.86 **A**, *Syphacia obvelata* male, showing the middle mamelon (arrow) at the center of the body. **B**, *S. muris* male, showing the first mamelon at midbody (arrow).

in the mucosa of the cecum and colon. Adult worms are 11 to 28 mm $\times$ 0.3 to 0.4 mm. The male of *P. uncinata* has a sucker and two spicules of equal length immediately cranial to the anus. The eggs are oval and have a characteristic thick ascarid shell (Fig. 4.87). The eggs are 40 to 50 μ m $\times$ 30 to 40 μ m. Antemortem, eggs may be detected by fecal flotation or direct fecal smear. Occasionally, extremely heavy infections may cause diarrhea and weight loss.

The life cycle of *P. uncinata* is direct, and transmission occurs through feed and water contaminated with infective eggs. *P. uncinata* has not been found in other species of animals and is not considered a public health hazard.

Technician's Note

The ascarid of guinea pigs is nonpathogenic but causes symptoms from intestinal disturbances with extremely heavy infections.



Nematodes of Rabbits

Gastrointestinal Tract

Parasite: *Passalurus ambiguus*

Host: Rabbits

Location of Adult: Cecum and colon

Distribution: Worldwide

Derivation of Genus: Tailed worm named for a researcher named Passal

Transmission Route: Ingestion of infective ova

Common Name: Pinworm of rabbits

Zoonotic: No

Passalurus ambiguus is a nonpathogenic pinworm found in the cecum and colon of domestic and cottontail rabbits and hares. It is a pinworm that has an obvious round esophageal bulb. Adult females are approximately 10 mm long (Fig. 4.88), and males are 4 to 5 mm long (Fig. 4.89). Females have a long, finely pointed tail. Eggs are oval and slightly flattened on one side, measuring approximately 43 $\times$ 103 μ m (Fig. 4.90). Eggs are deposited in the feces and resemble the morulated hookworm eggs of dogs.

Infection with *P. ambiguus* can be detected antemortem by observing typical eggs in fecal flotation preparations. On postmortem examination, the white, hair-like adult worms can be found in the cecum and proximal colon. Rabbits can



Fig. 4.88 Adult female *Passalurus ambiguus*. Note the long, slender tail.

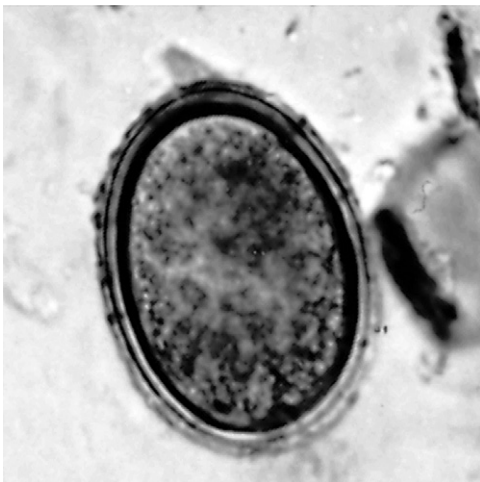


Fig. 4.87 Egg of *Paraspidodera uncinata*, the cecal pinworm of guinea pigs.



Fig. 4.89 Adult male *Passalurus ambiguus*.



Fig. 4.90 Ova of *Passalurus ambiguus* in fecal flotation.

tolerate heavy infections with no apparent clinical signs. It is believed that these pinworms feed on bacteria in the intestinal contents without disturbing the mucosal lining of the cecum.

Eggs passed in the feces are immediately infective, so control of this parasite is quite difficult. Transmission is by ingestion of infective eggs. Clients should be advised to use feeders elevated off the floor of the rabbit hutch and to prevent wild hares and cottontail rabbits from having access to pet rabbits and their feed and bedding. *P. ambiguus* is species specific and has no zoonotic potential.

Technician's Note



The pinworm of rabbits is nonpathogenic and is believed to feed on the bacteria of the intestinal contents, thus not disturbing the intestinal mucosa.

Parasite: *Obeliscoides cuniculi* and *Trichostrongylus calcaratus*

Host: Rabbits

Location of Adult: Stomach (*O. cuniculi*) and small intestine (*T. calcaratus*)

Distribution: Worldwide

Derivation of Genus: Round hair (*T. calcaratus*);

Obeliscoides, shaped like a pointed pillar

Transmission Route: Ingestion of infective larvae

Common Name: Trichostrongyles of rabbits

Zoonotic: No

Trichostrongyles are primarily parasites of ruminants and other large animals. However, these nematodes are also common in wild rabbits and uncommon in domestic rabbits. Diagnosticians must be aware of the possibility of infection with one or more rabbit trichostrongyles. Adult

Obeliscoides cuniculi are found in the stomach of rabbits, and adult *Trichostrongylus calcaratus* are found in the small intestine, where they feed on the host's blood. The males of these species are distinguished by the copulatory bursa on the posterior end. *O. cuniculi* females are 16 mm long and 0.5 mm wide, and males are 12 × 0.2 mm. Male and female adults may be found in the stomach on postmortem examination. Eggs are 80 × 45 μm and are thin shelled and oval. They may be easily observed with fecal flotation procedures. This nematode can produce hemorrhagic gastritis. Transmission is by ingestion of the larval form after eggs have been passed in the feces.

Technician's Note



The trichostrongyles of rabbits use a direct life cycle where a new host is infected by ingestion of infective larvae rather than by using an intermediate host. The ova can be found on fecal flotation.

Adults of *T. calcaratus* are found in the small intestine and generally are smaller than those of *O. cuniculi*. Females of *T. calcaratus* are 6.4 mm × 100 μm, and males are 5.7 mm × 115 μm. The thin-shelled eggs are 65 × 33 μm and may be observed on fecal flotation. Rabbits infected with *T. calcaratus* may develop anemia. The life cycle of this trichostrongyle is direct, and transmission is by ingestion of infective larvae. As with other parasites that infect wild rabbits, prevention and control depend on keeping feed and bedding inaccessible to wild hares and cottontail rabbits.

Technician's Note



Rabbit trichostrongyles are typically found in wild rabbits rather than domestic rabbits.

Nematodes of Pet and Aviary Birds

Gastrointestinal Tract

Parasite: *Ascaridia* species

Host: Lovebirds, cockatiels, macaws, parakeets, poultry, and waterfowl

Location of Adult: Small intestine

Distribution: Worldwide

Derivation of Genus: Intestinal worm

Transmission Route: Ingestion of infective ova

Common Name: Ascarids of birds

Zoonotic: No

Nematodes occur infrequently in pet and aviary birds. *Ascaridia* is occasionally seen in lovebirds, cockatiels, and macaws (Figs. 4.91 and 4.92). Ascarids are very common in grass parakeets and can be demonstrated on both direct smear examination and fecal flotation. The eggs are thick-shelled roundworm-type eggs (see Fig. 4.91). These roundworms are also common in backyard poultry and in waterfowl and can cause intestinal obstruction with large infections. In turkeys and peafowl, *Heterakis gallinarum* serves as an intermediate host for *Histomonas meleagridis*, the protozoan that produces infectious enterohepatitis.

Technician's Note



Although the ascarid of birds infects different bird species, it is most commonly seen in backyard poultry and waterfowl.



Fig. 4.91 A roundworm (*Ascaridia*) egg in a fecal smear from a cockatiel.

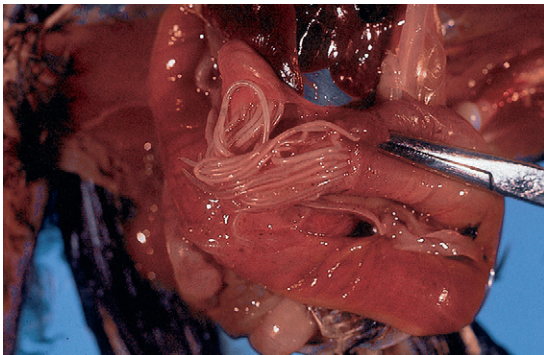


Fig. 4.92 Nematodes occur infrequently in pet and aviary birds. *Ascaridia* is occasionally seen in the small intestine of lovebirds, cockatiels, and macaws.

Parasite: *Spiroptera incesta*, *Dispharynx nasuta*, and *Tetrameres* species

Host: Australian finches—*S. incesta*, finches—*D. nasuta*, and pigeons—*Tetrameres* species

Location of Adult: Ventriculus, ventriculus, and proventriculus, respectively

Intermediate Host: Insect, insect, and sow bug, respectively

Distribution: Tropical and subtropical regions (*D. nasuta*)

Derivation of Genus: *Spiroptera*: coiled wing; *Dispharynx*: abnormal throat; *Tetrameres*: made up of four parts

Transmission Route: Ingestion of infective insect, ingestion of infective insect, and ingestion of infective sow bug, respectively

Common Name: Spirurids of birds

Zoonotic: No

Spirurids can infect a variety of avian species but are generally uncommon in pet birds. *Spiroptera incesta* can infect Australian finches; *Dispharynx nasuta* infects other finches. Infection by spirurids can be difficult to detect in finches. When spirurids are suspected, histologic examination of the ventriculus is recommended. The eggs of the spirurids are characterized by a thick wall and the presence of an embryonating larva within each egg. *Tetrameres*, a globose (spherical) spirurid, are typically found in the wall of the proventriculus of pigeons (see Fig. 4.4). Adults typically produce damage by living within the host.

Technician's Note



The spirurids of birds are not commonly found in pet birds.

Parasite: *Capillaria* species

Host: Pheasants, peafowl, and other poultry

Location of Adult: Crop and upper alimentary tract

Distribution: Worldwide

Derivation of Genus: Hair-like

Transmission Route: Ingestion of infective ova or paratenic host, earthworm

Common Name: Poultry capillarid

Zoonotic: No

Capillaria species may be found in the crop and upper alimentary tract of pheasants, peafowl, and other poultry. These hair-like nematodes have been reported in a variety of imported psittacine birds. The tiny adult worms can often be recovered from the wall of the esophagus or the crop, where they can cause inflammation and other

disturbances. A direct smear of a sample from this area or a fecal flotation often reveals the characteristic thick-walled bipolar eggs, which are similar to those of whipworms, the *Trichuris* species. The eggs are shed in the feces and develop into infective ova. These infective ova can be ingested directly by a new host or by an earthworm as a paratenic host. The earthworm can then be ingested, and the parasite continues its life cycle in the bird.

Technician's Note



Capillaria species use a direct life cycle or a paratenic host, the earthworm, as a means of transmission from one host to another. The parasite does not undergo any life cycle stages in the earthworm. It is merely used to transport the parasite from one host to another.

Chapter Four Test

MATCHING—Match the scientific name of each parasite in the left hand column with its common name, phrase, or term in the right hand column.

A. <i>Spirocerca lupi</i>	1. Hookworms of dogs and cats
B. <i>Ollulanus tricuspis</i>	2. Bovine trichostrongyles
C. <i>Toxocara</i> , <i>Toxascaris</i> species	3. Canine heartworm
D. <i>Ancylostoma</i> , <i>Uncinaria</i> species	4. Intestinal threadworm of swine
E. <i>Trichuris vulpis</i>	5. Swine kidney worm
F. <i>Dirofilaria immitis</i>	6. Esophageal worm of dogs
G. <i>Diectophyma renale</i>	7. Rabbit pinworm
H. <i>Aelurostrongylus abstrusus</i>	8. Equine ascarid
I. <i>Haemonchus</i> , <i>Ostertagia</i> , <i>Trichostrongylus</i> , and <i>Cooperia</i> species	9. Feline lungworm
J. <i>Thelazia rhodesii</i>	10. Equine pinworm
K. <i>Setaria cervi</i>	11. Proventriculus worm of pigeons
L. <i>Parascaris equorum</i>	12. Ascarids of dogs and cats
M. <i>Strongylus vulgaris</i> , <i>S. edentatus</i> , and <i>S. equinus</i>	13. Abdominal worm of cattle
N. <i>Oxyuris equi</i>	14. Feline trichostrongyle
O. <i>Strongyloides ransomi</i>	15. Mouse pinworm
P. <i>Oesophagostomum dentatum</i>	16. Free-living soil nematodes or facultative parasites
Q. <i>Ascaris suum</i>	17. Large strongyles of horses
R. <i>Stephanurus dentatus</i>	18. Whipworm of dogs
S. <i>Trichinella spiralis</i>	19. Swine ascarid
T. <i>Syphacia obvelata</i>	20. Guinea worm of dogs
U. <i>Passalurus ambiguus</i>	21. Eyeworm of ruminants
V. <i>Tetrameres</i> species	22. Giant kidney worm
W. <i>Enterobius vermicularis</i>	23. Human pinworm (pseudoparasite of dogs and cats)
X. <i>Pelodera strongyloides</i>	24. Stomach worm of dogs and cats
Y. <i>Physaloptera</i> species	25. Trichina worm
Z. <i>Dracunculus insignis</i>	26. Nodular worm of swine

MATCHING—Match the parasite in the left hand column with the correct diagnostic technique or term in the right hand column.

A. <i>Spirocerca lupi</i>	1. Observation of microfilariae using the modified Knott test in conjunction with commercially available ELISA
B. <i>Dioctophyma renale</i>	2. Observation of bipolar, football shaped eggs in fecal flotation
C. <i>Trichuris vulpis</i>	3. Necropsy revealing large nodules within the wall of the large intestine
D. <i>Oslerus osleri</i>	4. Observation of paper-clip shaped eggs on fecal flotation
E. <i>Dirofilaria immitis</i>	5. Observation of infective first-stage larvae with an S shaped appendage on the tail
F. <i>Stephanurus dentatus</i>	6. Observation of large, rough, bipolar, barrel shaped eggs on urine sedimentation
G. <i>Oesophagostomum dentatum</i>	7. Flotation of feline vomitus revealing infective third-stage larvae
H. <i>Oxyuris equi</i>	8. Microscopic examination of muscle biopsy specimen revealing encysted larvae in muscle tissue
I. <i>Ollulanus tricuspis</i>	9. Cellophane tape impressions of anus revealing larvated eggs
J. <i>Trichinella spiralis</i>	10. Observation of strongyle-type eggs in pig urine

MATCHING—Match the parasite in the left hand column with the pathology it produces in the right hand column.

A. Physaloptera species	1. Adult nematodes firmly attached to the mucosa of small intestine; voracious blood suckers
B. <i>Toxocara canis</i>	2. Blood suckers; tiny stylet in the tip of the whip-like anterior end that cannulates blood vessels
C. <i>Trichuris vulpis</i>	3. Ingestion of solid tissue; renal parenchyma
D. <i>Oslerus osleri</i>	4. Physical blockage of the lumen of the small intestine
E. <i>Gongylonema pulchrum</i>	5. Parasite embedded in esophageal submucosa in a zigzag fashion
F. <i>Setaria equina</i>	6. Adult nematodes firmly attached to the stomach mucosa; blood suckers
G. <i>Ancylostoma caninum</i>	7. Formation of nodules in the esophagus
H. <i>Oxyuris equi</i>	8. Formation of nodules at the bifurcation of the trachea
I. <i>Spirocerca lupi</i>	9. Pruritus in the anal region; hairs at the base of the tail broken off from attempts at scratching the anus
J. <i>Dioctophyma renale</i>	10. Nonpathogenic; solitary worms found free within the abdominal cavity

Questions for Thought and Discussion

1. Why is it important to learn the life cycles of the nematode parasites of domesticated animals?
2. Why is it important to learn the scientific names, hosts, and locations of the nematode parasites of domesticated animals?

Chapter

5

The Phylum Platyhelminthes, Class Cestoda

OUTLINE

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Cotyloda (Pseudotapeworms)	81
Key Morphologic Features	81
Life Cycle of the Pseudotapeworm	83

LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Briefly discuss the external morphology of cestodes.
- Describe the important external morphologic features for differentiating both true tapeworms and pseudotapeworms.
- Describe the four types of cestode eggs.
- Compare the life cycle of a typical true tapeworm with that of a typical pseudotapeworm.
- Integrate vocabulary terms with the cestode parasites covered in [Chapter 6](#).

KEY TERMS

Acetabula	Hexacanth embryos
Armed tapeworm	Hydatid cyst
Bothria	Immature proglottids
Cestodes	Mature proglottids
Coenurus	Metacestode stage
Copepod	Neck
Coracidium	Plerocercoid
Cysticercoid	Proceroid
Cysticercus	Proglottids
Gravid proglottids	Pseudophyllidean egg
Hermaphroditic	Pseudotapeworm
Hexacanth	Pyriiform apparatus type

Rostellum
Scolex
Strobila
Tegument

Tetrathyridium
Trematodes
True tapeworm
Unarmed tapeworm

The phylum Platyhelminthes, the flatworms, includes the **trematodes** (or flukes) discussed in [Chapters 7 and 8](#) and the **cestodes** (or tapeworms) detailed in this chapter and [Chapter 6](#). Remember that the morphologic feature shared by these two classes is that they are both dorsoventrally flattened. However, whereas the flukes are flattened and leaf shaped, the tapeworms are ribbon-like and segmented into identical compartments called **proglottids** ([Fig. 5.1](#)).

Technician's Note



Cestodes are dorsoventrally flattened, ribbon-like, and segmented into identical compartments called *proglottids*.

Members of the phylum Platyhelminthes, class Cestoda, are often referred to as *cestodes* or *tapeworms*. Their bodies are usually long, segmented, and flattened, almost ribbon-like in appearance. Within the class Cestoda are two subclasses, Eucestoda (true tapeworms) and Cotyloda (pseudotapeworms). Members of both of these classes are important parasites of domesticated and wild animals and of humans.

Eucestoda (True Tapeworms)

Phylum: Platyhelminthes
Class: Cestoda



Fig. 5.1 Example of a typical tapeworm with a dorsoventrally flattened, ribbon-like appearance. Every tapeworm is segmented into identical compartments called *proglottids*.

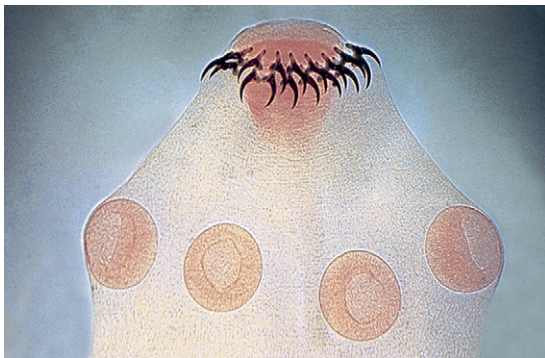


Fig. 5.2 Located on the anterior end of the true tapeworm is the holdfast organelle, the scolex, or head. The scolex of the adult true tapeworm has four suckers, called *acetabula*, with which the tapeworm holds on to the lining of the small intestine, the predilection site of most adult tapeworms.

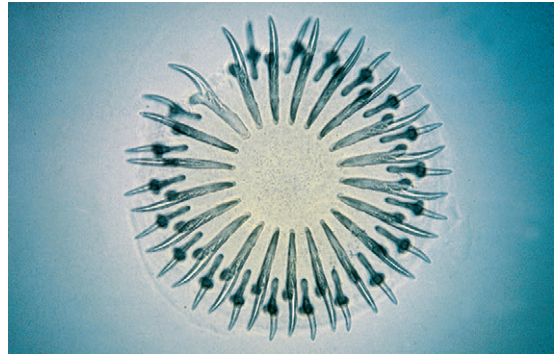


Fig. 5.3 Anchor-like organelle, the rostellum, on the anterior end of the tapeworm. The rostellum usually has backward-facing hooks used to anchor the tapeworm farther into the mucosa of the small intestine. If the tapeworm has a rostellum, it is said to be an *armed* tapeworm; if the tapeworm lacks the rostellum, it is said to be an *unarmed* tapeworm.

do not have a mouth; instead, they absorb the nutrients acquired from the host's intestine through their **tegument**, or body wall. In addition to the suckers, some true tapeworms may possess an anchor-like organelle called the **rostellum** (Fig. 5.3). The rostellum usually has backward-facing hooks. With these hooks, the tapeworm further anchors itself in the mucosa of the small intestine. If the tapeworm has a rostellum, it is said to be an **armed tapeworm**; if the tapeworm lacks the rostellum, it is said to be an **unarmed tapeworm**.

Technician's Note



The suckers on the cestode are not associated with food intake; instead, the cestode absorbs nutrients from the host through its tegument.

Key Morphologic Features

As mentioned, tapeworms are long, segmented, flattened, almost ribbon-like parasites. On the extreme anterior end of the typical **true tapeworm** is the holdfast organelle, the **scolex**, or head (Fig. 5.2). The scolex of the adult true tapeworm has four suckers called **acetabula**, with which it holds on to the lining of the small intestine, the predilection site, or "home," of most adult tapeworms. Unlike the oral sucker of the digenetic trematode, the suckers of the true tapeworm are *not* associated with intake of food but rather serve as organs of attachment. True tapeworms

Just posterior to the scolex of the true tapeworm is a germinal, or growth, region called the **neck**. It is from the neck that the rest of the true tapeworm's body, the **strobila**, arises. The strobila is composed of individual proglottids that are arranged much like the boxcars in a railroad train. The proglottids closest to the scolex and the neck of the true tapeworm are the **immature**, or youngest, **proglottids** (Fig. 5.4); those that are intermediate in distance from the scolex and the neck are the **mature proglottids** (Fig. 5.5); and those farthest from the scolex and the neck are the **gravid proglottids** (Fig. 5.6).

As with the **hermaphroditic** digenetic trematodes, each proglottid of a true tapeworm contains complete sets of both male and female reproductive organs. As with the flukes, tapeworms are hermaphroditic. The sex

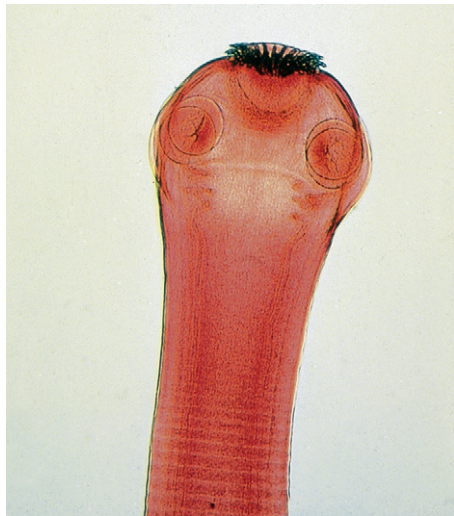


Fig. 5.4 Proglottids closest to the scolex and neck of the true tapeworm are the immature, or youngest, proglottids. Immature proglottids contain immature, nonfunctional male and female reproductive organs.

organs of these tapeworms are usually located along the lateral aspects of the proglottid. Cross-fertilization and self-fertilization take place between and among individual proglottids. Immature proglottids contain male and female reproductive organs that are sexually immature; these are “prepuberty” proglottids. Mature proglottids contain male and female reproductive organs that are sexually mature and completely functional, or capable of reproduction. Gravid proglottids contain male and female reproductive organs that have grown old or are “spent,” having degenerated to the point that the only portion remaining is the uterus filled with tapeworm eggs. Tapeworm proglottids can usually be observed with the naked eye in the feces of the definitive host ([Fig. 5.7](#)). Other organ systems (nervous, excretory) are represented; however, they are not as important as the reproductive system. As with the digenetic trematodes, or flukes, tapeworms are “designed” to reproduce and produce offspring.

Technician's Note



Each segment of the tapeworm contains male and female reproductive organs. Mature proglottids can self-fertilize or cross-fertilize with other segments. The gravid proglottids contain the eggs of the tapeworm.

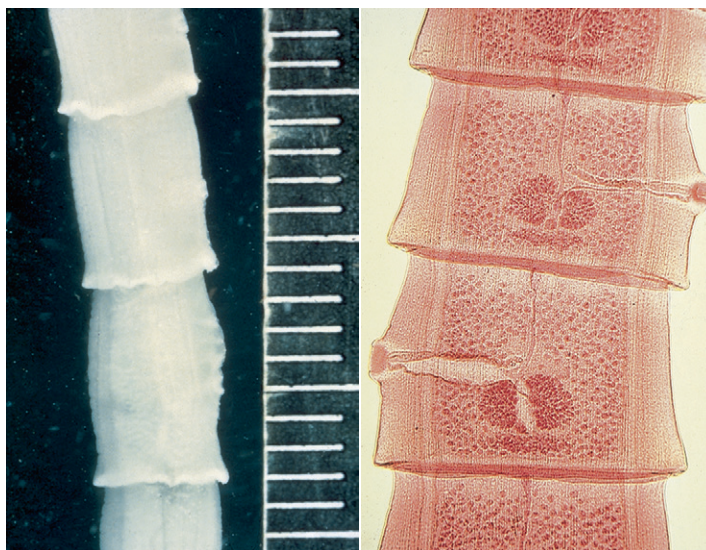


Fig. 5.5 Tapeworm proglottids intermediate in distance to the scolex and neck of the true tapeworm are mature, or adolescent, proglottids. Mature proglottids contain mature, functional male and female reproductive organs.

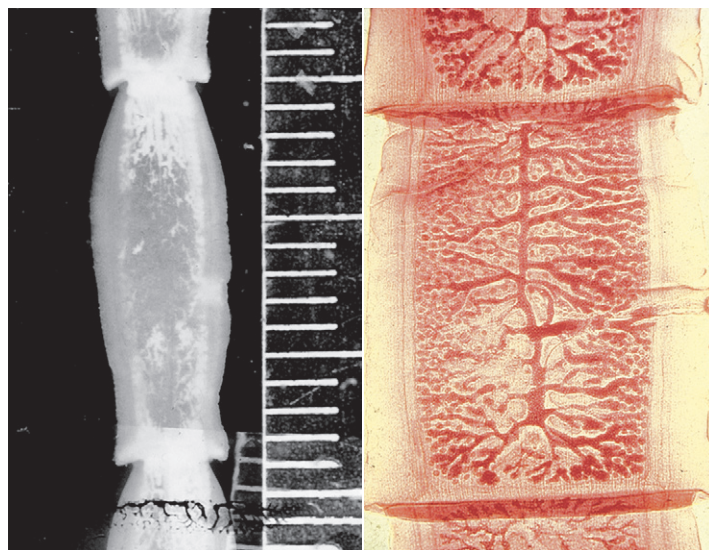


Fig. 5.6 Tapeworm proglottids farthest from the scolex and neck of the true tapeworm are gravid, or aged, proglottids. Gravid proglottids contain male and female reproductive organs that have grown old and degenerated so that only the uterus filled with eggs remains.



Fig. 5.7 Tapeworm proglottids (*Dipylidium caninum*) observed in feces of the definitive host.

The eggs found in the gravid proglottids contain the larval stage, or **hexacanth**, with six hooks. The hexacanth can be contained within one of four egg types: the **pyriform apparatus type**, *Dipylidium* type, *Taenia* type, and pseudophyllidean type. The pyriform apparatus type (Fig. 5.8, A) is an egg with three coverings, the innermost of which is pear shaped and is called the *pyriform apparatus*. The *Dipylidium* egg packet contains multiple hexacanth within one egg (see Fig. 5.8, B). The *Taenia* egg

has a wide outer shell with a thicker outer covering and a six-hooked hexacanth within the egg (see Fig. 5.8, C). The oval **pseudophyllidean egg** has an operculum (see Fig. 5.8, D) at one end. The hexacanth within it contains six hooks.

Technician's Note

Tapeworms can produce one of four types of eggs: pseudophyllidean type, *Dipylidium* type, *Taenia* type, and pyriform apparatus type.

Life Cycle of the True Tapeworm

The life cycle of a typical true tapeworm is more complicated than that of a digenetic trematode. In most cases, the gravid proglottids of the true tapeworm pass to the outside environment, sometimes singly and sometimes in chains, one behind the other. These proglottids rupture in the external environment and release thousands of **hexacanth embryos**, or eggs, to the outside environment (Fig. 5.9). To continue the life cycle, the egg must be ingested by a suitable intermediate host, either an invertebrate

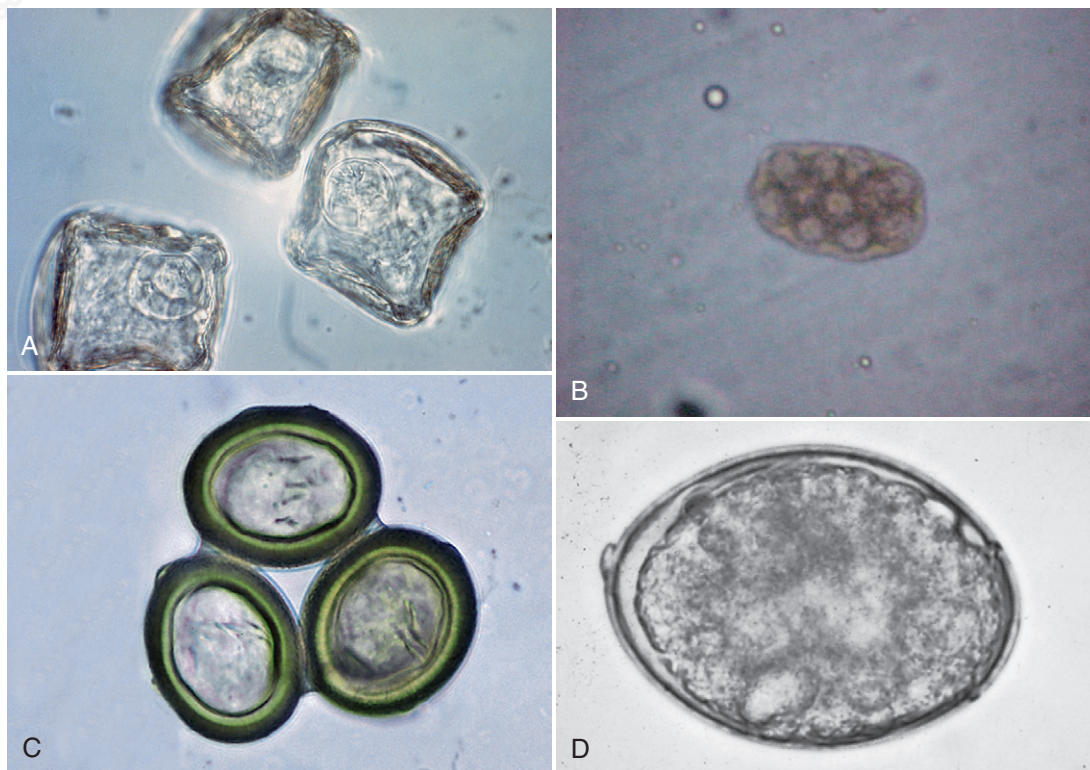


Fig. 5.8 Tapeworm eggs can be seen in four basic types. **A**, Pyriform apparatus type of egg. **B**, *Dipylidium* eggs, as seen in *Dipylidium caninum*. **C**, *Taenia* egg, as seen in *Taenia pisiformis*. **D**, Pseudophyllidean egg, as seen in *Diphyllobothrium latum*.



Fig. 5.9 Tapeworm egg, or hexacanth embryo. Tapeworm eggs are released to the outside environment. Each tapeworm egg is infective for the intermediate host and produces one metacystode stage. The unmarked egg is an *Ancylostoma caninum*.

or a vertebrate. Within this host, the egg develops into a **metacystode stage**, or larval tapeworm. The metacystode may take one of several forms: **cysticercoid**, **cysticercus**, **coenurus**, **hydatid cyst**, or **tetrathyridium**. These larval stages differ in their choice of host, their structure, their predilection site, and their pathogenicity to the intermediate host. Sometimes the metacystode, or larval stage of the tapeworm, is more pathogenic to the intermediate host than the adult or mature tapeworm is to the definitive host. The definitive host becomes infected by ingesting the intermediate host containing the metacystode stage. The "juvenile," or developing, tapeworm emerges from the metacystode stage, attaches to the lining of the small intestine, and begins to produce the strobila, which is composed of proglottids.

Tapeworm proglottids have muscles that enable them to move about. Owners of infected animals often observe

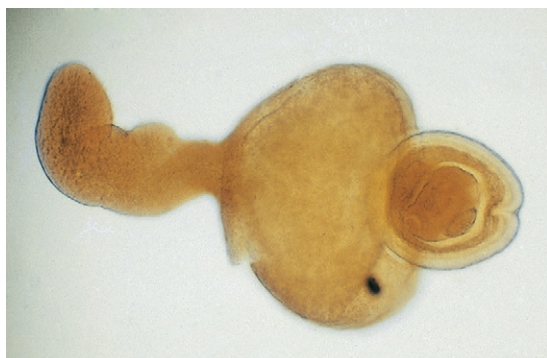


Fig. 5.10 Microscopic larval (metacestode) stage known as a *cysticercoid*. The cysticercoid is tiny (microscopic) and contains a small, fluid-filled space; the cysticercoid develops within the intermediate host. The definitive host becomes infected by ingesting the intermediate host containing the cysticercoid larval stage. Examples of tapeworms that develop into the cysticercoid stage in the intermediate host are *Thysanosoma actinoides* of cattle, *Anoplocephala* species of horses, and *Dipylidium caninum* of dogs and cats.



Fig. 5.11 The hexacanth embryo of some tapeworms develops into the *cysticercus*, or bladder worm, stage. The bladder worm is a fluid-filled larval stage within tissues of a vertebrate intermediate host. The definitive host becomes infected by ingesting the intermediate host containing the bladder worm larval stage. Examples of tapeworms that develop into the cysticercus stage in an intermediate host are the *Taenia* species.

these tapeworms as “little white worms” crawling on the animal’s feces, hair coat, or bedding. Tapeworm proglottids often contain eggs when they are passed into the feces. These hexacanth embryos are eggs with embryos that have an internal structure and six hooks (see Fig. 5.9). The hexacanth embryos are ingested by the intermediate host in which the tapeworm develops.

Technician’s Note

The owner of an animal infected with tapeworms often sees “little white worms” crawling in the animal’s feces when the animal defecates. When the segments dry out, they often are observed as uncooked “rice” granules in the environment of the animal.

The intermediate host may be an arthropod, such as a flea or a grain mite. In this host, the hexacanth embryo develops into a microscopic larval stage known as a *cysticercoid* (Fig. 5.10). The cysticercoid is tiny and contains a small, fluid-filled space. The definitive host becomes infected by ingesting the intermediate host containing the cysticercoid larval stage. Examples of tapeworms that develop into a cysticercoid stage in an intermediate host are the fringed tapeworm of cattle (*Thysanosoma actinoides*) and the double-pored tapeworm of dogs and cats (*Dipylidium caninum*).

Sometimes the intermediate host is a mammalian host such as a rabbit, in which the hexacanth embryo develops into a cysticercus, or “bladder worm,” stage (Fig. 5.11). The bladder worm is a fluid-filled larval stage within the tissues of the vertebrate intermediate host. The definitive host becomes infected by ingesting the intermediate host containing the bladder worm larval stage (Fig. 5.12). Examples of tapeworms that have a bladder worm stage (or a variation of the bladder worm stage) in an intermediate host are the canine taeniid tapeworm (*Taenia pisiformis*) and the *Coenurus* tapeworm (*Multiceps multiceps*). Other tapeworms that use a variation of the bladder worm stage are *Echinococcus granulosus* and *Echinococcus multilocularis*, the hydatid cyst tapeworms. Chapter 6 covers these tapeworms and their larval stages in greater detail.

Cotyloda (Pseudotapeworms)

Phylum: Platyhelminthes

Class: Cestoda

Key Morphologic Features

Members of the subclass Cotyloda, the pseudotapeworms, are tapeworms; they are long, segmented, flattened, almost ribbon-like parasites. These tapeworms resemble true tapeworms in that on the extreme anterior end of the typical **pseudotapeworm** is the holdfast

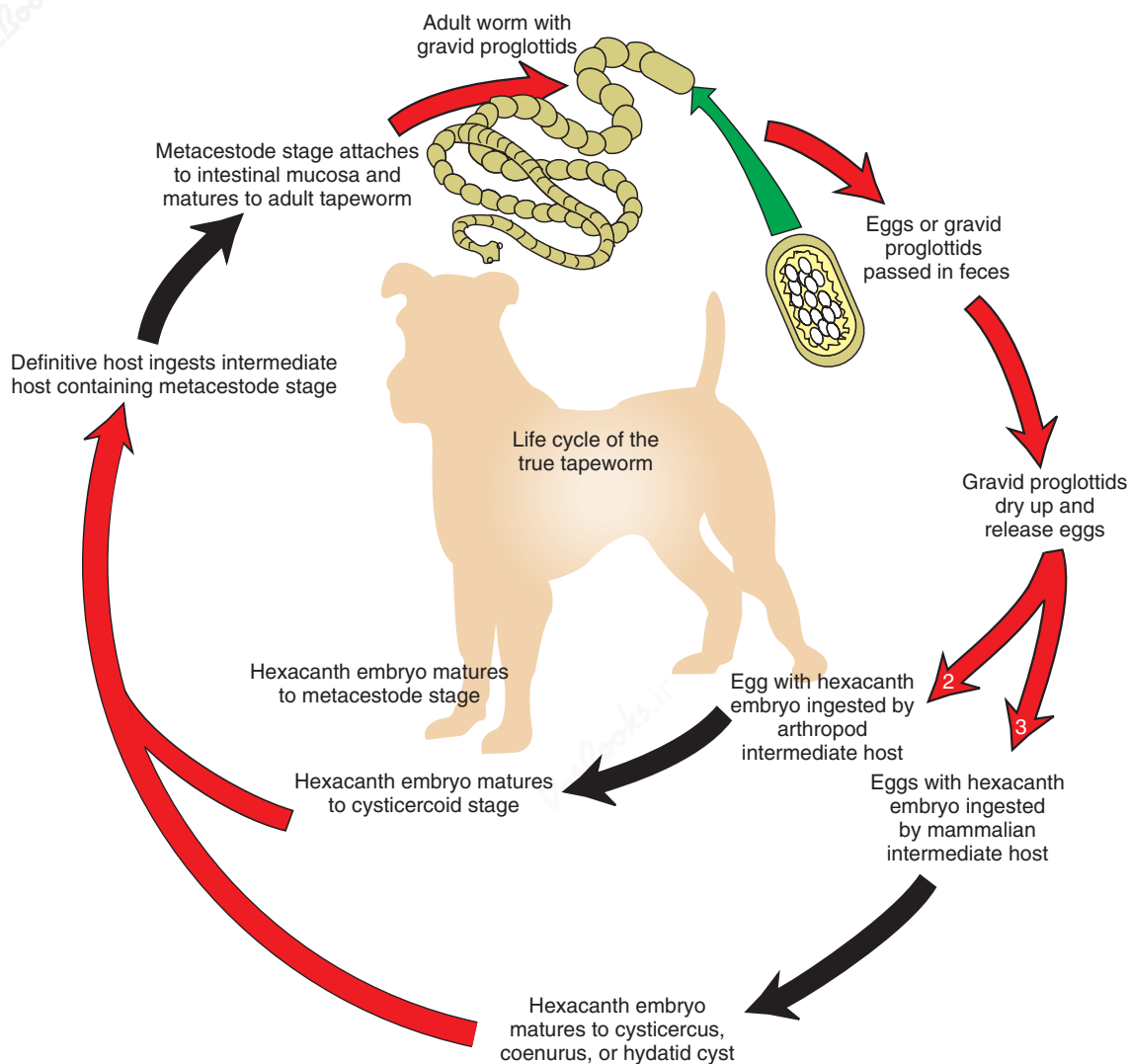


Fig. 5.12 Life cycle of the true tapeworm.

organelle, the scolex, or head. Instead of possessing four holdfast suckers, or acetabula, the typical pseudotapeworm has two slit-like organelles called **bothria** (Fig. 5.13). Bothria are longitudinal grooves along the length of the scolex. The pseudotapeworm attaches to the lining of the small intestine by means of the bothria. As with true tapeworms, pseudotapeworms do not have a mouth; instead, they absorb the nutrients acquired from the host's intestine through their tegument, or body wall.

Technician's Note



Instead of using a scolex with suckers to attach to the host, the pseudotapeworm uses two slit-like organelles called *bothria* to attach to the host's intestines.

The strobila of the pseudotapeworm is similar to that of the true tapeworm. The neck, or growth region, is just

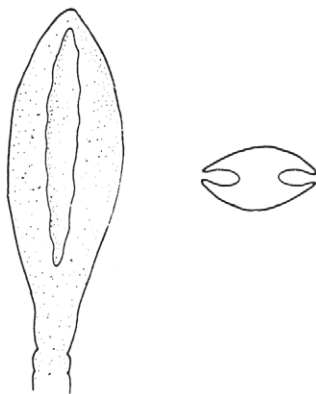


Fig. 5.13 Slit-like bothria on the anterior end of the typical pseudotapeworm.

posterior to the scolex, and the pseudotapeworm's body arises from this. The strobila of the pseudotapeworm also is composed of immature, mature, and gravid proglottids. As with true tapeworms, pseudotapeworms are hermaphroditic, and each proglottid of a pseudotapeworm contains complete sets of both male and female reproductive organs. The sex organs of these tapeworms are usually located along the central region of each proglottid. There is a centrally located uterine pore through which eggs are voided to the external environment. The eggs of the pseudotapeworm do not resemble those of the true tapeworm. Oddly, they resemble the eggs of a digenetic trematode—they are operculated. In most cases, the spent proglottids of the pseudotapeworm pass to the outside environment in long chains.

Technician's Note

The body of the pseudotapeworm is composed of immature, mature, and gravid proglottids with male and female reproductive organs in each segment.

Life Cycle of the Pseudotapeworm

The life cycle of the pseudotapeworm is slightly more complicated than that of a true tapeworm. The operculated eggs are passed singly to the external environment. If these eggs make contact with water, they hatch, releasing a ciliated hexacanth embryo out of the operculum. This ciliated hexacanth embryo is called a **coracidium**. The coracidium must be ingested by a suitable first intermediate host, an aquatic crustacean called a **copepod**. Within the copepod, the coracidium develops to a stage called a **proceroid**. If the copepod containing the proceroid is ingested by the second intermediate host, usually a fish of some type, the proceroid develops into the second stage, which is infective for the definitive host. This stage is called the **plerocercoid** stage. The definitive host becomes infected by ingesting the second intermediate host containing the plerocercoid stage. This plerocercoid stage is the juvenile, or developing, tapeworm; it possesses slit-like bothria. When the plerocercoid stage is ingested by the definitive host, it emerges from the metacystode stage, attaches to the lining of the small intestine, and begins to produce the strobila (Fig. 5.14).

Technician's Note

The life cycle of the pseudotapeworm is more complex than that of the true tapeworm, using two intermediate hosts, the second of which is infective to the definitive host.

There are two important species of pseudotapeworms: *Diphyllbothrium latum*, the "broad fish tapeworm," and *Spirometra mansonioides*, the "zipper tapeworm."

Chapter 6 details the major true tapeworms and pseudotapeworms that infect domesticated animals.

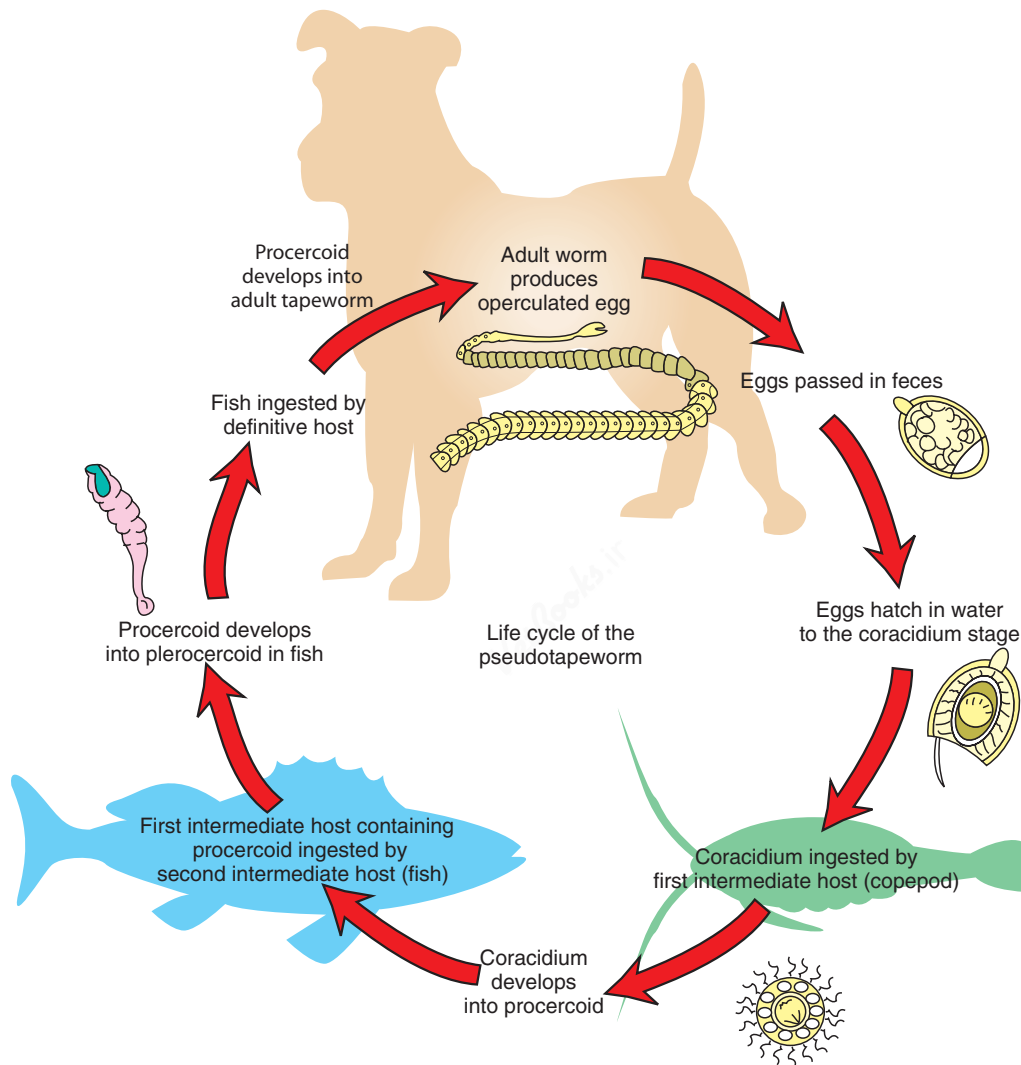


Fig. 5.14 Life cycle of the pseudotapeworm.

Chapter Five Test

MATCHING—Match the scientific term in the left hand column with the appropriate definition in the right hand column.

A. Eucestode	1. Slit-like structures on the scolex of the pseudotapeworm
B. Armed scolex	2. Possessing both male and female reproductive organs
C. Tegument	3. Lacking a rostellum
D. Hexacanth embryo	4. True tapeworm
E. Coracidium	5. Larval tapeworm
F. Hermaphroditic	6. Ciliated stage emerging from an operculated pseudotapeworm egg
G. Bothria	7. All of the connected proglottids (immature, mature, and gravid proglottids)
H. Metacestode	8. Tapeworm egg containing six hooks
I. Strobila	9. Tapeworm's body wall
J. Unarmed scolex	10. Possessing a rostellum

Questions for Thought and Discussion

- How can a gravid proglottid be used in making a definitive diagnosis of cestodiasis in any definitive host?
- Compare and contrast the following types of cestode eggs. You may use drawings with labels to illustrate the differences. Give examples of cestodes that typify these egg types (see [Chapter 6](#) for examples).
 - Egg packet
 - Egg with a pyriform apparatus
 - Hexacanth embryo
 - Pseudotapeworm egg
- Compare and contrast the “typical cestode life cycle” of a true tapeworm versus the life cycle of a pseudotapeworm.
- What are some external morphologic features used to identify intact adult cestodes, both true tapeworms and pseudotapeworms?
- Define the following morphologic terms observed in a veterinary practice:
 - Gravid proglottid
 - Scolex
 - Hexacanth embryo
 - Egg packet
 - Cysticercoid

Tapeworms That Parasitize Domestic Animals and Humans

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LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Identify the tapeworm parasites (both adult and larval forms) of the following domesticated animals: dog, cat, cattle, sheep, horse, and selected laboratory animals.
- Understand that many cestode parasites are associated with two scientific names, one scientific name for the adult form of the parasite and one scientific name for the larval (metacestode) stage of the parasite.
- Understand the correlation and integration between vertebrate or invertebrate hosts that serve as intermediate hosts for larval (metacestode) stages of cestodes and the vertebrate hosts that serve as definitive hosts for the adult stages of their corresponding cestode parasites.
- Understand the concepts behind the metacestode stages relative to their roles in the life cycles of both true tapeworms and pseudotapeworms.

KEY TERMS

Bothria	Oncosphere
Coenurus	Operculated ovum
Coracidium	Oribatid grain mites
Cysticercoid	Plerocercoid
Cysticercus or bladder worm	Proceroid
Egg packet	Pseudotapeworm
Embryophore	Psocids
Hexacanth six-toothed embryo	Pyriform apparatus
Hydatid cyst	Sparganum
Lappets	Strobilocercus
Metacestode	Tetrathyridium
Multilocular or alveolar hydatid cyst	True tapeworm
	Typical taeniid type of egg
	Unilocular hydatid cyst

Eucestoda (True Tapeworms)

Phylum: Platyhelminthes (flatworms)
 Class: Cestoda (tapeworms)
 Subclass: Eucestoda (true tapeworms)

Mice, Rats, Gerbils, and Hamsters

Intestinal Tract

Parasite: ♦ *Hymenolepis nana*

Parasite: *Hymenolepis diminuta*

Host: Mice, rats, gerbils, hamsters, dogs, and humans

Location of Adult: Small intestine

Distribution: Worldwide

Derivation of Genus: Membrane covering

Intermediate Host: None necessary (*H. nana*); fleas, flour beetles, and other arthropods (*H. diminuta*)

Transmission Route: Ingestion of infective fleas, grain beetle, or cockroach (*H. diminuta*); ingestion of infective egg or autoinfection (*H. nana*)

Common Name: Rodent tapeworm

Zoonotic: *H. nana*: yes; *H. diminuta*: yes

Technician's Note

Although *Hymenolepis nana* and *Hymenolepis diminuta* are mainly parasites of mice, rats, gerbils, and hamsters, they have been found in dogs and humans.

Hymenolepis nana and *Hymenolepis diminuta* parasitize mice, rats, gerbils, and hamsters. These tapeworms are small and slender. Adults of *H. nana* are 1 mm wide and 25 to 40 mm in length, and adults of *H. diminuta* are 3 to 4 mm wide and 20 to 60 mm in length. These **true tapeworms** reside in the small intestine of the rodent definitive host and are usually detected on postmortem examination of the small intestine. The scolex of *H. nana* has a ring of hooks on its anterior end; it has an armed rostellum (Fig. 6.1). The scolex of *H. diminuta* has no hooks; it is unarmed (Fig. 6.2).

H. nana has a direct life cycle, whereas *H. diminuta* requires an intermediate host for infection. The eggs of *H. nana* are passed in the feces and are swallowed by a host. The hexacanth enters the villus of the small intestine and matures into a nontailed **cysticercoid**. The cysticercoid returns to the lumen of the small intestine, attaches to the lining, and matures to adulthood. *H. diminuta* also passes

its eggs in the feces, which are ingested by an intermediate arthropod host. The **hexacanth six-toothed embryo** (embryo containing three pairs of hooks) matures into a tailed cysticercoid. The arthropod is ingested by a definitive host, and the cysticercoid attaches to the lining of the small intestine and matures into an adult.

Technician's Note

Hymenolepis nana is unique in that it is the only tapeworm that does not need an intermediate host for any developmental stage in its life cycle.

The eggs of *Hymenolepis* species may be detected on fecal flotation. Veterinary technicians should be aware that the eggs of this tapeworm are shed intermittently in the feces. Sometimes individual proglottids are also recovered, but these do not float. Fig. 6.3 shows stained proglottids of

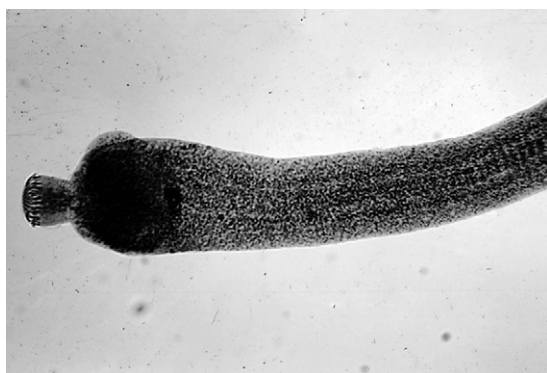


Fig. 6.1 Scolex of *Hymenolepis nana*, showing armed rostellum on scolex.

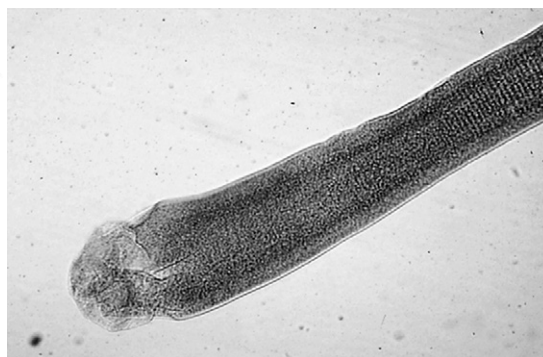


Fig. 6.2 Scolex of *Hymenolepis diminuta*, showing unarmed scolex.

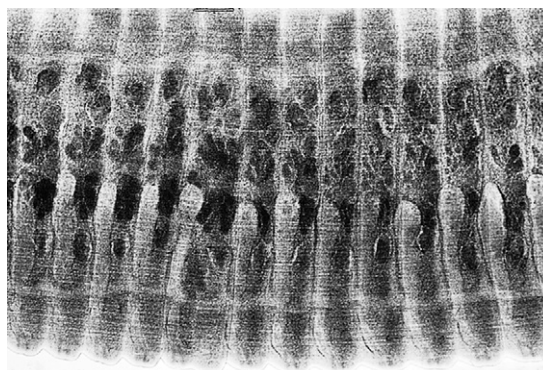


Fig. 6.3 Stained proglottids of *Hymenolepis diminuta*.

H. diminuta. The oval egg of *H. nana* measures 44 to 62 μm $\times$ 30 to 55 μm (Fig. 6.4). The egg of *H. diminuta* is more spherical and measures 62 to 88 μm $\times$ 30 to 55 μm . The embryo within the egg of both species measures 24 to 30 μm $\times$ 16 to 25 μm and contains three pairs of hooks (hexacanth embryo). Infected animals may be treated with niclosamide or praziquantel.

Both of these tapeworms have zoonotic potential. *H. nana* is unique in that it does not require an intermediate host; therefore it is directly infective to other rodents and to humans. Autoinfection by *H. nana* can occur when its eggs hatch in the small intestine of the host and subsequently infect that host. *H. diminuta* uses an insect (flea, grain beetle, or cockroach) as an intermediate host to complete its life cycle. The cysticercoid develops within the insect intermediate host (Fig. 6.5).



Fig. 6.4 The oval egg of *Hymenolepis nana* measures 44 to 62 μm $\times$ 30 to 55 μm .

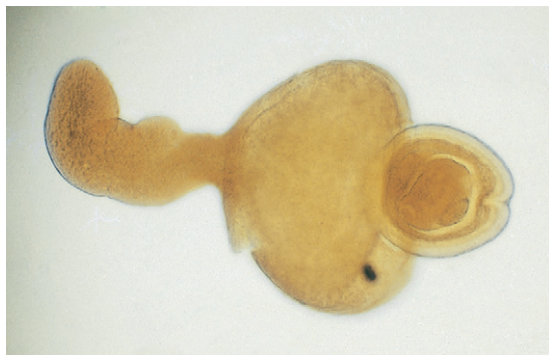


Fig. 6.5 Cysticercoid (larval) stage has been dissected from the insect intermediate host.

Technician's Note



Both *Hymenolepis nana* and *Hymenolepis diminuta* can infect humans.

Ruminants

Intestinal Tract

Moniezia species and *Thysanosoma actinoides* are true tapeworms that infect the intestinal tract of ruminants.

Parasite: *Moniezia benedini* and *Moniezia expansa*

Host: Cattle (*M. benedini*); cattle, sheep, and goats (*M. expansa*)

Location of Adult: Small intestine

Intermediate Host: Grain mites

Distribution: Worldwide

Derivation of Genus: *Moniezia*—to be single

Transmission Route: Ingestion of infective grain mite

Common Name: Ruminant tapeworms

Zoonotic: No

Moniezia Species

Moniezia species are long (up to 6 m) tapeworms found in the small intestine of cattle, sheep, and goats. *Moniezia* species are large tapeworms and can be up to 1.6 cm at the widest margins (Fig. 6.6). The scolex of *Moniezia* is unarmed; it lacks an armed rostellum (Fig. 6.7). Individual proglottids are very short and wide—"squatty." Each proglottid contains two sets of laterally located genital organs and associated pores (Fig. 6.8). These tapeworms produce eggs with a characteristic square or triangular shape. Both species will produce eggs with a three-layered eggshell; the innermost lining is a pyriform (pear shaped) apparatus. Two species are common among ruminants: *Moniezia*

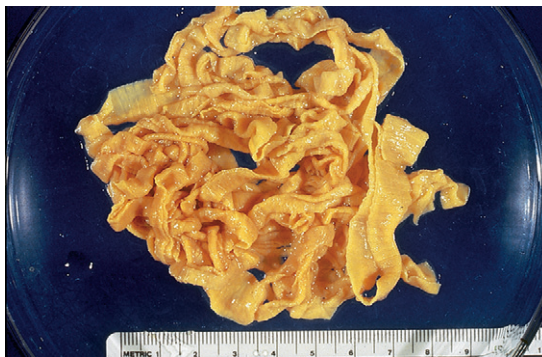


Fig. 6.6 *Moniezia* species are large tapeworms. They can grow to 6 m long and up to 1.6 cm at the widest margins.



Fig. 6.7 The scolex of *Moniezia* is unarmed; it lacks an armed rostellum.

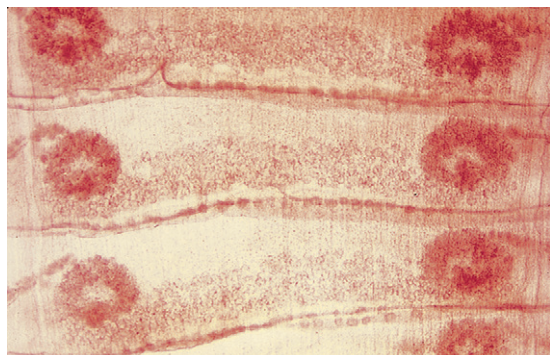


Fig. 6.8 Each proglottid of the adult *Moniezia* species contains two sets of laterally located genital organs and genital pores.

benedini in cattle and *Moniezia expansa* in cattle, sheep, and goats. The eggs of both species can be easily differentiated using standard fecal flotation procedures. The eggs of *M. expansa* are triangular or pyramidal and 56 to 67 μm in diameter. The eggs of *M. benedini* are square or cuboidal and approximately 75 μm in diameter (Fig. 6.9). The prepatent period for these tapeworms is approximately 40 days.



Fig. 6.9 *Moniezia* species produce eggs with a characteristic square or triangular shape. Two species are common among ruminants, *Moniezia benedini* in cattle and *Moniezia expansa* in cattle, sheep, and goats. The eggs of both species can be easily differentiated using standard fecal flotation procedures. The eggs of *M. expansa* are triangular or pyramidal and 56 to 67 μm in diameter. The eggs of *M. benedini* are square or cuboidal and approximately 75 μm in diameter. Both eggs contain a pyriform apparatus.

The **metacystode**, or larval, stage of *Moniezia* is the cysticeroid stage, which may be found within the intermediate hosts, **oribatid grain mites**. Intact proglottids and eggs are found in the feces of the ruminant definitive host. Mites become infected by ingesting the hexacanth embryo, which develops into the cysticeroid stage within the body of the grain mite. Ruminants become infected by ingesting cysticeroid-infected mites that infest the grain. The cysticeroid is a tiny, microscopic stage and probably will not be observed by the veterinarian (see Fig. 6.5). For every cysticeroid that is ingested by the ruminant, one adult tapeworm will develop in the small intestine of that ruminant (Fig. 6.10). Large numbers of adults can cause rupture of the gut or can obstruct the lumen of the intestines, especially in young animals. It is important that the veterinarian recognize the oribatid mite as the source of this tapeworm and understand the importance of effective tapeworm therapeutics (morantel, niclosamide, albendazole, fenbendazole, or oxfendazole) in cattle. Pasture rotation, in addition to therapeutics, is essential in greatly reducing the transmission of this parasite.

Technician's Note



Moniezia species eggs can be found with standard fecal flotation techniques. *Moniezia benedini* eggs have a square or cuboidal shape, whereas *Moniezia expansa* eggs are triangular or pyramidal.

Technician's Note



Pasture rotation is essential in reducing the transmission of ruminant tapeworms.

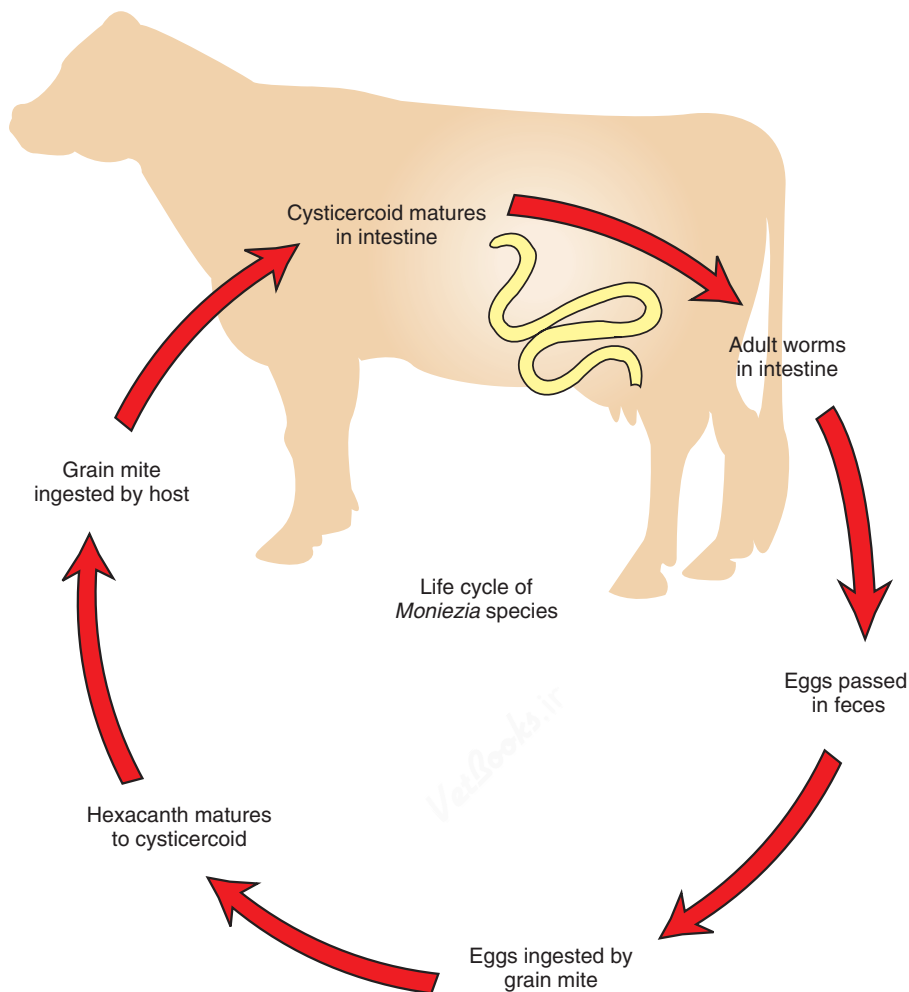


Fig. 6.10 Life cycle of *Moniezia* species.

Parasite: *Thysanosoma actinoides*

Host: Sheep, goats, and cattle

Location of Adult: Lumen of the bile duct, pancreatic ducts, and small intestine

Intermediate Host: Unknown, proposed hosts are psocids

Distribution: North and South America

Derivation of Genus: Fringed body

Transmission Route: Ingestion of unknown intermediate host

Common Name: Fringed tapeworm of sheep and goats

Zoonotic: No

Thysanosoma actinoides

T. actinoides is the fringed tapeworm found in the bile ducts (can cause bile duct obstruction), pancreatic ducts (can cause obstruction of the pancreatic duct), and small intestine of ruminants (Fig. 6.11). The adult tapeworm measures 8 mm × 15 to 30 cm and possesses an unarmed scolex. As with *Moniezia* species, the proglottids are very short; however, these proglottids possess a unique feature: a very prominent fringe located on the posterior aspect of each proglottid. (Fig. 6.12 shows the fringed adult *T. actinoides*.)



Fig. 6.11 *Thysanosoma actinoides*, the fringed tapeworm, is unusual in that it is not found in the intestine (as are most adult tapeworms). Instead, it resides in the bile duct of sheep.



Fig. 6.12 The adult *Thysanosoma actinoides* measures 8 mm x 15 to 30 cm. Note that proglottids are very short. They demonstrate a unique morphologic feature, a conspicuous fringe located on the posterior aspect of each proglottid, thus the common name *fringed tapeworm*.

Eggs of this tapeworm occur in packets of 6 to 12 eggs, with individual eggs measuring $19 \times 27 \mu\text{m}$. These eggs do not possess a pyriform apparatus. The eggs can be found on standard fecal flotation procedures. Adults can be identified at necropsy.

Technician's Note

These fringed tapeworms are unique among the adult tapeworms in that they possess a very prominent fringe along the posterior margin of each proglottid. The adults are also found in an unusual location for tapeworms, the lumen of the bile duct.

The metacestode (larval) stage of *T. actinoides* is the cysticeroid stage, which may be found within the proposed intermediate hosts, psocids. **Psocids** are primitive insects often associated with vegetation. These insects become infected by ingesting the hexacanth embryo, which develops into the cysticeroid stage within the body of the psocid. Ruminants may become infected by accidentally ingesting cysticeroid-infected psocids that infest vegetation. The cysticeroid is a microscopic stage and probably will not be observed by the veterinarian. For every cysticeroid that is ingested by a ruminant, one adult tapeworm will develop in the small intestine of that ruminant. It is important that the veterinarian recognize psocids as the source of this tapeworm and understand the importance of effective tapeworm therapeutics (niclosamide or praziquantel, as well as pasture rotation) in cattle.

Metacestode (Larval) Stages Found in the Musculature of Food Animals

Parasite: ♦ *Taenia saginata* (adult tapeworm)/*Cysticercus bovis* (metacestode [larval] stage)

Host: Humans

Location of Adult: Small intestine

Intermediate Host: Cattle

Distribution: Worldwide

Derivation of Genus: Flat band, bandage, or tape/bladder tail

Transmission Route: Ingestion of raw or undercooked infective beef

Common Name: Beef tapeworm of humans, beef measles, measly beef of cattle

Zoonotic: Yes

Cattle may serve as intermediate hosts for a tapeworm of humans, *Taenia saginata*. The adult tapeworm is unusual among the *Taenia* species in that it does not have an armed rostellum like the rest of the species. Adults possess 14 to 32 lateral branches of the uterus within the gravid proglottid. The eggs are typical taeniid-type ova with a striated embryophore (shell) surrounding an oncosphere with six hooklets inside. The adults can cause obstruction of the intestinal tract if present in sufficient numbers.

Technician's Note

Taenia saginata is unusual in that it has an unarmed rostellum, whereas all other *Taenia* species possess an armed rostellum.

The larval stage for this tapeworm is a **cysticercus**, or **bladder worm**, called *Cysticercus bovis*. A cysticercus is a

single invaginated scolex in a large fluid-filled cyst, cavity, or vesicle. This condition in cattle is often referred to as *beef measles* or *measly beef*. These infective metacestodes are found in the musculature (skeletal and cardiac muscles) of cattle. If enough cysticerci are present in the muscle tissue, they can interfere with muscle function and produce pain and myositis. Humans become infected with this zoonotic tapeworm by ingesting poorly cooked beef. (Fig. 6.13 shows the cysticercus of *C. bovis* within beef muscle.)

Parasite: ♦ *Taenia solium* (adult tapeworm)/*Cysticercus cellulosae* (metacestode [larval] stage)

Host: Human

Location of Adult: Small intestine

Intermediate Host: Pigs

Distribution: Underdeveloped countries, including Latin America, India, Africa, and the Far East

Derivation of Genus: Flat band, bandage, or tape/bladder tail

Transmission Route: Ingestion of infective undercooked or raw pork

Common Name: Pork tapeworm of humans, measly pork, pork measles of swine

Zoonotic: Yes

Pigs may serve as the intermediate host for a similar tapeworm of humans, *Taenia solium*. The adult possesses an armed rostellum with a double row of hooks. It is best identified by its 7 to 16 lateral branches of the uterus within each gravid proglottid. The eggs are typical taeniid-type ova with a striated embryophore surrounding an oncosphere with six hooklets inside. In large numbers, the adult worms can cause intestinal obstruction. The ova can be found on standard fecal flotation. The adults can be identified by their characteristic lateral branches of the uterus.



Fig. 6.13 Gross view of the cysticercus of the larval form of the beef tapeworm, *Taenia saginata* (*Cysticercus bovis*), within the muscle of a beef cow.

Technician's Note



The adult pork tapeworm of humans can cause intestinal obstruction in the human host if present in sufficient numbers.

The larval stage for this tapeworm is a cysticercus, or bladder worm, known as *Cysticercus cellulosae*. This metacestode stage in pigs is often referred to as *pork measles* or *measly pork*. These metacestodes are found in the musculature (skeletal and cardiac muscles) of pigs. Humans become infected with this zoonotic tapeworm by ingesting poorly cooked pork. It is also important to note that if humans ingest the eggs of *T. solium*, the cysticercus can develop within their muscles (Fig. 6.14) and within nervous tissue such as the brain, eye, and spinal cord.

The adult stages of the metacestode stages (*C. bovis* and *C. cellulosae*) are found in the small intestine of humans. Because humans may become infected by ingesting poorly cooked beef or pork, these are important zoonotic tapeworms.

Technician's Note



Prevention of *Taenia saginata* and *Taenia solium* can be accomplished by thoroughly cooking beef or pork to destroy the cysticercus within the meat, thus interrupting the life cycle. Also, hands should be washed after handling raw beef or pork.

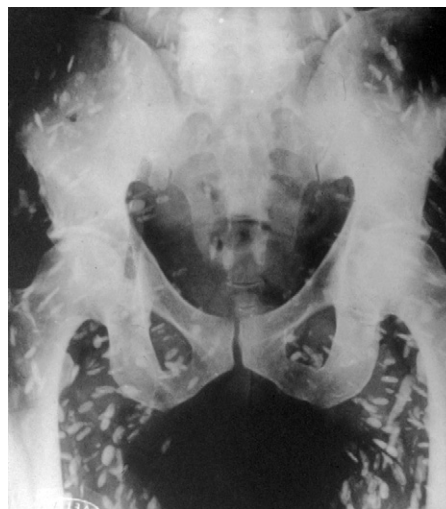


Fig. 6.14 Radiographic view of cysticerci of the larval form of pork tapeworm, *Taenia solium* (*Cysticercus cellulosae*), within human muscle.

Metacestode (Larval) Stages Found in the Abdominal Cavity of Food Animals

Parasite: *Taenia hydatigena* (adult tapeworm)/*Cysticercus tenuicollis* (metacestode [larval] stage)

Host: Dogs

Location of Adult: Small intestine

Intermediate Host: Cattle, sheep, goats

Distribution: Worldwide

Derivation of Genus: Flat band, bandage, or tape/bladder tail

Transmission Route: Ingestion of infective abdominal omentum of ruminants

Common Name: Canine taeniid/bovine bladder worm

Zoonotic: No

For *Taenia hydatigena*, an adult tapeworm found in the small intestine of dogs, the larval stage is a ping-pong-ball-sized, fluid-filled bladder called *Cysticercus tenuicollis*, which is usually attached to the greater omentum or other abdominal organs of the ruminant intermediate host (Fig. 6.15) and is considered nonpathogenic to the intermediate host. The adult worm has an armed rostellum. The proglottids have a single lateral genital pore. The eggs are typical taeniid-type ova with a striated embryophore surrounding an oncosphere with six hooklets inside. In large numbers, the adults can cause obstruction of the intestinal tract. To acquire this tapeworm, dogs become infected by ingesting the abdominal viscera of cysticercus-infected ruminants. For every cysticercus that is ingested by the dog, one adult tapeworm will develop in the small intestine of that dog. The diagnosis is made by finding the taeniid ova on standard fecal flotation. It is important that the veterinarian recognize the ruminant as the source of

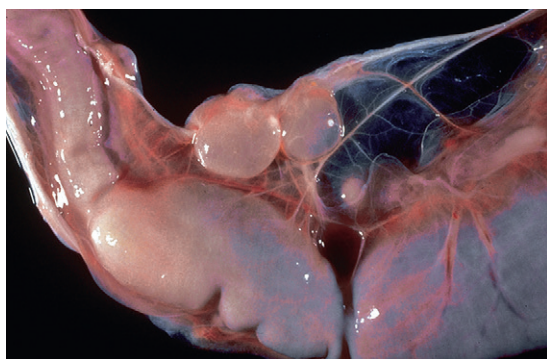


Fig. 6.15 The larval stage for *Taenia hydatigena* is a ping-pong-ball-sized, fluid-filled bladder (*Cysticercus tenuicollis*) that is usually attached to the greater omentum or other abdominal organs of the ruminant intermediate host.

this tapeworm and understand the importance of preventing predation or ingestion of ruminant offal by the dog. Necropsy of the intermediate host reveals the cysticercus stage in the abdominal cavity of the ruminant intermediate host.

Technician's Note

Typical taeniid-type eggs can be found on standard fecal flotation.

Horses

Intestinal Tract

Parasite: *Anoplocephala perfoliata*, *Anoplocephala magna*, and *Paranoplocephala mamillana*

Host: Horses

Location of Adult: Small intestine, large intestine, and cecum (*A. perfoliata*); small intestine and occasionally stomach (*A. magna* and *P. mamillana*)

Intermediate Host: Grain mites

Distribution: Worldwide

Derivation of Genus: Unarmed head/bearing an unarmed head

Transmission Route: Ingestion of infective grain mites

Common Name: Lappeted equine tapeworm

(*A. perfoliata*) and equine tapeworm with large scolex (*A. magna*); dwarf tapeworm (*P. mamillana*); collectively, equine tapeworms

Zoonotic: No

Technician's Note

Anoplocephala perfoliata adults are easily identified by their morphologic features (lappets just posterior to the scolex) and characteristic ovum with its pyriform apparatus.

Anoplocephala perfoliata, *Anoplocephala magna*, and *Paranoplocephala mamillana* are the equine tapeworms. *A. perfoliata* is found in the small and large intestine and cecum; *A. magna* and *P. mamillana* are found in the small intestine and occasionally the stomach. *A. perfoliata* can measure from 5 to 8 cm in length and up to 1.2 cm in width. The scolex is oblong, 2 to 3 mm in diameter, unarmed, with very prominent lappets (two round protuberances) behind each of the four suckers. The proglottids are wider than long, and each proglottid has only one set of male and female reproductive organs (Fig. 6.16). *A.*

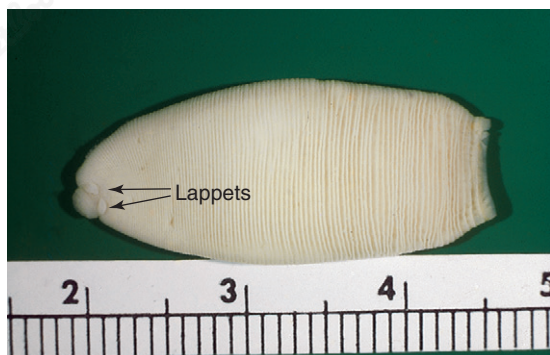


Fig. 6.16 Adult specimen of *Anoplocephala perfoliata*, an equine tapeworm. The scolex is oblong, is 2 to 3 mm in diameter, and has very prominent lappets behind each of four suckers. Proglottids are wider than they are long, and each has only one set of male and female reproductive organs.



Fig. 6.17 Adult specimen of *Anoplocephala magna*, an equine tapeworm. The scolex is quite large, 4 to 6 mm in diameter, and lacks prominent lappets.

magna can measure up to 80 cm in length and 2.5 cm in width. The scolex is large and oblong, 4 to 6 mm in diameter, unarmed but lacking the lappets of *A. perfoliata* (Fig. 6.17). *P. mamillana*, also known as the *dwarf tapeworm*, is only 6 to 50 mm in length and 4 to 6 mm in width (Fig. 6.18). The scolex is quite narrow. The adults of all three species can cause granulation tissue at the site of attachment in the intestinal wall.

The eggs of *A. perfoliata* are thick walled, with one or more flattened sides measuring 65 to 80 μm in diameter; those of *A. magna* are similar but slightly smaller, measuring 50 to 60 μm . The eggs of *P. mamillana* are oval and thin walled, measuring 51 $\times$ 37 μm . The eggs of all three species have a three-layered eggshell; the innermost lining is a pyriform (pear shaped) apparatus. The hexacanth embryo can be visualized just inside the pyriform apparatus

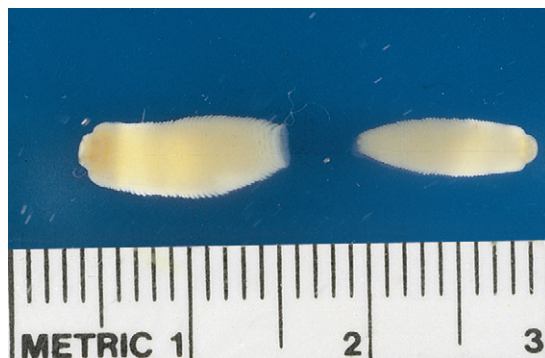


Fig. 6.18 Adult specimens of *Paranoplocephala mamillana*, the dwarf equine tapeworm. The scolex is quite narrow and lacks prominent lappets. Note: These specimens are entire specimens and not individual proglottids.



Fig. 6.19 Fecal flotation revealing the egg of *Anoplocephala perfoliata*. The egg is thick walled, with one or more flattened sides measuring 65 to 80 μm in diameter; those of *Anoplocephala magna* are similar but slightly smaller, measuring 50 to 60 μm . Eggs have an innermost lining called the *pyriform* (pear shaped) apparatus.

(Fig. 6.19). The eggs of all equine tapeworms can be recovered using standard fecal flotation. The prepatent period for all three species ranges from 28 to 42 days.

Technician's Note



All three species of equine tapeworms can be identified on standard fecal flotation by observing their triangular, three-layered-shell ova with the pyriform apparatus.

As in *Moniezia* species in ruminants, the metacystode (larval) stage of equine tapeworms is the cysticercoid stage,

which may be found within the intermediate hosts, oribatid grain mites. Intact proglottids and eggs are found in the feces of the equine definitive host. Mites become infected by ingesting the hexacanth embryo, which develops into the cysticercoid stage within the body of the grain mites. Horses become infected by ingesting cysticercoid-infected mites infesting the grain. The cysticercoid is a microscopic stage and probably will not be observed by the veterinarian. For every cysticercoid that is ingested by the ruminant, one adult tapeworm will develop in the small intestine of that ruminant (see Fig. 6.10). It is important that the veterinarian recognize the oribatid mite as the source of this tapeworm and understand the importance of pasture rotation and effective tapeworm therapeutics (pyrantel pamoate and pyrantel tartrate; praziquantel has been used with success but is not approved by the U.S. Food and Drug Administration [FDA]) in horses.

Technician's Note



Pasture rotation and deworming protocols are effective in reducing these equine tapeworms in horses.

True Tapeworms of Dogs and Cats

Tapeworms that infect dogs and cats are *Dipylidium caninum*, *Taenia pisiformis*, *Taenia hydatigena*, *Taenia ovis*, *Taenia taeniaeformis*, *Multiceps multiceps*, *Multiceps serialis*, *Echinococcus granulosus*, *Echinococcus multilocularis*, and *Mesocostoides* species.

Dipylidium caninum

Parasite: ♦ *Dipylidium caninum*

Host: Dogs and cats

Location of Adult: Small intestine

Intermediate Host: Adult fleas

Distribution: Worldwide

Derivation of Genus: Having two entrances

Transmission Route: Ingestion of infective adult flea

Common Name: Double-pored tapeworm or cucumber seed tapeworm

Zoonotic: Yes

Dipylidium caninum is often called the *double-pored* or *cucumber seed tapeworm*. This is the most common tapeworm found in the small intestine of the dog and cat because the dog or cat becomes infected by ingesting the flea intermediate host. Fleas often contain this parasite's infective cysticercoid stage. The adult tapeworm can grow to a length of 50 cm (Fig. 6.20). The scolex of this tapeworm is armed and consists of a prominent proboscis

covered with rearward-facing, rose-thorn-like hooks (Fig. 6.21). This tapeworm usually demonstrates its presence by the release of and the appearance of its motile terminal gravid proglottids, which are usually found on the feces (Fig. 6.22). They may also be found on the pet's hair coat or in the bedding of the host. In the fresh state, these proglottids resemble cucumber seeds (cucumber seed tapeworm). These proglottids have a lateral pore located along the midpoint of each of their long edges (double-pored tapeworm) (Fig. 6.23). Gravid proglottids contain thousands of unique egg packets, each containing 20 to 30 hexacanth embryos (Fig. 6.24). (Fig. 6.25 shows an individual



Fig. 6.20 Adult specimen of *Dipylidium caninum*, the double-pored or cucumber seed tapeworm of dogs and cats. Adult tapeworms can grow to 50 cm long. This tapeworm usually demonstrates its presence by the release and appearance of motile terminal gravid proglottids, which are usually found on feces, the hair coat, or bedding. In the fresh state, proglottids resemble cucumber seeds, thus the common name *cucumber seed tapeworm*.



Fig. 6.21 The scolex of *Dipylidium caninum* is armed and consists of a prominent proboscis covered with rearward-facing, rose-thorn-like hooks.



Fig. 6.22 *Dipylidium caninum* usually demonstrates its presence by the release and appearance of motile terminal gravid proglottids which are usually found on feces.

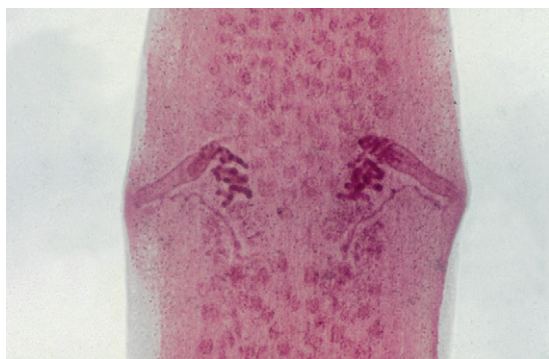


Fig. 6.23 These proglottids of *Dipylidium caninum* have a lateral pore along the midpoint of each long edge, thus the second common name *double-pored tapeworm*.

egg packet of *D. caninum* containing hexacanth embryos.) The proglottids of *D. caninum* often dry out in the external environment. As they lose moisture, they shrivel up, resembling uncooked grains of rice (Fig. 6.26). If reconstituted with water, the dried proglottids usually assume their former cucumber seed appearance. The prepatent period for *D. caninum* is 14 to 21 days.

Technician's Note



In sufficient numbers, adult *Dipylidium caninum* tapeworms can cause intestinal obstruction in the host.

The metacestode (larval) stage of this tapeworm is the cysticercoid stage, which may be found within the flea intermediate host. Larval fleas become infected by ingesting the hexacanth embryo, which develops into the cysticercoid

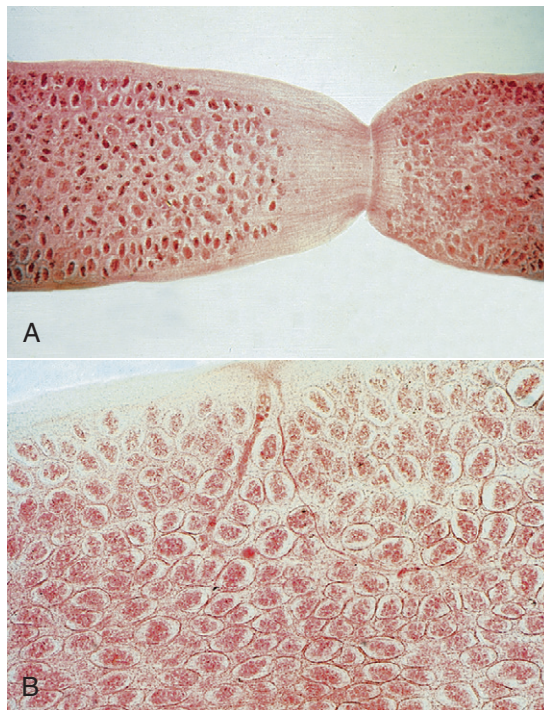


Fig. 6.24 Gravid proglottids of *Dipylidium caninum* are filled with thousands of egg packets. **A**, Gravid proglottid showing egg packets. **B**, Close-up of gravid proglottid showing egg packets containing hexacanth embryos.



Fig. 6.25 If fresh proglottids of *Dipylidium caninum* are teased or broken open, they may reveal thousands of egg packets, each containing 20 to 30 hexacanth embryos.

stage within the body of the adult flea. Dogs and cats become infected by ingesting cysticercoid-infected adult fleas (Fig. 6.27). The cysticercoid is a microscopic stage and probably will not be observed by the veterinarian.



Fig. 6.26 Dried proglottids of *Dipylidium caninum* resemble uncooked grains of rice. When water is added, they assume their natural state.

For every cysticercoid that is ingested by the dog or cat, one adult tapeworm will develop in the small intestine of that dog or cat. If a human (e.g., child) ingests a flea containing the cysticercoid stage, this tapeworm will develop to the adult stage within the small intestine. It is a zoonotic parasite.

This tapeworm is typically diagnosed in one of two ways. The egg packets can be found on fecal flotation (see Fig. 6.24) if the gravid proglottids dry up and release the egg packets. The gravid proglottids may also be seen by the client in the feces, on bedding, or in the hair coat. It is important that the veterinarian recognize the flea as the source of this tapeworm and understand the importance of flea control in effective tapeworm therapeutics. *D. caninum* is typically treated with a single dose of praziquantel or epsiprantel. All pets in the household must be treated for both fleas and tapeworms.

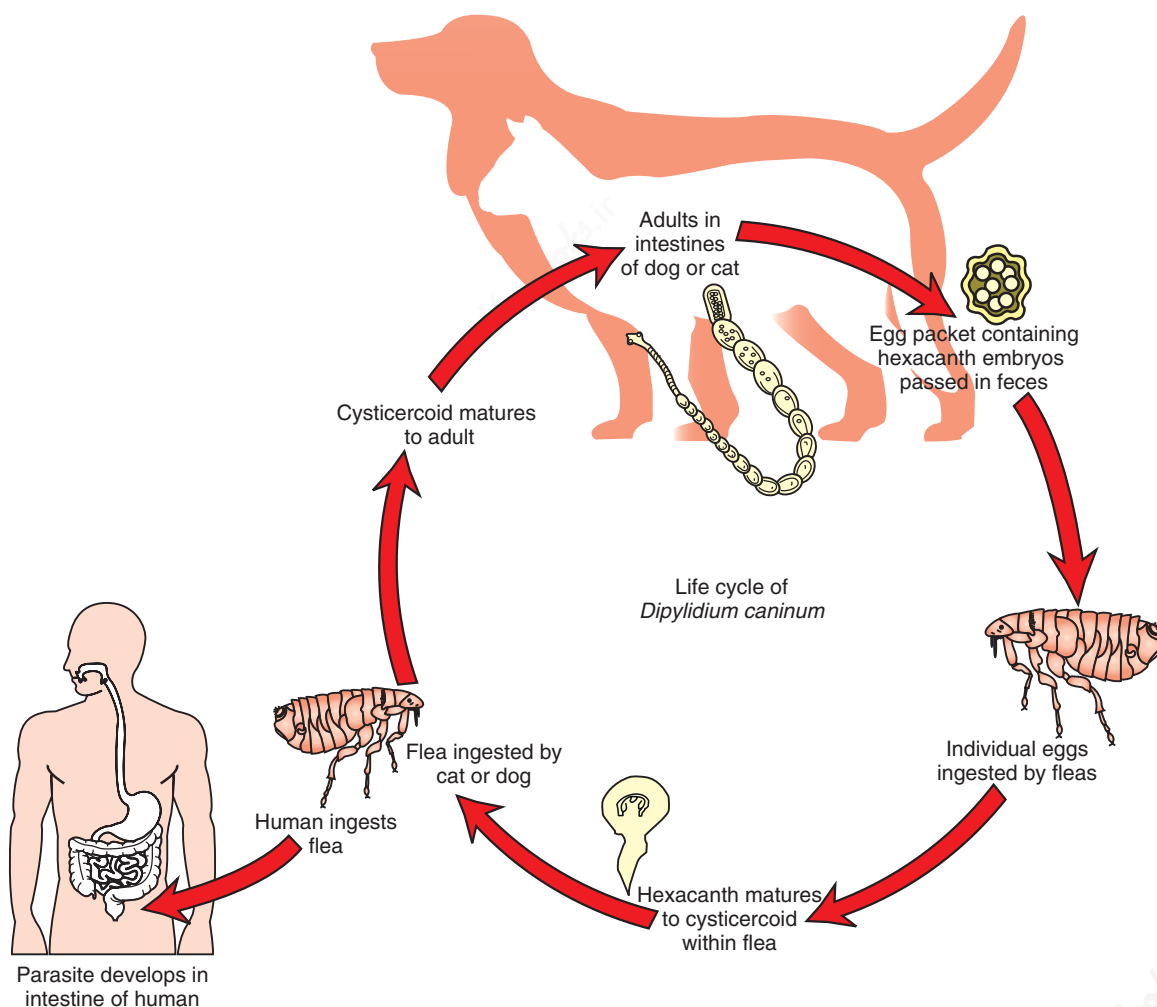


Fig. 6.27 Life cycle of *Dipylidium caninum*.

CASE PRESENTATION 6-1

Setting Up the Scenario

Mr. Michelson presented Pixie, a 3-year-old spayed Persian cat, for her annual physical examination and routine vaccinations. During the history-taking session, Mr. Michelson revealed to you that Pixie had what appeared to be tapeworm proglottids, moving “creatures” resembling grains of cooked white rice, in her fresh stool sample and on the living room couch where she often naps. A fecal sample was performed, and one of the tapeworm proglottids was torn open to release the characteristic egg packets of *Dipylidium caninum*. Dr. James will administer a cestocide to remove this very common problem tapeworm but has asked you, as the veterinary technician, to educate Mr. Michelson regarding the details of *D. caninum*'s life cycle and zoonotic importance.

What Information Must the Veterinary Technician Convey to Mr. Michelson?

The veterinary technician enters the examination room and begins the explanation. “Mr. Michelson, Pixie has been diagnosed with *D. caninum*, a helminth parasite often referred to as the *cucumber seed tapeworm* or the *double-pored tapeworm*. To complete its life cycle, this tapeworm uses the flea as an intermediate host. The flea is the means by which this tapeworm is transmitted from an infected dog or cat to an uninfected dog or cat. Because Pixie is not subjected to any routine flea-control programs, she has become infested with fleas. If Pixie is infested with

fleas within her hair coat, I am sorry to inform you that your home will also be infested with fleas; in fact, there are several developmental life cycle stages of fleas that may be found throughout Pixie's environment (your home or your yard). It is the flea that makes the transmission of *D. caninum* possible. Pixie was infected by ingesting at least one adult flea containing the infective stage of the tapeworm. Dr. James has prescribed medication to remove the tapeworms, but you must use additional flea-control programs to reduce the flea population in and on Pixie, your other pets, your home, and your yard. Removing fleas from the environment will prevent reinfection with the tapeworms and infection in your other pets if they happen to ingest infected fleas. Because fleas can be found year-round, we recommend treating all of your pets with an established year-round flea control program to prevent reinfestation with fleas and the accompanying reinfection with tapeworms.

“It is also important to understand that humans, especially children, can become infected with *D. caninum* if these infective fleas are ingested. Therefore flea treatment on your pets and in your house and yard will protect you and your family from infection with this tapeworm. Do you have any questions?”

The veterinary technician noted in Pixie's medical record that these discussions regarding flea control and prevention, especially the portion regarding the zoonotic potential of *D. caninum*, had taken place with Mr. Michelson.

Technician's Note

Dipylidium caninum can be diagnosed by finding the characteristic egg packets on standard fecal flotation (this tends to be rare) or by observing the gravid proglottids in the feces.

***Taenia pisiformis*, *Taenia hydatigena*, and *Taenia ovis*/Cysticercus *pisiformis*, *Cysticercus tenuicollis*, and *Cysticercus ovis* (Metacestode [larval] tapeworm)**

Parasite: *Taenia pisiformis*, *Taenia hydatigena*, and *Taenia ovis*

Host: Dogs

Location of Adult: Small intestine

Intermediate Host: Rabbits and hares (*T. pisiformis*); ruminants (*T. hydatigena*); sheep (*T. ovis*)

Distribution: Worldwide

Derivation of Genus: Flat band, bandage, or tape

Transmission Route: Ingestion of infective intermediate host

Common Name: Canine taeniid (*T. pisiformis* and

T. hydatigena); mutton tapeworm of dogs (*T. ovis*)

Zoonotic: No

Taenia pisiformis, *Taenia hydatigena*, and *Taenia ovis* are the canine taeniids. The canine taeniids measure from 1 to 2 cm (*T. ovis*) to 200 cm (*T. pisiformis*) and up to 75 to 500 cm (*T. hydatigena*) in length. These adult taeniids are found within the small intestine of the canine definitive host (Fig. 6.28), where, in sufficient numbers, they can cause intestinal obstruction. The scolex of all these tapeworms is armed, consisting of two rows of rostellar hooks (Fig. 6.29). As with *D. caninum*, the *Taenia* species manifest by the appearance of motile, terminal, gravid proglottids on the feces, on the pet's hair coat, or in the bedding of the host. In the fresh state, these proglottids have a single lateral pore located along the midpoint of either of their long edges (unlike the double-pored tapeworm) (Fig. 6.30).



Fig. 6.28 Adult canine taeniids are found in the small intestine of the canine definitive host.



Fig. 6.29 Details of the scolex of the canine taeniid. Note the four suckers and armed rostellum.

Technician's Note



Gravid proglottids found in the feces can be teased open and the ova identified as *Dipylidium* or taeniid-type ova to speciate the genus of the tapeworm represented by the gravid proglottids.

As with *D. caninum*, if the fresh proglottids are teased or broken open, they may reveal typical hexacanth embryos (Fig. 6.31). These hexacanth embryos have a striated egg-shell (called the **embryophore**) and contain six hooks (or teeth) within the interior of the egg. This egg is referred to as a **typical taeniid type of egg**. The proglottids of *Taenia* species also dry out in the external environment and resemble uncooked grains of rice. If reconstituted with water, they usually assume their former single-pored appearance. If gravid proglottids of *Taenia* species are recovered from a dog's or cat's feces, the proglottid should be torn

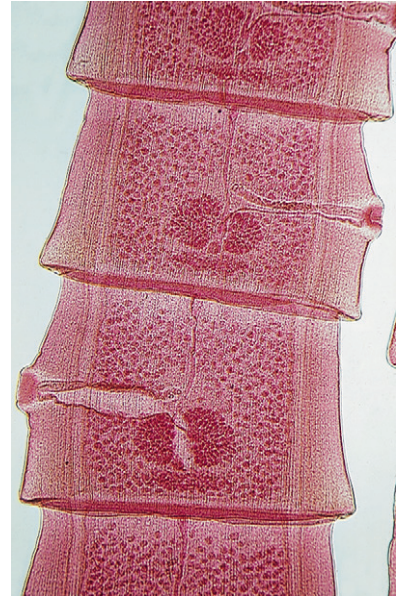


Fig. 6.30 Mature proglottids of *Taenia* species demonstrating a single lateral pore located along the midpoint of long edges (as opposed to the double-pored tapeworm).



Fig. 6.31 Tapeworm egg, or hexacanth embryo. Tapeworm eggs are released to the outside environment. Each tapeworm egg is infective for the intermediate host and produces one metacystode stage. The unmarked egg is an *Ancylostoma caninum*.

open or macerated in a drop of saline solution on a glass slide to reveal the characteristic eggs under the compound microscope.

The eggs of the taeniid tapeworms are slightly oval and are 43 to 53 μm $\times$ 43 to 49 μm in diameter (*T. pisiformis*), 36 to 39 μm $\times$ 31 to 35 μm in diameter (*T. hydatigena*), and 19 to 31 μm $\times$ 24 to 26 μm in diameter (*T. ovis*).

Eggs of *Taenia* species contain a single **oncosphere** (literally a “growth ball”) with three pairs of hooks (six total). The oncosphere is often called a *hexacanth embryo*. The eggs of the taeniids are very similar to those of *Echinococcus* and *Multiceps* species.

The metacestode (larval) stage for *T. pisiformis*, *T. hydatigena*, and *T. ovis* is the cysticercus, or bladder worm stage, which may be found within the respective rabbit, ruminant, or ovine intermediate hosts.

Technician's Note



The intermediate hosts of the canine taeniid tapeworms ingest the ova from the feces of the canine host. The ova then develop into a cysticercus stage in the intermediate host.

For *T. pisiformis* and *T. hydatigena*, the rabbit and the ruminant become infected by ingesting the taeniid eggs or hexacanth embryos, often found close to canine feces. These embryos hatch and develop into the cysticercus stage within the peritoneal cavity of the intermediate hosts. For *T. pisiformis*, the larval stage is a pea-sized, fluid-filled bladder (called *Cysticercus pisiformis*), usually attached to the greater omentum or other abdominal organs of the rabbit (Fig. 6.32). Dogs become infected by killing and ingesting cysticercus-infected rabbits. For every cysticercus that is ingested by the dog, one adult tapeworm develops in the small intestine of that dog (Fig. 6.33). It is important that the veterinarian recognize the rabbit as the source of this tapeworm and understand the importance of preventing predation or the ingestion of rabbit carrion by the dog. *T. pisiformis* can be treated with praziquantel or epsiprantel.

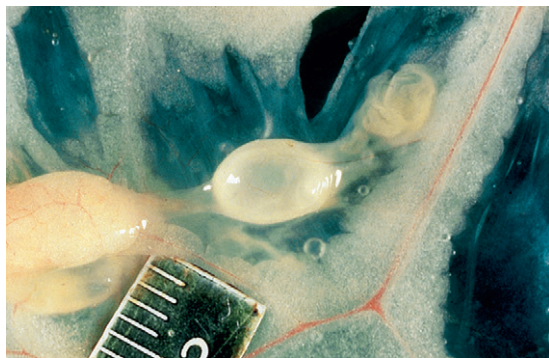


Fig. 6.32 The larval stage for *Taenia pisiformis* is a pea-sized, fluid-filled bladder (*Cysticercus pisiformis*). The larval stage is usually attached to the greater omentum or other abdominal organs of the rabbit intermediate host.

For *T. hydatigena*, the tenuicollis stage is a ping-pong-ball-sized, fluid-filled bladder (called *Cysticercus tenuicollis*), usually attached to the greater omentum or other abdominal organs of the ruminant intermediate host (Fig. 6.34; see also Fig. 6.15). To acquire this tapeworm, dogs become infected by ingesting the abdominal viscera of cysticercus-infected ruminants (see Fig. 6.33). For every cysticercus that is ingested by the dog, one adult tapeworm will develop in the small intestine of that dog. It is important that the veterinarian recognize the ruminant as the source of this tapeworm and understand the importance of preventing predation or ingestion of ruminant offal by the dog.

For *T. ovis*, the larval stage is a fluid-filled bladder (called *Cysticercus ovis*) found within the musculature of the ovine intermediate host (very similar to the cysticerci of *C. bovis* and *C. cellulosae* described earlier) (see Fig. 6.13). To acquire this tapeworm, dogs become infected by ingesting the musculature of cysticercus-infected sheep (see Fig. 6.33). For every cysticercus that is ingested by the dog, one adult tapeworm will develop in the small intestine of that dog. It is important that the veterinarian recognize sheep muscle (uncooked mutton) as the source of this tapeworm and understand the importance of preventing predation and ingestion of sheep muscle by dogs.

Technician's Note



The dog is infected with the canine taeniid by eating the intermediate host containing the cysticercus stage of the tapeworm. Preventing predation of the intermediate host will stop the life cycle of the tapeworm.

Taenia taeniaeformis (*Hydatigera taeniaeformis*)

Parasite: *Taenia taeniaeformis*/*Cysticercus fasciolaris*
(metacestode [larval] stage)

Host: Cats

Location of Adult: Small intestines

Intermediate Host: Rats and mice

Distribution: Worldwide

Derivation of Genus: Flat band, bandage, or tape

Transmission Route: Ingestion of infective rats or mice

Common Name: Feline taeniid or feline tapeworm

Zoonotic: No

Taenia taeniaeformis, or *Hydatigera taeniaeformis*, is called the *feline tapeworm* or the *feline taeniid*. This tapeworm, which may be up to 60 cm in length, is observed infrequently in cats that are allowed to roam and prey on

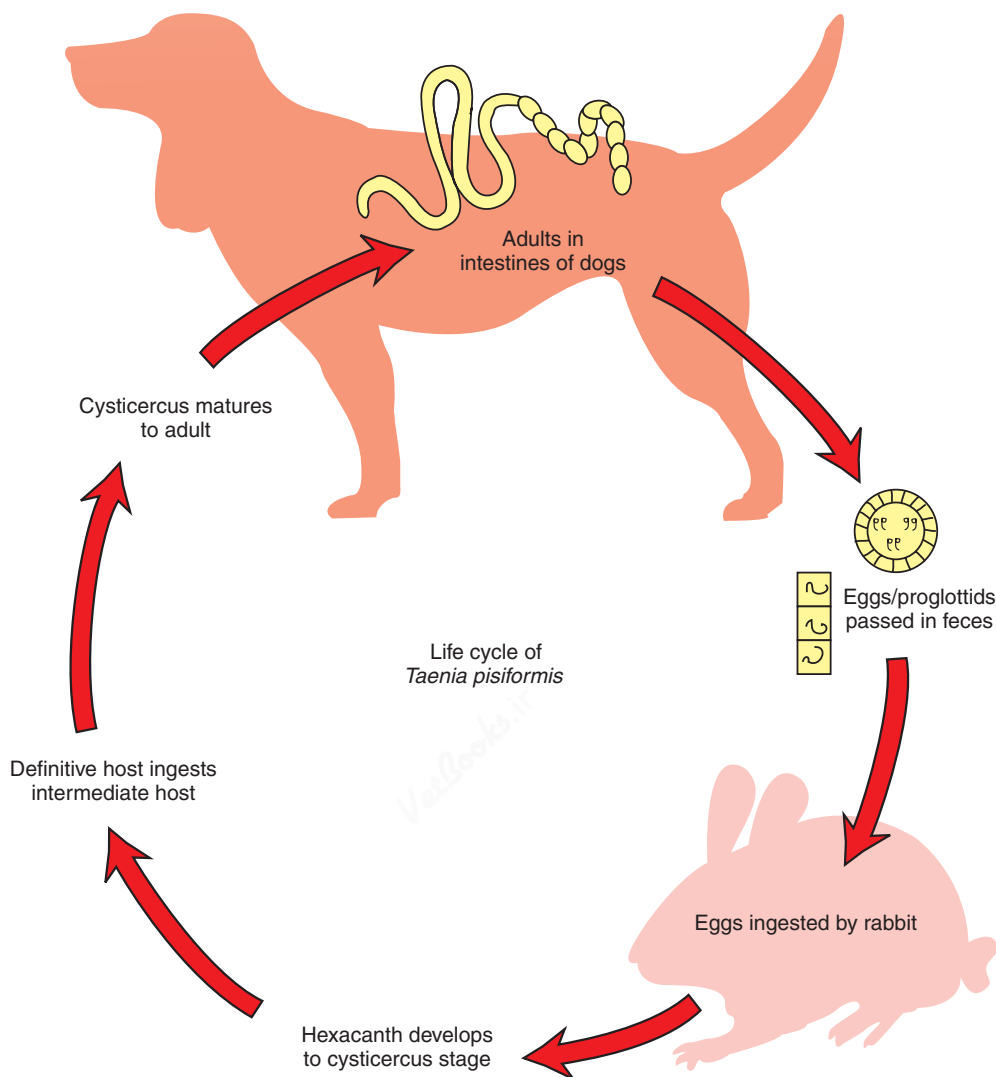


Fig. 6.33 Life cycle of *Taenia pisiformis*.

rabbits and rodents. The armed scolex is similar to that of the canine taeniids, as are the proglottids; however, in the fresh or intact state, the terminal proglottids of *T. taeniaeformis* are said to be bell shaped. The egg of this tapeworm is 31 to 36 μm in diameter and contains a single oncosphere with three pairs of hooks. For this reason, the oncosphere is often called a *hexacanth* (or six-toothed) *embryo*. As with the eggs of the canine taeniids, the egg is very similar to that of the *Echinococcus* species. (See Fig. 6.31 for unique features of this taeniid type of tapeworm egg.)

Technician's Note

Taenia taeniaeformis produces a taeniid-type ovum and appears similar to that of the canine taeniids, except the terminal proglottids are bell shaped.

The metacestode (larval) stage for *T. taeniaeformis* is the **strobilocercus**, a morphologic variation of the cysticercus (bladder worm) stage. For *T. taeniaeformis* to develop,



Fig. 6.34 The larval stage for *Taenia hydatigena* is a ping-pong-ball-sized, fluid-filled bladder (*Cysticercus tenuicollis*), usually attached to the greater omentum or other abdominal organs of the ruminant intermediate host.



Fig. 6.35 The larval stage for *Taenia taeniaeformis* is a strobilocercus (*Cysticercus fasciolaris*). The strobilocercus is a scolex attached to a long neck, which connects to a bladder.

the rodent intermediate host becomes infected by ingesting the taeniid eggs, or hexacanth embryos, often found in proximity to feline feces. The embryo hatches and develops into the cysticercus stage within the liver of the intermediate host. For the first 42 days in this location, it develops as a cysticercus. On day 42, however, the cysticercus changes its form into that of a strobilocercus. For *T. taeniaeformis*, the strobilocercus is a scolex attached to a long neck, which connects to a bladder; this stage has the scientific name *Cysticercus fasciolaris* (Figs. 6.35, 6.36, and 6.37). The cat becomes infected by killing the rat or mouse and ingesting the strobilocercus from the liver. The neck and its connected bladder are digested, the scolex attaches, and the tapeworm begins to grow in the cat's intestine (see Fig. 6.33). For every strobilocercus that is ingested by the cat, one adult tapeworm will develop in the small intestine of that cat. It is important that the veterinarian recognize the rat or mouse as the source of this tapeworm and understand the importance of preventing predation or the ingestion of rat or mouse carrion by the cat. The cat can be treated with praziquantel.

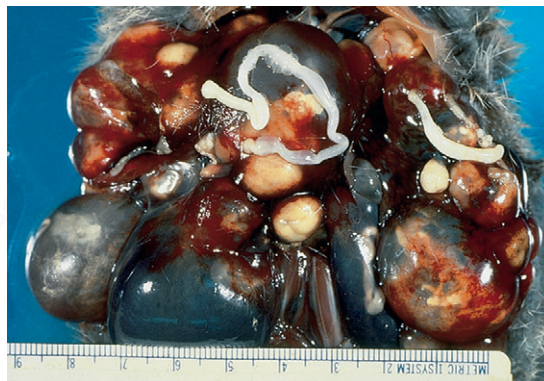


Fig. 6.36 The strobilocercus is found in the liver of a rodent intermediate host.



Fig. 6.37 Detail of an individual strobilocercus, *Cysticercus fasciolaris*.

Technician's Note



Taenia taeniaeformis uses a strobilocercus as its metacystode stage. The strobilocercus is a fluid-filled bladder that connects to a long strobila that connects to a scolex. This life cycle stage is unique because it is like no other taeniid tapeworm life cycle.

Multiceps multiceps* and *Multiceps serialis*, also known as *Taenia multiceps* and *Taenia serialis

Parasite: *Multiceps multiceps* and *Multiceps serialis*/*Coenurus cerebralis*, *Coenurus serialis* (metacestode [larval] tapeworm)

Host: Dogs

Location of Adult: Small intestines

Intermediate Host: Sheep (*M. multiceps*) and rabbits (*M. serialis*)

Distribution: Worldwide (*M. multiceps*)

Derivation of Genus: Many heads

Transmission Route: Ingestion of infected intermediate host

Common Name: Coenurus-producing tapeworm

Zoonotic: No

Multiceps multiceps and *Multiceps serialis* are also taeniid tapeworms of the small intestine of canids. The adults of *M. multiceps* are 40 to 100 cm in length; those of *M. serialis* can grow up to 72 cm. Both possess a scolex with a double row of rostellar hooks. In sufficient numbers, the adult tapeworms can obstruct the intestinal tract.

The eggs of *M. multiceps* are 29 to 37 μm in diameter, and those of *M. serialis* are elliptic and measure 31 to 34 μm $\times$ 29 to 30 μm . Both contain a single oncosphere with three pairs of hooks. As with the eggs of the canine and feline taeniids, the eggs of *Multiceps* species are very similar to those of *Taenia* and *Echinococcus* species. (See Fig. 6.31 for unique features of this taeniid type of tapeworm.)

Technician's Note

The taeniid-type ova of *Multiceps* species can be found on standard fecal flotation.

The metacestode (larval) stage for *M. multiceps* and *M. serialis* is the **coenurus** stage, which may be found within the respective ovine or rabbit intermediate host. This coenurus also has a scientific name: *Coenurus cerebralis* for *M. multiceps* and *Coenurus serialis* for *M. serialis*. It is essentially a single large bladder with several invaginated scolices attached to its inner wall. The coenurus is found within the tissues of the respective intermediate host. For each coenurus that is ingested by the dog, several adult tapeworms develop, one for each invaginated scolex ingested.

For *M. multiceps*, the sheep intermediate host becomes infected by ingesting taeniid eggs, or hexacanth embryos, which are often found close to canine feces. These embryos hatch and migrate to neurologic tissue (either brain or

spinal cord tissue), where they develop into the coenurus stage within the tissue hosts. Naturally, the presence of these large space-occupying lesions within the brain and spinal cord can produce neurologic signs in the infected sheep. The larval stage of *M. multiceps* may be up to 5 cm in diameter and is a fluid-filled bladder (called *C. cerebralis*) with many individual scolices lining the walls of the bladder. Dogs become infected either by killing the sheep and ingesting coenurus-infected neural tissue or by being fed such tissue by their shepherd owners. For every coenurus that is ingested by the dog, many adult tapeworms will develop in the small intestine of that dog. It is important that the veterinarian recognize the sheep as the source of this tapeworm and understand the importance of preventing predation or the ingestion of sheep carrion or offal by the dog.

Technician's Note

Multiceps multiceps is associated with the formation of a coenurus in the brain or nervous tissue of the ovine intermediate host.

For *M. serialis*, the rabbit intermediate host becomes infected by ingesting the taeniid eggs or hexacanth embryos often found in proximity to canine feces. These embryos hatch and migrate to the rabbit's subcutaneous tissues, where they develop into the coenurus stage. The presence of these large bladder-like cysts within the subcutaneous tissues of the rabbit can interfere with movement and speed, making the rabbit easy prey. For *M. serialis*, the larval stage may be up to 4 cm in diameter and is a fluid-filled bladder called *C. serialis* (Fig. 6.38), with many individual invaginated scolices lining the walls of the bladder. Dogs become infected either by killing the slow-moving rabbit and ingesting coenurus-infected subcutaneous tissues or by being fed such tissues by their rabbit-hunting owners. For every coenurus that is ingested by the dog, many adult tapeworms will develop in the small intestine of that dog. It is important that the veterinarian recognize the rabbit as the source of this tapeworm and understand the importance of preventing predation or the ingestion of rabbit carrion or offal by the dog.

Technician's Note

Multiceps serialis is associated with the formation of a coenurus in the subcutaneous or intermuscular connective tissue of the rabbit intermediate host.

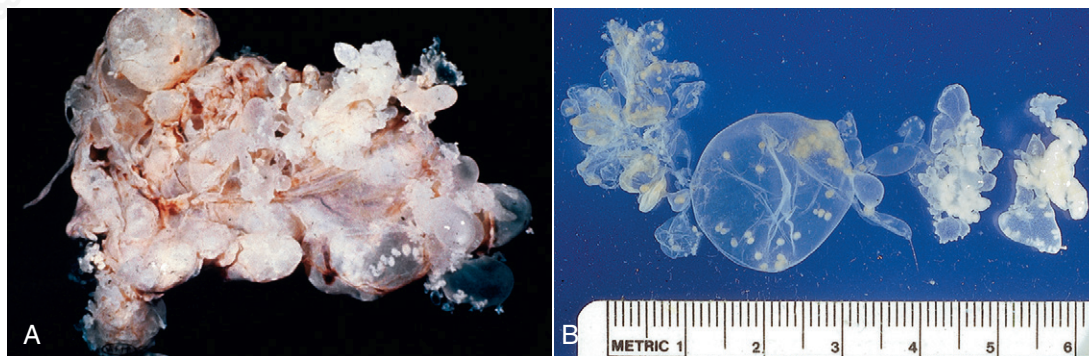


Fig. 6.38 **A**, *Coenurus serialis* from subcutaneous connective tissues of a rabbit. **B**, Note the individual invaginated scolices lining the walls of the bladder.

Echinococcus granulosus* and *Echinococcus multilocularis

Parasite: ♦ *Echinococcus granulosus* and *Echinococcus multilocularis*

Host: Dogs (*E. granulosus*); cats (*E. multilocularis*)

Location of Adult: Small intestine

Intermediate Host: Sheep, cattle, and other herbivores (*E. granulosus*); rats, mice, and voles (*E. multilocularis*); humans (both)

Distribution: Worldwide (*E. granulosus*); countries in the Northern Hemisphere (*E. multilocularis*)

Derivation of Genus: Spiny berry

Transmission Route: Ingestion of infective intermediate host

Common Name: Unilocular hydatid tapeworm (*E. granulosus*); multilocular hydatid tapeworm (*E. multilocularis*)

Zoonotic: Yes

Echinococcus granulosus and *Echinococcus multilocularis* are the hydatid disease tapeworms associated with unilocular and multilocular hydatid disease. *E. granulosus* is the hydatid cyst tapeworm of dogs, and *E. multilocularis* is the hydatid cyst tapeworm of cats. These are important parasites because of their extreme zoonotic potential.

The adult *Echinococcus* is a tiny tapeworm, only 1.2 to 7 mm in length. The entire tapeworm has a scolex, followed by only three proglottids: immature, mature, and gravid (Fig. 6.39). When passed, the tiny gravid proglottids likely will be overlooked by the client, the veterinary technician, and the veterinarian. Definitive diagnosis of *Echinococcus* species infection is best achieved by identifying adult tapeworms taken from the host's intestinal tract. In the rare instance in which *Echinococcus* species infection is suspected, antemortem diagnosis is accomplished by purging the dog or cat using arecoline hydrobromide and collecting its feces.



Fig. 6.39 Adult *Echinococcus* species is a tiny tapeworm, only 1.2 to 7 mm in length. The entire tapeworm has only three proglottids: immature, mature, and gravid.

Technician's Note



The adult *Echinococcus* tapeworms cannot accumulate in sufficient numbers to cause intestinal blockage. Their pathogenicity lies in the fact that their eggs can develop into unilocular or multilocular (depending on species) **hydatid cysts** in the liver, lungs, or brain of the intermediate hosts.

Purging the infected dog or cat is usually performed only when infection is strongly suspected. Entire worms or their proglottids may be collected from the final clear mucus. Because of serious zoonotic potential, all evacuated material should be handled with caution. After the feces have been examined, the evacuate should be incinerated. Rubber gloves should be worn when handling suspect feces.

Diagnosis of *Echinococcus* species in either a definitive or an intermediate host warrants reporting to state and federal authorities.

The egg of *E. granulosus* is ovoid, 32 to 36 μm $\times$ 25 to 30 μm , and contains a single oncosphere with three

pairs of hooks. The egg of *E. multilocularis* is ovoid, 30 to 40 μm , and contains a single oncosphere with three pairs of hooks. Because of serious zoonotic potential (see Chapter 16), any “suspect” eggs of *Echinococcus* species should be handled with extreme caution. These eggs are very similar in appearance to those of *Taenia* and *Multiceps* species. (See Fig. 6.31 for unique features of this taeniid type of tapeworm.)

The metacestode (larval) stage for *E. granulosus* and *E. multilocularis* is the hydatid cyst stage, which may be found within the respective ruminant or rodent intermediate host. The hydatid cyst for *E. granulosus* is a **unilocular hydatid cyst** found within the liver, lung, and other organs of the ruminant intermediate host. The hydatid cyst for *E. multilocularis* is a **multilocular or alveolar hydatid cyst** found within the liver or lungs of the rodent intermediate host. Humans may also serve as an intermediate host for both of these tapeworms. Humans become infected by ingesting the eggs of these tapeworm species.

The unilocular (single-compartment) hydatid cyst of *E. granulosus* has a thick cyst wall with a thin germinal membrane located just inside it. Brood capsules containing protoscolices “bud” from this germinal membrane. When a dog ingests the hydatid cyst containing the brood capsules and protoscolices, each protoscolex develops into an adult tapeworm (Fig. 6.40).

Technician's Note

Humans can serve as an intermediate host for both species of *Echinococcus* tapeworms.

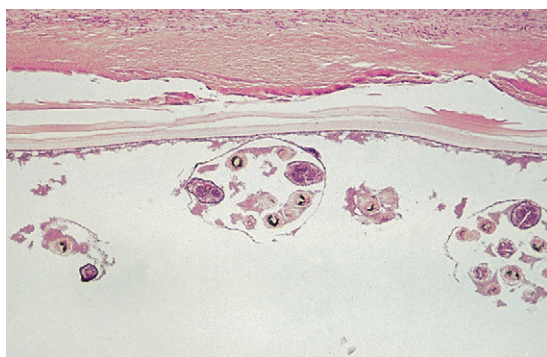


Fig. 6.40 Photomicrograph of a unilocular hydatid cyst of *Echinococcus granulosus* showing a thick multilayered wall and a thin, granular germinal membrane. Spherical brood capsules containing protoscolices arise from the germinal membrane.

The multilocular (multicompartment) hydatid cyst of *E. multilocularis* lacks the thick cyst wall of the unilocular hydatid cyst. It is often described as *alveolar* or similar to a “bunch of grapes.” Lacking the thick cyst wall of the unilocular cyst, the multilocular cyst is very invasive, often replacing normal tissue, similar to a malignant cancer. It also possesses a thin germinal membrane. Brood capsules containing protoscolices bud from the germinal membrane. When a cat ingests the hydatid cyst containing the brood capsules and protoscolices, each protoscolex will develop into an adult tapeworm in the intestine of the cat.

Praziquantel can be used to treat adult *Echinococcus* worms but will not affect the hydatid cyst stage. The best treatment for the hydatid cyst stage of the parasites is preventing ingestion of the eggs.

Technician's Note

Echinococcus species are the tiniest tapeworms of veterinary parasitology, but “dynamite comes in little packages.” As zoonotic diseases go, these tapeworms pack a BIG PUNCH! If diagnosed, this parasite must be reported to state and federal authorities.

Mesocestoides Species

Parasite: *Mesocestoides* species

Host: Dogs, cats, and other carnivores

Location of Adult: Small intestine

Intermediate Host: First intermediate host, oribatid mite; second intermediate host, rats and mice

Distribution: North America, Asia, Europe, and Africa

Derivation of Genus: The form of a middle girdle

Transmission Route: Ingestion of infective intermediate host

Common Name: Tetrathyridium tapeworm

Zoonotic: No

Mesocestoides species may parasitize the small intestine of carnivores, including the dog and the cat. These are small- to medium-sized true tapeworms, ranging from 12 cm to more than 2 m in length (Fig. 6.41). The scolex of this tapeworm is oblong with four suckers, is unarmed (Fig. 6.42), and has a centrally located uterine pore. In sufficient numbers, the adult tapeworms can cause intestinal obstruction. Gravid proglottids of *Mesocestoides* have a unique appearance (Fig. 6.43). The eggs of *Mesocestoides* species contain a single oncosphere (hexacanth embryo) with three pairs of hooks. (See Fig. 6.44 for features of this egg.) The striated embryophore (shell) is lacking.

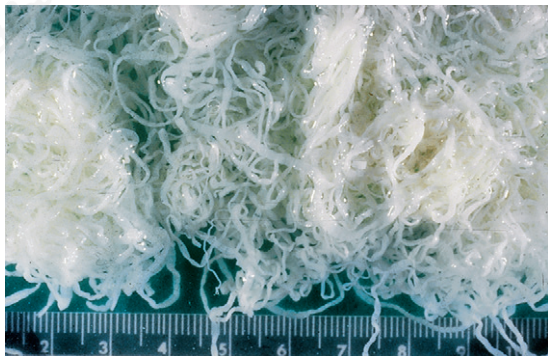


Fig. 6.41 Adult *Mesocostoides* species are medium-sized tapeworms, ranging from 12 cm to more than 2 m long.



Fig. 6.42 The scolex of *Mesocostoides* species is oblong, has four suckers, and is unarmed.



Fig. 6.43 Gravid proglottids of *Mesocostoides* have a unique appearance.



Fig. 6.44 Eggs of *Mesocostoides* species contain a single oncosphere with three pairs of hooks. The oncosphere is often called a *hexacanth embryo*.

Technician's Note



Mesocostoides species of tapeworms are unusual true tapeworms in that they use two intermediate hosts instead of one intermediate host.

Mesocostoides is an unusual genus among the true tapeworms in that it is the only one that uses two intermediate hosts. (The pseudotapeworms described in the next section use two intermediate hosts.) The egg is a hexacanth

embryo. If it is ingested by an oribatid mite, it develops into a cysticercoid within that mite (much like the cysticercoids of *Dipylidium*, *Moniezia*, *Thysanosoma*, and *Anoplocephala* species). If this cysticercoid-containing mite is ingested by a mouse or reptile, the cysticercoid develops into a **tetrathyridium**, a solid-bodied metacestode stage with a deeply invaginated, acetabular scolex (Fig. 6.45). This tetrathyridium is approximately 1 cm in diameter and is capable of multiplying exponentially; that is, one tetrathyridium becomes two, two become four, four become eight, and so on (Figs. 6.46 and 6.47). This type of asexual reproduction



Fig. 6.45 The metacystode stage for *Mesocestoides* species is a tetrathyridium, a solid-bodied metacystode stage with a deeply invaginated, acetabular scolex.

produces large numbers of tetrathyridia that are infective to the canine or feline definitive host. The tetrathyridia multiply in the body of the second intermediate host and are often confined to the serous cavities, particularly the peritoneal cavity (Fig. 6.48), and other internal organs such as the liver (Figs. 6.49 and 6.50). Tetrathyridia often multiply so much within the abdominal cavity that they greatly expand the girth of the intermediate host. When ingested by the definitive host, each tetrathyridium becomes an adult tapeworm within the intestine of that definitive host.

Technician's Note

The ova of the tetrathyridium tapeworms can be found with standard fecal flotation procedures.



Fig. 6.46 Tetrathyridium is about 1 cm in diameter and is capable of multiplying exponentially (i.e., one tetrathyridium becomes two, two become four, four become eight).

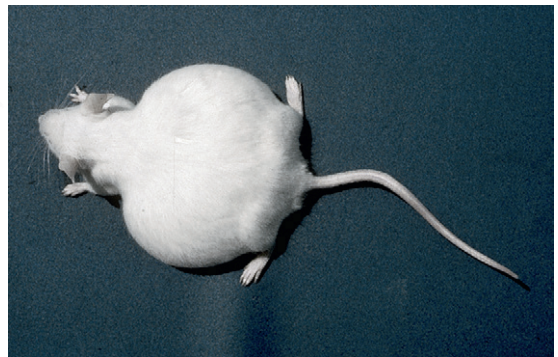


Fig. 6.48 Tetrathyridia multiply in the body of a second intermediate host and are often confined to serous cavities, particularly the peritoneal cavity.

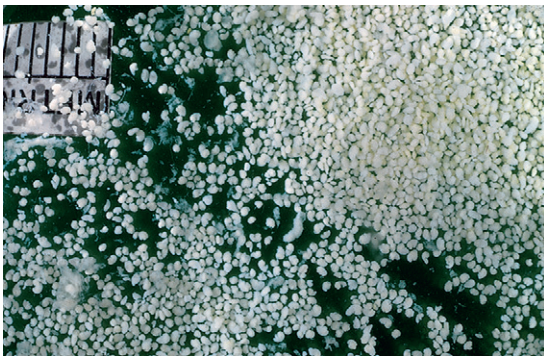


Fig. 6.47 This type of asexual reproduction produces large numbers of tetrathyridia that are infective to the canine or feline definitive host.

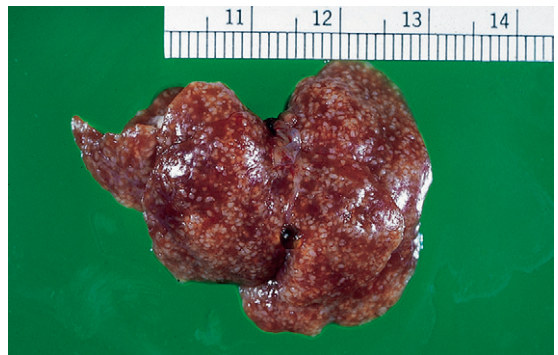


Fig. 6.49 Tetrathyridia multiply in internal organs such as the liver.

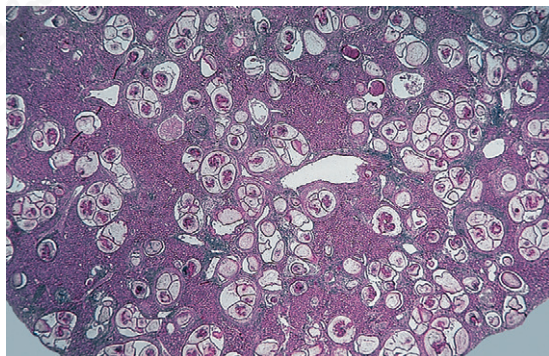


Fig. 6.50 Histopathology of the liver of a rat infected with tetrahyridia.



Fig. 6.51 Representative pseudotapeworm (*Diphyllbothrium latum*), with centrally located reproductive organs and genital pores.

Cotyloda (Pseudotapeworms)

Phylum: Platyhelminthes

Class: Cestoda

Subclass: Cotyloda

Members of the subclass Cotyloda, or **pseudotapeworms**, grossly resemble the members of the subclass Eucestoda. These flatworms are ribbon-like and divided into a long chain of proglottids. These are hermaphroditic tapeworms, but instead of possessing laterally located reproductive organs and genital pores, they have centrally located reproductive organs and genital pores (Fig. 6.51). The egg for members of this subclass is operculated (Fig. 6.52) and almost identical to the egg of the digenetic trematodes. Most pseudotapeworms release their operculated eggs directly from the uterus; the eggs then pass out to the external environment in the feces of the definitive host. The adult tapeworms occasionally release chains of gravid proglottids when these terminal proglottids have become aged or spent. Instead of possessing four suckers and (possibly) a rostellum, the pseudotapeworm has two slit-like organs of attachment (known as **bothria**) on the lateral aspects of the scolex. Fig. 6.53 shows the scolex of *Diphyllbothrium latum*.

During its life cycle, the pseudotapeworm uses two intermediate hosts. The pseudophyllidean-type operculated egg makes contact with water and releases a ciliated hexacanth embryo. This stage is called a **coracidium**. The coracidium is a motile hexacanth embryo that is covered with tiny hairs (cilia). It emerges through the operculum of a pseudotapeworm egg. After emergence, it swims in the water. The coracidium is ingested by a microscopic aquatic crustacean and, within that crustacean, develops into a stage called a **proceroid**. The crustacean with the proceroid is later ingested by a fish or an amphibian and, within the musculature of that

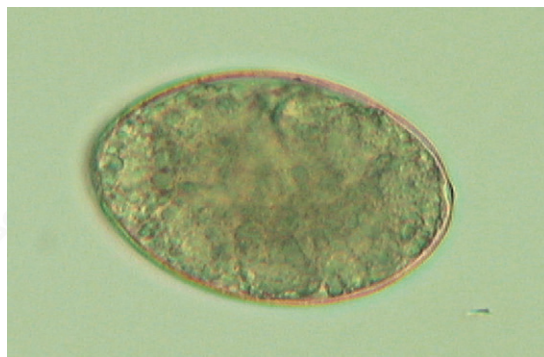


Fig. 6.52 The operculated egg of the pseudotapeworm is almost identical to the egg of digenetic trematodes. Most pseudotapeworms release eggs directly from the uterus; eggs then pass out to the external environment in the feces of the definitive host.

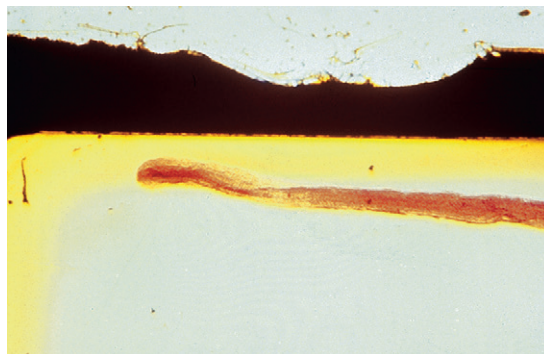


Fig. 6.53 Anterior end (scolex) of *Diphyllbothrium latum*.

host, develops into a solid-bodied metacystode stage called a **plerocercoid**, or **sparganum**. The definitive host becomes infected by ingesting the second intermediate host with this plerocercoid (sparganum) stage. The scolex attaches in the small intestine and begins to “grow” a new tapeworm.

The important pseudotapeworms of animals are the *Spirometra* species and *Dipyllobothrium* species.

Technician's Note



The pseudotapeworms use two intermediate hosts in their life cycle.

Spirometra species

Parasite: ♦ *Spirometra* species

Host: Dogs and cats

Location of Adult: Small intestine

Intermediate Hosts: First intermediate host, aquatic crustacean; second intermediate host, fish or frogs

Distribution: North and South America, Far East, and Australia

Derivation of Genus: Coiled or spiral uterus

Transmission Route: Ingestion of infective fish or frog

Common Name: Zipper tapeworm or sparganosis tapeworm

Zoonotic: Yes

Spirometra species are often referred to as *zipper* or *sparganosis tapeworms*. These medium-sized tapeworms are often found in the small intestine of both the dog and the cat and are often found in pets residing in Florida and along the Gulf Coast of North America. The adult pseudotapeworm possesses four suckers on its anterior end. This pseudotapeworm has two slit-like holdfast organs called *bothria*. In sufficient numbers, the adults can cause intestinal obstruction. This tapeworm is a clinical oddity because it produces an operculated egg. Each proglottid of *Spirometra* species possesses a centrally located, spiraled uterus and an associated uterine pore through which eggs are released. These tapeworms characteristically release eggs until they exhaust their uterine contents. Gravid segments are usually not discharged into the pet's feces. The tapeworm is unique because while it is attached to the host's jejunum, the mature proglottids often separate along the longitudinal axis for a short distance. The tapeworm appears to “unzip,” thus its common name, the *zipper tapeworm*. Spent “zipped” and “unzipped” proglottids often appear in the feces of the pet. (See Fig. 6.54 for unique features of this pseudotapeworm.)



Fig. 6.54 Adult *Spirometra* species with centrally located, spiraled uterus and uterine pore through which eggs are released. Gravid segments usually are not discharged into the feces. This tapeworm is unique because while attached to the host's jejunum, mature proglottids often separate along the longitudinal axis for a short distance. The tapeworm appears to unzip, thus its common name, *zipper tapeworm*.

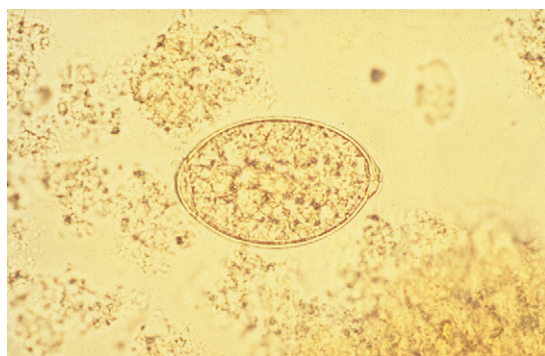


Fig. 6.55 The egg of *Spirometra mansonioides* is operculated, resembling the egg of a fluke (digenetic trematode).

Technician's Note



Dogs and humans are capable of serving as second intermediate hosts—becoming infected by ingesting copepods with proceroid-stage larvae.

The egg of *Spirometra* species resembles that of a fluke (digenetic trematode). The egg has a distinct operculum at one end of the pole of the shell (**operculated ovum**). The eggs are oval and yellowish-brown. They average $60 \times 36 \mu\text{m}$, have an asymmetric appearance, and tend to be rather pointed at one end (Fig. 6.55). When the eggs rupture, a distinct operculum is visible. The eggs are unembryonated when passed in the feces.

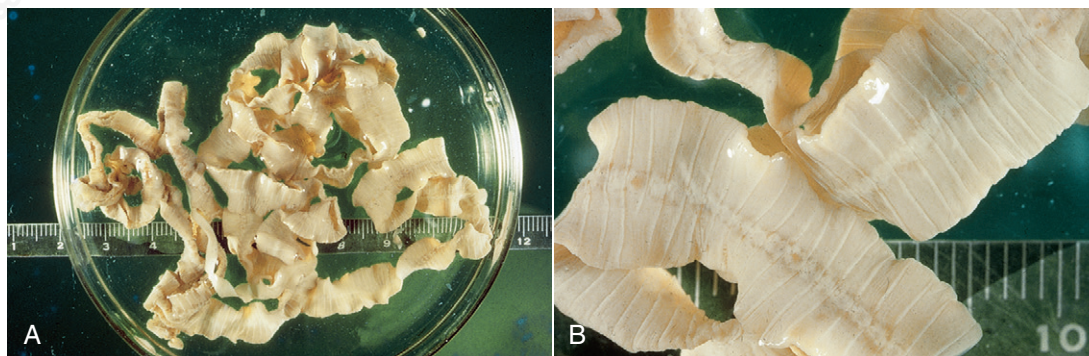


Fig. 6.56 **A**, Adult *Diphylobothrium* species can measure 2 to 12 m long, although this tapeworm probably does not attain maximum length in dogs and cats. **B**, Each proglottid has a centrally located, rosette shaped uterus and an associated uterine pore through which eggs are released.

The metacystode (larval) stage for *Spirometra* species is the sparganum, a solid-bodied stage with slit-like mouthparts. This stage is found in the musculature of its intermediate hosts, fish and amphibians such as frogs. Dogs and cats can become infected with both the tetrathyridial and adult stages of the parasites by ingesting the fish and amphibian intermediate hosts. It is important that the veterinarian recognize the fish and the amphibian as the sources of this tapeworm and understand the importance of preventing predation or the ingestion of carrion or offal by the dog and cat.

Technician's Note



The eggs of the zipper tapeworm can be found with standard fecal flotation procedures.

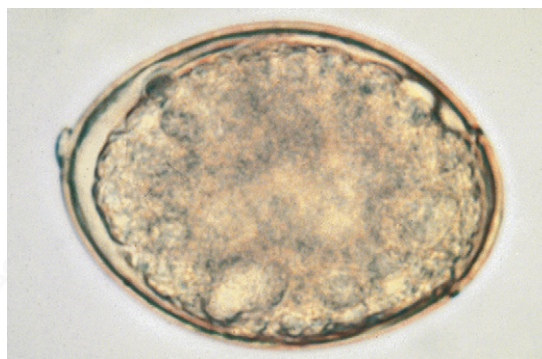


Fig. 6.57 The egg of *Diphylobothrium* species also resembles that of a fluke (digenetic trematode). The egg is oval, with a distinct operculum at the opposite end of the pole of the shell. Eggs are light brown and average 67 to 71 $\mu\text{m} \times 40$ to 51 μm . Eggs tend to be rounded on one end, with an operculum on the opposite end. Eggs are unembryonated when passed in the feces.

Diphylobothrium species

Parasite: ♦ *Diphylobothrium latum*

Host: Dogs, cats, and humans

Location of Adult: Small intestine

Intermediate Hosts: First intermediate host, aquatic crustacean; second intermediate host, fish

Distribution: Scandinavian countries, Ukraine, and North America

Derivation of Genus: Double leaf

Transmission Route: Ingestion of infective fish

Common Name: Broad fish tapeworm

Zoonotic: Yes

Diphylobothrium species are often referred to as *broad fish tapeworms*. This tapeworm can be 2 to 12 m in length; however, it probably does not attain this maximum length in dogs and cats. Instead of possessing four suckers on its anterior end, this pseudotapeworm has two slit-like holdfast

organs called *bothria*. The adults absorb vitamin B₁₂ to the point that the tapeworm can produce pernicious anemia in the host and can cause intestinal obstruction. Each proglottid of this tapeworm has a centrally located, rosette shaped uterus and an associated uterine pore through which the eggs are released (Fig. 6.56). These tapeworms continually release eggs until they exhaust their uterine contents. The terminal proglottids become senile rather than gravid and detach in chains rather than individually. The egg of *Diphylobothrium* species also resembles that of a fluke (digenetic trematode). The egg is oval and possesses a distinct operculum at one end of the pole of the shell. The eggs are light brown, averaging 67 to 71 $\mu\text{m} \times 40$ to 51 μm , and tend to be rounded on one end (Fig. 6.57). The operculum is present on the end opposite the rounded pole. The eggs are unembryonated when passed in the feces.

Technician's Note

The eggs of *D. latum* are unembryonated with an operculum opposite the rounded pole. The eggs can be found with standard fecal flotation procedures.

The metacestode (larval) stage for *Diphyllbothrium* species is the plerocercoid, a solid-bodied stage with slit-like mouthparts. This stage is found in the musculature of the fish intermediate host. Dogs and cats become infected by ingesting the fish intermediate host. It is important that the veterinarian recognize the fish as the source of this tapeworm and understand the importance of preventing predation or the ingestion of raw fish by the dog and cat.

Chapter Six Test

MATCHING—Match the scientific term in the left hand column with the correct phrase or term in the right hand column.

A. <i>Coenurus cerebralis</i>	1. Noninvaginated scolex in a small cavity or vesicle or bladder found in invertebrates
B. <i>Cysticercus fasciolaris</i>	2. Zipper tapeworm
C. <i>Echinococcus granulosus</i>	3. Double-pored tapeworm or cucumber seed tapeworm
D. <i>Anoplocephala perfoliata</i>	4. Ruminant tapeworm
E. <i>Dipylidium caninum</i>	5. Neurologic signs in infected sheep
F. <i>Paranoplocephala mamillana</i>	6. Embryo containing three pairs of hooks
G. <i>Cysticercus bovis</i>	7. Sparganum
H. <i>Cysticercus cellulosae</i>	8. Lappets behind scolex
I. Typical taeniid-type ova	9. Strobilocercus in rats
J. <i>Moniezia</i> species	10. Rat tapeworm
K. Egg packet	11. Broad fish tapeworm
L. Hexacanth embryo	12. <i>Dipylidium caninum</i>
M. Pyriform apparatus	13. <i>Taenia saginata</i>
N. <i>Hymenolepis nana</i>	14. <i>Taenia</i> or <i>Multiceps</i> or <i>Echinococcus</i> species
O. Cysticercoid	15. Found in <i>Cyclops</i> species—aquatic crustacean
P. <i>Taenia hydatigena</i>	16. Fringed tapeworm
Q. <i>Thysanosoma actinoides</i>	17. Larval tapeworm
R. <i>Mesocestoides</i> species	18. Innermost lining of eggs of <i>Moniezia</i> species, <i>Anoplocephala</i> species
S. <i>Spirometra mansonoides</i>	19. Dwarf equine tapeworm
T. Ovum of pseudotapeworm	20. Unilocular hydatid cyst
U. <i>Diphyllbothrium latum</i>	21. <i>Cysticercus tenuicollis</i> in bovine omentum
V. Plerocercoid	22. Measly pork, pork measles
W. Proceroid	23. Effective cestocide; kills tapeworms
X. <i>Echinococcus multilocularis</i>	24. Tetrathyridium
Y. Praziquantel	25. Alveolar hydatid disease in rodents
Z. Metacestode stage	26. Operculated on one end

Questions for Thought and Discussion

1. How might *Coenurus cerebralis* and *Coenurus serialis* affect the behavior of the intermediate host, thus facilitating transmission to the definitive host?
2. Compare and contrast the following types of metacystode stages. You may use drawings with labels to illustrate differences. Give examples of cestodes that typify these metacystode stages (see this chapter for examples).
 - Cysticercoid and cysticercus
 - Cysticercus and coenurus
 - Unilocular and multilocular hydatid cysts
3. Why is a single gravid proglottid of *Dipylidium caninum* so important in facilitating the transmission of the parasite to the flea intermediate host?
4. What feature makes the tetrathyridia of *Mesocystoides* species so pathogenic to the second intermediate host?
5. Three genera of taeniid tapeworms (*Taenia*, *Multiceps*, and *Echinococcus* species) produce similar ova (typical taeniid-type ova) in a canine fecal flotation. Why is it important to wear disposable gloves when performing fecal examinations? HINT: The ovum of one of these three genera is capable of infecting humans; that is, one is a very serious zoonotic parasite. What might happen if a human ingested this pathology-producing ovum?
6. Why are the following terms or phrases so important in a veterinary clinical practice, either small animal or large animal?
 - Identifying the gravid proglottid of *Dipylidium caninum*
 - *Cysticercus bovis* and *Cysticercus cellulosae*
 - Unilocular and multilocular hydatid cysts

Chapter

7

The Phylum Platyhelminthes, Class Trematoda

OUTLINE

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Life Cycle of the Fluke	115

LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Identify the external and internal morphologic features of the digenetic fluke.
- Identify the developmental stages in the life cycle of a typical digenetic fluke.
- Compare and contrast monogenetic trematodes and digenetic trematodes.

KEY TERMS

Acetabulum (ventral sucker)	Miracidium
Adult fluke	Monogenetic fluke
Cercaria	Operculum
Digenetic fluke	Oral sucker
Hermaphroditic	Redia
Metacercaria	Sporocyst

The phylum Platyhelminthes, the flatworms, includes two of the strangest classes in the animal kingdom, the trematodes (or flukes) and the cestodes (or tapeworms). The morphologic feature common to these two classes is that the worms are dorsoventrally flattened.

Members of the phylum Platyhelminthes, class Trematoda, are often referred to as *trematodes* or *flukes*. Their bodies are often flattened, unsegmented, and leaf-like. An example of a typical fluke is *Fasciola hepatica* (Fig. 7.1). Within this class are two subclasses, the subclass Monogenea (the monogenetic trematodes) and the subclass Digenea

(the digenetic trematodes). Monogenetic trematodes usually parasitize fish, amphibians, and reptiles, whereas digenetic trematodes are usually associated with wild and domestic animals and humans.

Technician's Note



Trematodes are dorsoventrally flattened, unsegmented, and leaf-like parasites.

Subclass Monogenea

Phylum: Platyhelminthes

Class: Trematoda

Subclass: Monogenea

Monogenetic flukes or trematodes are usually ectoparasites of fish, amphibians, and reptiles. They attach to the exterior surfaces, such as the gills, skin, fins, and mouth. These trematodes attach to the host with a posterior adhesive organ that may have suckers, hooks, or clamps (Fig. 7.2). These parasites are usually diagnosed in veterinary practices that specialize in treating saltwater or freshwater aquarium fish or in aquacultural environments (e.g., fish farming). Because monogenetic trematodes are diagnosed so infrequently in veterinary practice, the emphasis in this chapter (and the next) is on the digenetic trematodes.

Technician's Note



Monogenetic trematodes are seen in aquatic fish, amphibians, and reptiles.

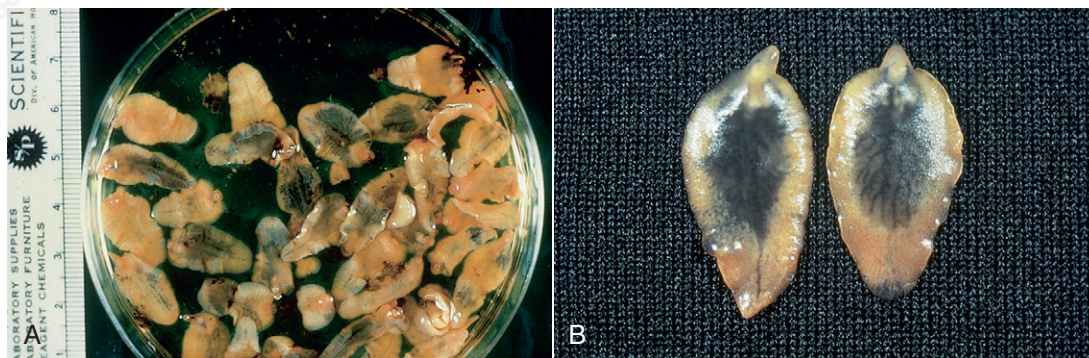


Fig. 7.1 A, Representative flukes. B, *Fasciola hepatica* with flattened, unsegmented, leaf-like bodies.



Fig. 7.2 Representative monogenetic fluke with a posterior adhesive organ that may have suckers, hooks, or clamps.

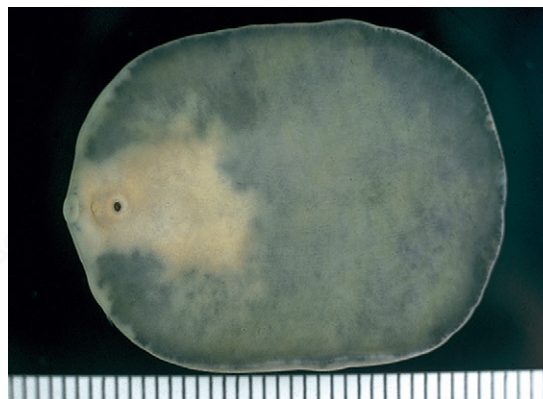


Fig. 7.3 Digenetic flukes are usually broad, leaf shaped, and flattened (see Fig. 7.1), although a few are thick and fleshy.

Subclass Digenea

Phylum: Platyhelminthes

Class: Trematoda

Subclass: Digenea

Digenetic trematodes, or **flukes**, are usually endoparasites of both domestic and wild animals and occasionally humans. Digenetic flukes are generally broad, leaf shaped, and flattened, although a few, such as *Fascioloides magna*, are thick and fleshy (Fig. 7.3). The members of one group of trematodes (the schistosomes) are long, thin, and worm-like, resembling the nematodes or roundworms.

Technician's Note



Digenetic trematodes are seen in domestic animals, wild animals, and occasionally human beings.

Key Morphologic Features

Fig. 7.4 details the internal morphology of a representative digenetic fluke. On or near the anterior end is the fluke's mouth, which is surrounded by a muscular **oral sucker**. This mouth connects to a muscular pharynx, which in turn leads to an esophagus, which bifurcates into two blind ceca. Flukes do not possess an anus; to release digested food, they

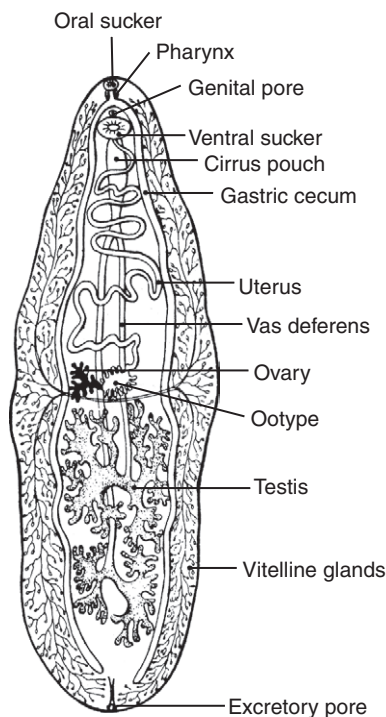


Fig. 7.4 Internal morphology of representative digenetic fluke. Note that digenetic flukes are hermaphroditic; that is, they contain both male and female reproductive organs.

regurgitate their cecal contents back into the tissues or organs they infect. These contents are often observed in the tissues on histopathologic section and are colloquially referred to as *fluke puke*. Flukes also possess a muscular organ of attachment called an **acetabulum**, or **ventral sucker**. This organ is used as a “holdfast organ” and is not associated with feeding.

Technician's Note

Flukes, or digenetic trematodes, do not possess an anus. They regurgitate their cecal contents back into the tissues or organs of the host upon which they have fed.

With the exception of the schistosomes, or blood flukes, all flukes are **hermaphroditic**; that is, each fluke possesses a complete set of both male and female reproductive organs. The male reproductive organs consist of two testes, the vas efferens, the vas deferens, the seminal vesicle, and the cirrus (the fluke’s version of a penis). The female reproductive organs consist of an ovary, an oviduct, a seminal receptacle, the yolk glands, the ootype, the Mehlis gland, vitelline glands, and the uterus. Self-fertilization usually takes place; however, cross-fertilization between two **adult flukes** also occurs.



Fig. 7.5 Fertilized operculated egg released by the female portion of the reproductive system of the hermaphroditic fluke. The operculum is a tiny “trapdoor” through which the miracidium emerges.

Life Cycle of the Fluke

The female portion of the fluke’s reproductive tract produces operculated eggs that have been stored in the uterus (Fig. 7.5). Eggs pass out of the uterus through the genital pore and are usually passed out to the external environment within the host’s feces. The operculated eggs embryonate in the external environment. If the egg makes contact with water, it will hatch and produce a motile stage called a **miracidium** (Fig. 7.6). The miracidium is covered with tiny hairs called *cilia*. The movement of the cilia allows the miracidium to swim in the water. The miracidium seeks out an aquatic snail (Fig. 7.7), the first intermediate host, then penetrates the skin of the snail and develops to the next stage, the **sporocyst**. The sporocyst is merely a sac in which the next stage, the **redia**, develops. Many rediae develop within the sporocyst. Within each redia, many cercariae develop (Fig. 7.8). The cercarial stage often has a tail and emerges from the snail and swims in the water (Fig. 7.9). Depending on the species of fluke, at this point, the **cercaria** will take one of the following three paths:

1. The cercaria may directly penetrate the skin of the definitive host.
2. The cercaria may attach to vegetation, lose its tail, secrete a thick cyst wall around itself, and thus develop into a **metacercaria** (Fig. 7.10). The vegetation with the attached encysted metacercaria will be ingested by the definitive host.
3. The cercaria may lose its tail, penetrate the second intermediate host, secrete a thick cyst wall around itself, and develop into a **metacercaria** within the second intermediate host. The second intermediate host with the encysted metacercaria will be ingested by the definitive host.



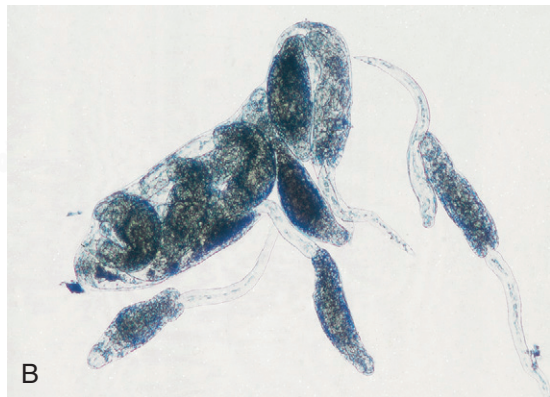
Fig. 7.6 The miracidium is the motile, ciliated stage that emerges through the operculum and eventually penetrates the snail, the first intermediate host.



Fig. 7.7 For most digenetic flukes, a snail is the first intermediate host.



A



B



C

Fig. 7.8 After the snail intermediate host has been penetrated, the next developmental stage, **A**, the sporocyst, is formed by the miracidium. **B**, The sporocyst stage forms many internal redial stages. **C**, Each redial stage forms many internal cercarial stages.

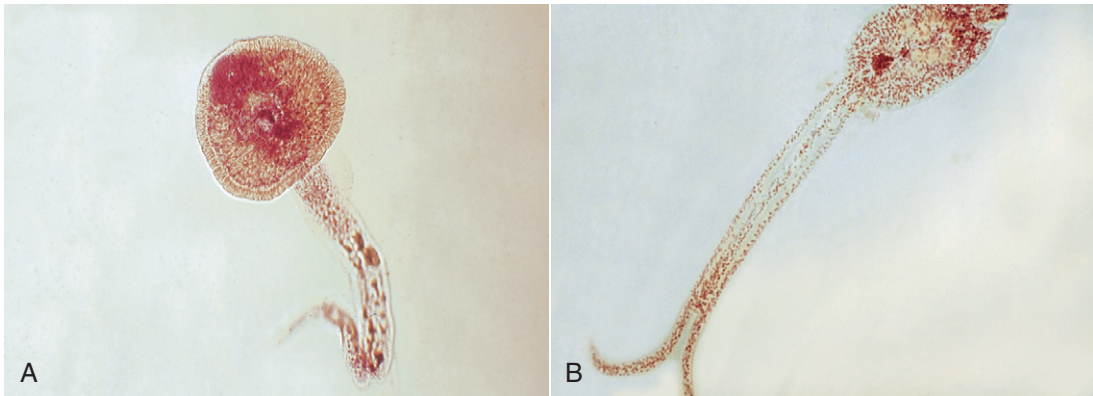


Fig. 7.9 The cercarial stage is released from the redial stage. This stage often has a tail and emerges from the snail to swim in the water. Rarely, the cercarial stage penetrates the skin of the definitive host.

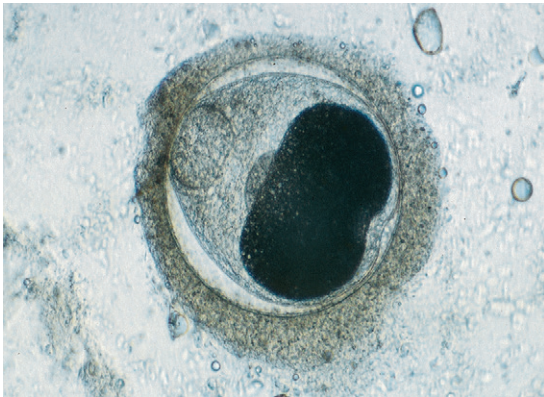


Fig. 7.10 Metacercarial stage dissected from the muscles of salmonid fish. The cercarial stage may swim to vegetation, drop its tail, secrete a thick cyst wall, and develop into the metacercarial stage, or the cercarial stage may drop its tail, penetrate or be eaten by a second intermediate host, secrete a thick cyst wall around itself, and develop to a metacercaria within the second intermediate host.

If the fluke takes the first option, the cercaria migrates to its predilection site (the site of infection) and develops into the adult fluke. If the fluke takes the second option, the thick cyst wall is digested by the host, and the juvenile fluke is released. The juvenile fluke then migrates to the predilection site and develops into an adult fluke. If the fluke takes the third option, the second intermediate host and the thick cyst wall are digested, and the juvenile fluke is released. The juvenile fluke then migrates to the predilection site and develops into an adult fluke. Most of the predilection sites of the flukes are associated with the digestive system. The exceptions are *Paragonimus kellicotti*, the lung fluke of dogs and cats, and the schistosomes, or blood flukes, which reside in the blood vessels. Once the adult stage of the fluke is reached, self-fertilization and cross-fertilization occur, and the life cycle begins again, with operculated eggs being released to the outside environment.

Technician's Note

With two exceptions, flukes may be found within the digestive system.

Technician's Note

The cercarial stage of the trematode life cycle can use one of three ways to enter a definitive host: penetrate the body directly, attach to vegetation and await ingestion, or penetrate the skin of a second intermediate host and await ingestion.

Chapter 8 details some of the important flukes of domestic animals (and in some cases, wild animals) in North America. As individual species, adult flukes can be quite distinctive in appearance. Flukes tend to be found in certain predilection tissue or organ sites within the

host's body. Although some may “wander” off course in the developmental life cycle, adult flukes are usually associated with certain tissue or organ sites. It is important for the diagnostician to associate certain flukes with their predilection sites.

Finally, digenetic flukes have a characteristic ovum that is almost unique to this subclass—the operculated egg (Fig. 7.11). Most of these flukes possess an oval egg with a distinct **operculum**, or door, on one pole (either end) of the egg. There are a few exceptions, and they are noted when these flukes are discussed.

Technician's Note

Digenetic trematodes have a characteristic operculated egg.



Fig. 7.11 Digenetic flukes have a characteristic ovum, the operculated egg, which is almost unique to this subclass. Most of these flukes possess this oval egg with a distinct operculum, or door, on one end of the egg. The egg of *Paragonimus kellicotti* has an operculum that is easily observed.

Chapter Seven Test

MATCHING—Match the scientific term in the left hand column with the correct phrase or term in the right hand column.

A. Monogenetic trematodes	1. Developmental stage after penetration of the miracidium into a snail (first intermediate host)
B. Acetabulum	2. Door or cap at one end, or pole, of the trematode egg
C. Miracidium	3. Ectoparasites of fish, amphibians, and reptiles
D. Sporocyst	4. Encysted stage in the life cycle of the trematode usually found on vegetation or within the second intermediate host
E. Redia	5. Endoparasitic flukes of both domestic and wild animals
F. Cercaria	6. Stage that follows the redia; stage that emerges from the second intermediate host
G. Operculum	7. Motile stage emerging from the operculated fluke egg
H. Hermaphroditic	8. Ventral sucker that is used as a holdfast organ of attachment for digenetic flukes
I. Metacercaria	9. Simultaneously possessing both male and female reproductive organs
J. Digenetic trematodes	10. Stage that develops on the inside of the sporocyst

Questions for Thought and Discussion

1. How are monogenetic trematodes different from digenetic trematodes?
2. Describe the developmental stages in the life cycle of a typical digenetic fluke.

Chapter

8

Trematodes (Flukes) of Animals and Humans

OUTLINE

Flukes of Ruminants (Cattle, Sheep, and Goats)	119
Flukes of Small Animals (Dogs and Cats)	122

LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Identify digenetic flukes to genus and/or species when given a trematode specimen and the host and location where the specimen was found within that host.

KEY TERMS

Amphistomes	Schistosome cercarial dermatitis
Black spot	
Operculum	Vitellaria
Schistosomes	

The following organisms are flukes that may parasitize domesticated and wild animals. A few species are known to parasitize humans.

Flukes of Ruminants (Cattle, Sheep, and Goats)

Parasite: ♦ *Dicrocoelium dendriticum*

Host: Sheep, goats, and cattle

Location of Adult: Bile duct

Intermediate Hosts: First intermediate host, *Cionella lubrica*, land snail; second intermediate host, *Formica fusca*, ant

Distribution: Worldwide

Derivation of Genus: Forked bowel

Transmission Route: Ingestion of infected ants

Common Name: Lancet fluke

Zoonotic: Yes (per *The Merck Veterinary Manual*)

Technician's Note



The lancet fluke is an unusual trematode in that it uses an ant as its first intermediate hosts and a land snail as its second intermediate host.

Dicrocoelium dendriticum is commonly referred to as the *lancet fluke* of sheep, goats, and cattle. This tiny, flattened, leaf-like fluke is only 6 to 10 mm long and 1.5 to 2.5 mm wide (Fig. 8-1) and has an oral sucker, a ventral sucker, tandem testes, and lateral **vitellaria** (accessory genital glands that secrete the yolk and shell for the fertilized ovum). These flukes are found in the fine branches of the bile duct and can produce hyperplasia of the bile duct's glandular epithelial lining, resulting in bile duct obstruction. This fluke produces brown embryonated eggs that are 36 to 46 $\mu\text{m} \times 10$ to 20 μm . The egg possesses an **operculum** (similar to a hinged hatch) on one pole (end) of the egg. This operculum is said to be indistinct. The first intermediate host is the land snail, *Cionella lubrica*, whereas the second intermediate host is the ant, *Formica fusca*. The eggs can be found on standard fecal flotation and fecal sedimentation procedures.

Parasite: *Paramphistomum* species and *Cotylophoron* species

Host: Cattle, sheep, goats, and other ruminants

Location of Adult: Rumen and reticulum

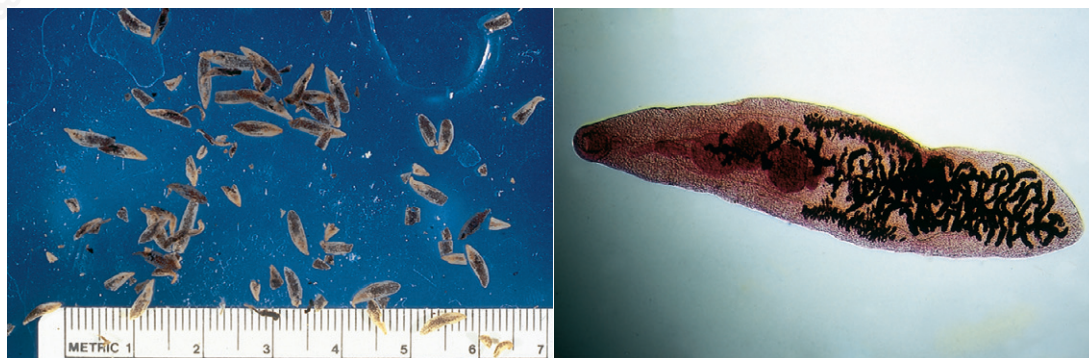


Fig. 8.1 Adult *Dicrocoelium dendriticum* is commonly referred to as the *lancet fluke* of sheep, goats, and cattle. This tiny, flattened, leaf-like fluke (6 to 10 mm long and 1.5 to 2.5 mm wide) is found in fine branches of the bile duct.

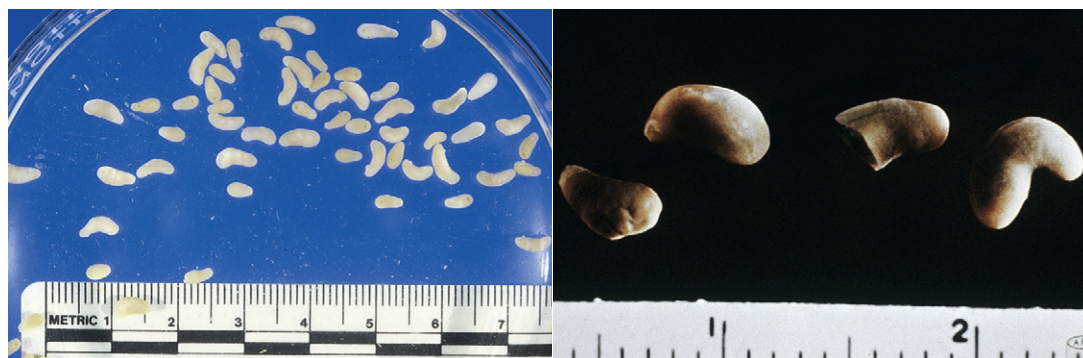


Fig. 8.2 Rumen flukes, or amphistomes (*Paramphistomum* and *Cotylophoron* species), have an oral sucker (feeding organelle) on the anterior end and a large ventral sucker (organ of attachment) on the posterior end.

Intermediate Hosts: First intermediate host, aquatic snail; second intermediate host, none; cercariae encyst on aquatic vegetation

Distribution: Worldwide (*Paramphistomum* sp.)

Derivation of Genus: Beyond a mouth on both sides (*Paramphistomum* sp.); ridge cup (*Cotylophoron* sp.), bears a cup shape

Transmission Route: Ingestion of aquatic vegetation with metacercariae

Common Name: Rumen flukes

Zoonotic: No

Rumen flukes comprise two genera of veterinary importance, *Paramphistomum* and *Cotylophoron* (Fig. 8-2). Rumen flukes belong to a group of flukes called **amphistomes** (*amphi* means “on both sides” or “double,” and *stome* means “mouth”); these flukes appear to possess a “mouth” at both

ends of their bodies. Amphistomes have an oral sucker (the feeding organelle, or “true mouth”) on the anterior end and a large ventral sucker (an organ of attachment) on the posterior end. The adult flukes closely resemble crisped rice cereal. In the fresh state, amphistomes are light-colored to blood red and pear shaped, approximately 5 to 13 mm × 2 to 5 mm. They attach with the oral sucker to the lining of the rumen and reticulum of cattle, sheep, goats, and many other ruminants and expose the ventral suckers (Fig. 8-3). The adult flukes are nonpathogenic; the pathogenicity of these flukes lies in the migration of the juvenile forms in the small intestine. These juvenile forms are known for the ability to ingest large plugs of intestinal lining. The eggs of *Paramphistomum* species measure 114 to 176 μm × 73 to 100 μm; the eggs of *Cotylophoron* species measure 125 to 135 μm by 61 × 68 μm. The prepatent period for *Paramphistomum* species is 80 to 95 days.



Fig. 8.3 Rumen flukes among rumen papillae.

Technician's Note



The oral sucker of the rumen fluke is on the anterior end of the fluke, and the ventral sucker is on the posterior end.

Parasite: ♦ *Fasciola hepatica*

Host: Cattle, sheep, and other ruminants

Location of Adult: Bile duct

Intermediate Hosts: First intermediate host, aquatic snail; second intermediate host, none; cercariae encyst on aquatic vegetation

Distribution: Worldwide

Derivation of Genus: Small band

Transmission Route: Ingestion of aquatic vegetation with metacercariae

Common Name: Liver fluke

Zoonotic: Yes (per *The Merck Veterinary Manual*)

Fasciola hepatica is the liver fluke of cattle, sheep, and other ruminants. It is perhaps the most economically important fluke in veterinary medicine because it causes "liver rot," clay pipe-stem fibrosis, or liver condemnation at slaughter as a result of obstruction of the bile ducts. This fluke is the best-known fluke among those parasitizing food animals; parasitologists have studied *F. hepatica* more than any other fluke. Adult flukes are found in the bile ducts of the liver and possess a unique appearance. They are flattened and leaf-like, measuring 30×13 mm (Fig. 8-4). These liver flukes are broader in the anterior region than in the posterior region and possess an anterior cone shaped projection that is followed by a pair of prominent, laterally directed shoulders. The internal morphology is not easily discernible because of the superimposition of the highly branched



Fig. 8.4 Adult liver flukes (*Fasciola hepatica*) are broader in the anterior region and have a prominent anterior cone shaped projection, followed by prominent shoulders. In the fresh state, these flukes are grayish-brown and measure 30×13 mm.

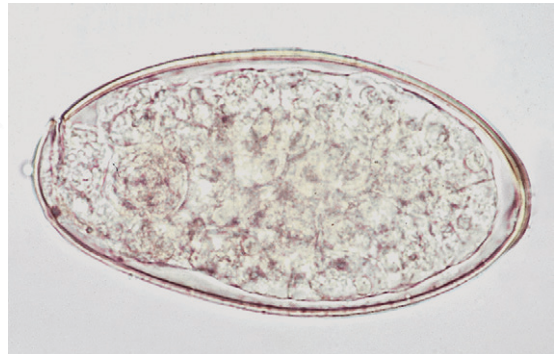


Fig. 8.5 Egg of *Fasciola hepatica*. Eggs are oval, operculated, and yellow-brown and measure 130 to 150 $\mu\text{m} \times 60$ to 90 μm .

ceca over highly branched testes, ova, and vitellaria. These flukes are tan to reddish-brown in the fresh state; preserved specimens take on a grayish appearance. Their eggs are oval and yellowish-brown and measure 130 to 150 $\mu\text{m} \times 60$ to 90 μm . Each egg possesses a distinct operculum (Fig. 8-5). The eggs can be found on fecal sedimentation.

Technician's Note



Fasciola hepatica is the most studied fluke affecting domestic livestock, and it is a very important fluke in terms of its economic effects on the hosts.

Parasite: *Fascioloides magna*

Host: White-tailed deer

Location of Adult: Liver parenchyma

Intermediate Host: Aquatic snail; the cercariae encyst on aquatic vegetation

Distribution: North America, Central and Southwestern Europe

Derivation of Genus: Band shape

Transmission Route: Ingestion of vegetation with metacercariae

Common Name: Liver fluke of wild ruminants (deer)

Zoonotic: No

Fascioloides magna is also a liver fluke; however, this fluke has the white-tailed deer as its true definitive host. It may also use cattle, sheep, and pigs as incidental hosts. The adult flukes are found in the liver parenchyma and possess a unique appearance. They are large, flattened, flesh-colored, oval flukes measuring up to 10 cm in length, 2.5 cm in width, and 4.5 mm in thickness, approximately the size of a U.S. gold dollar (Fig. 8-6). These flukes lack the anterior cone-like projection of *F. hepatica*. The egg is operculated, up to 170 μm in length and 100 μm in width. *F. magna* flukes produce open cysts in the liver parenchyma of white-tailed deer. These cysts communicate with the bile ducts, allowing eggs to be passed to the external environment. Thus eggs are often found during fecal sedimentation procedures of these infected hosts. In incidental hosts such as cattle and sheep, however, these flukes produce closed cysts in the liver parenchyma. These cysts do not communicate with the bile ducts, so the egg of *F. magna* cannot pass to the external environment. Incidental hosts act as “dead-end” hosts; that is, they are not capable of transmitting this parasite to other animals.

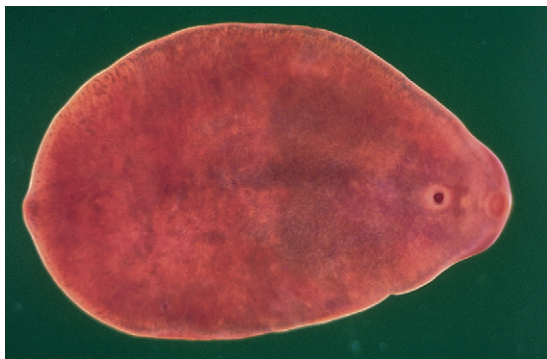


Fig. 8.6 Adult *Fascioloides magna* are large, flattened, flesh-colored, oval flukes measuring up to 10 cm in length, 2.5 cm in width, and 4.5 mm in thickness. These flukes lack the anterior cone-like projection of adult *Fasciola hepatica*.

Eggs of the flukes just mentioned may be recovered from feces using either the fecal sedimentation procedure or a commercially available fluke egg recovery test.

Technician's Note



The eggs of *F. magna* can be found on fecal sedimentation technique from feces of the white-tailed deer. Necropsy is necessary to find the adult flukes in the incidental hosts.

Flukes of Small Animals (Dogs and Cats)

Parasite: *Platynosomum fastosum*

Host: Cats

Location of Adult: Bile ducts

Intermediate Host: First intermediate host, land snail; second intermediate host, lizard

Distribution: South America, southern United States, West Africa, Pacific Islands, Malaysia, and the Caribbean

Derivation of Genus: Flat disease-causing

Transmission Route: Ingestion of infected lizards

Common Name: Lizard-poisoning fluke of cats

Zoonotic: No

Platynosomum fastosum is the “lizard-poisoning fluke” of cats. The fluke received this common name because cats become infected by ingesting the lizard second intermediate host that contains the infective metacercarial stages of the fluke. These adult flukes are found in the liver, gallbladder, and bile ducts and less often in the small intestine of cats, producing signs such as diarrhea, vomiting, icterus, and even death from the obstruction of the bile duct. *P. fastosum* is a tiny, flattened, leaf-like fluke that is only 4 to 8 mm long and 1.5 to 2.5 mm wide, with an oral sucker, ventral sucker, parallel (side-by-side) testes, and lateral vitellaria found in the fine branches of the bile duct of cats; it can produce desquamation (stripping) of the bile duct’s glandular epithelial lining (Fig. 8-7). The fluke’s brownish operculated eggs are oval, measuring 34 to 50 μm $\times$ 20 to 35 μm (Fig. 8-8). The eggs can be found on standard fecal flotation. Adults can be found in the bile ducts on necropsy.

Technician's Note



Platynosomum fastosum is associated with “lizard poisoning” in cats.

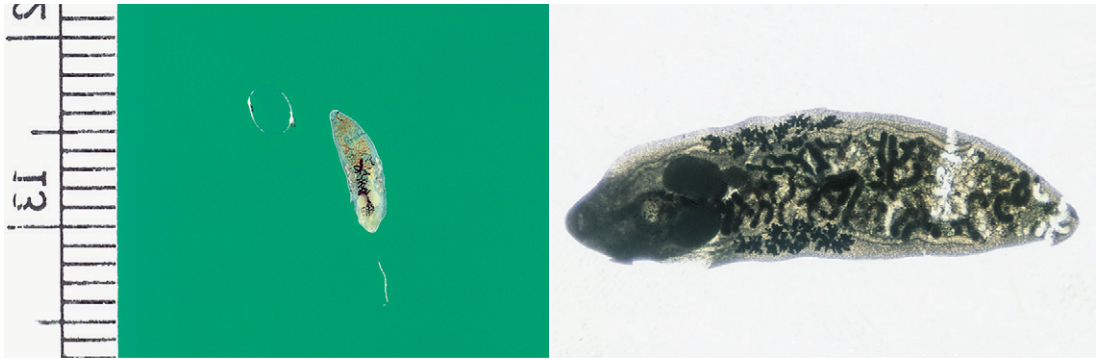


Fig. 8.7 The adult *Platynosomum fastosum*, the lizard-poisoning fluke of cats, is a tiny, flattened, leaf-like fluke (only 4 to 8 mm long and 1.5 to 1.2 mm wide) found in the fine branches of the bile duct of cats.

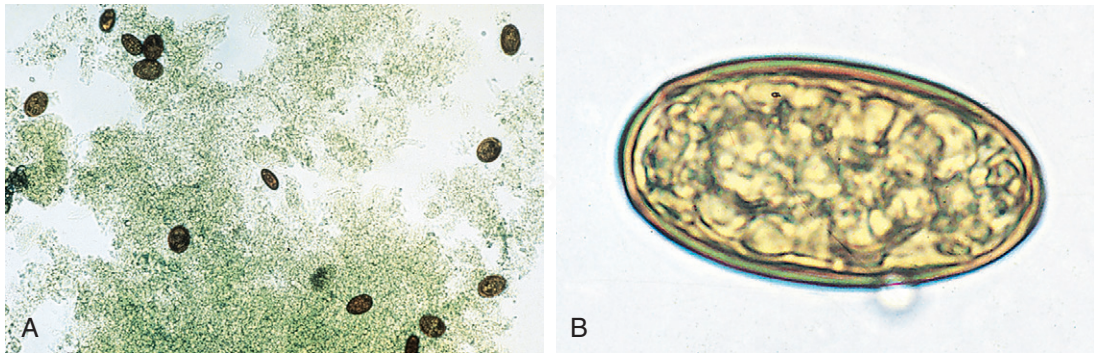


Fig. 8.8 **A**, Eggs of *Platynosomum fastosum*. **B**, These oval, brown, operculated eggs measure 34 to 50 μm by 20 to 35 μm .

Parasite: ♦ *Nanophyetus salmincola*

Host: Dogs

Location of Adult: Small intestine

Intermediate Host: First intermediate host, freshwater snail; second intermediate host, salmon

Distribution: Pacific Northwest region of North America

Derivation of Genus: Dwarf form

Transmission Route: Ingestion of infected salmon

Common Name: Salmon-poisoning fluke of dogs

Zoonotic: Yes (per Companion Animal Parasite Council)

Nanophyetus salmincola is the “salmon-poisoning fluke” of dogs in the Pacific Northwest region of North America. This fluke received its common name because dogs become infected by ingesting the salmon (fish) second intermediate host that contains the infective metacercarial stage of this fluke. The adult fluke inhabits the small intestine and serves

as a vector for rickettsial agents that produce “salmon poisoning” and “Elokomine fluke fever” in dogs. Whereas *F. magna* is the largest fluke of our domesticated animals, *N. salmincola* is the smallest, measuring only 0.5 to 1.1 mm in length (Fig. 8-9). The color of adult flukes is white to cream. The eggs are yellowish-brown with an indistinct operculum and a small, blunt point at the end opposite to the operculum. The eggs are 52 to 82 μm $\times$ 32 to 56 μm (Fig. 8-10).

Technician's Note

The salmon-poisoning fluke causes pathology to the host by harboring the rickettsial agents that produce salmon poisoning and Elokomine fluke fever.





Fig. 8.9 Adult *Nanophyetus salmincola*, the salmon-poisoning fluke of the Pacific Northwest. This fluke measures only 0.5 to 1.1 mm in length. The color of adult flukes is white to cream.



Fig. 8.11 The egg of the *Alaria* species is large, golden brown, and operculated, measuring 98 to 134 μm $\times$ 62 to 68 μm .



Fig. 8.10 The egg of *Nanophyetus salmincola* is yellowish-brown, with an indistinct operculum and a small, blunt point at the end opposite the operculum. Eggs are 52 to 82 μm $\times$ 32 to 56 μm .

Parasite: *Alaria* species

Host: Dogs and cats

Location of Adult: Small intestine

Intermediate Host: First intermediate host, snail; second intermediate host, frog, snake, or mouse

Distribution: Northern United States and Canada

Derivation of Genus: Winged

Transmission Route: Ingestion of infected frog, snake, or mouse

Common Name: Intestinal flukes of dogs and cats

Zoonotic: No

Alaria species are intestinal flukes of dogs and cats and are found throughout the northern half of the North American continent. This fluke is 2 to 6 mm in length. It has a unique appearance among the flukes in that its anterior half is flattened and expanded and its posterior half is rounded and globose. The eggs are large, golden brown, and operculated. They measure 98 to 134 μm $\times$ 62 to 68 μm (Fig. 8-11).



Fig. 8.12 Adult *Paragonimus kellicotti* flukes are unusual in that they are found in the lung parenchyma, not the gastrointestinal tract.

Technician's Note



The adult *Alaria* does not seem to cause any apparent effect in the host. It is the migration of the larvae that seems to cause pathologic findings/conditions in the host.

All the flukes covered in this chapter so far (in both ruminants and small animals) are parasites of portions of the digestive system, either the intestine or the ducts within the liver. The following flukes, however, are found in sites other than those associated with the digestive system. *Paragonimus kellicotti* is the lung fluke of dogs and cats found in cystic spaces in the lung parenchyma. *Heterobilharzia americana*, the canine schistosome, is a blood fluke that parasitizes the mesenteric veins of the small and large intestines and the portal veins of the dog.

Parasite: ♦ *Paragonimus kellicotti*

Host: Dogs and cats

Location of Adult: Lung parenchyma

Intermediate Host: First intermediate host, operculated snail; second intermediate host, crayfish

Distribution: North America

Derivation of Genus: Alongside gonads

Transmission Route: Ingestion of infective crayfish

Common Name: Lung fluke of dogs and cats

Zoonotic: Yes but rare and only if raw crayfish are ingested (per *The Merck Veterinary Manual*)

Adult *P. kellicotti* flukes are found in cystic spaces within the lung parenchyma of both dogs and cats (Fig. 8-12). These cystic spaces connect to the terminal bronchioles. The eggs are found in sputum or feces. Adults are thick, brownish-red flukes measuring up to 16 mm long × 8 mm wide (Fig. 8-13). Eggs are yellowish brown, with a rather distinct operculum. The eggs are 75 to 118 μm × 42 to 67 μm; the shell at the pole opposite the operculum is somewhat thickened (Fig. 8-14). These fluke eggs can be recovered using fecal sedimentation techniques; however, the eggs of *P. kellicotti* are usually recovered using standard fecal flotation solutions. These eggs can also be recovered in the sputum by tracheal washing. The adult flukes within the cystic spaces in the lung parenchyma can be observed with thoracic radiography.

Technician's Note



Eggs of the lung fluke can be found on fecal sedimentation of feces or sputum. The adults may be seen in cystic spaces in the lung parenchyma on thoracic radiographs.

Parasite: ♦ *Heterobilharzia americana*

Host: Dogs

Location of Adult: Mesenteric veins of the small and large intestines and the portal veins

Intermediate Host: Freshwater snail

Distribution: North America, particularly the Gulf states of the United States

Derivation: Another fluke named after Theodor Bilharz, German physician

Transmission Route: Metacercariae enter through the skin of the dog

Common Name: Schistosome of the dog

Zoonotic: Yes (per Companion Animal Parasite Council)

Heterobilharzia americana, the canine schistosome, is a blood fluke that parasitizes the mesenteric veins of the small and large intestines and the portal veins of the dog (Fig. 8-15 and 8-16). *Schistosome* means “split body.” The blood flukes, or **schistosomes**, are unique flukes in that they are not hermaphroditic. Separate sexes exist, so there are male schistosomes and female schistosomes. Because these flukes reside in the fine branches of the mesenteric veins where they can obstruct the veins, they are long and slender. Females may be as long as 9 mm, and males are about 6.5 mm in length (Fig. 8-17). This fluke is enzootic in the mudflats of the Mississippi Delta and the coastal swampland of Louisiana. Although *H. americana* inhabits the blood vasculature, it manifests its presence by a bloody diarrhea. Infected dogs also exhibit emaciation and anorexia. Diagnosis is by identification of the thin-shelled egg, about 80 × 50 μm, which contains a miracidium on fecal sedimentation. (See Fig. 8-18 for morphologic features of the egg of *H. americana*.)

Box 8-1 briefly discusses the blood flukes of humans while Box 8-2 discusses flukes of fish and Box 8-3 discusses flukes of wild birds.

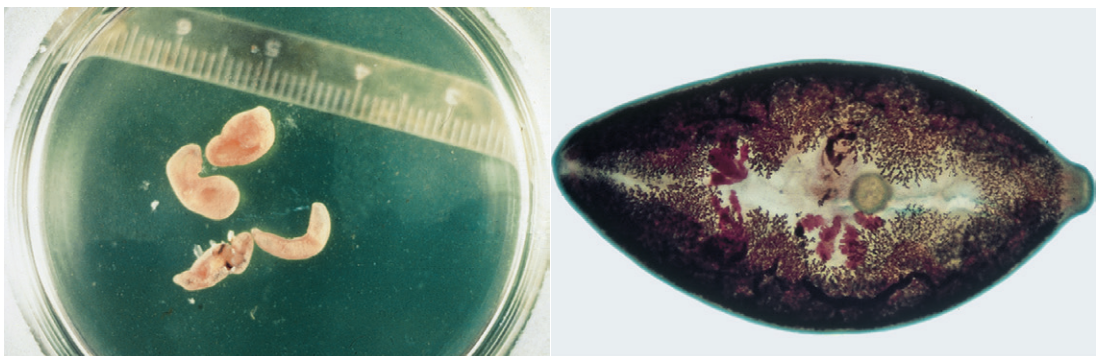


Fig. 8.13 Adult *Paragonimus kellicotti* are thick, brownish-red flukes measuring up to 16 mm long × 8 mm wide. Adult flukes are found within the lung parenchyma.

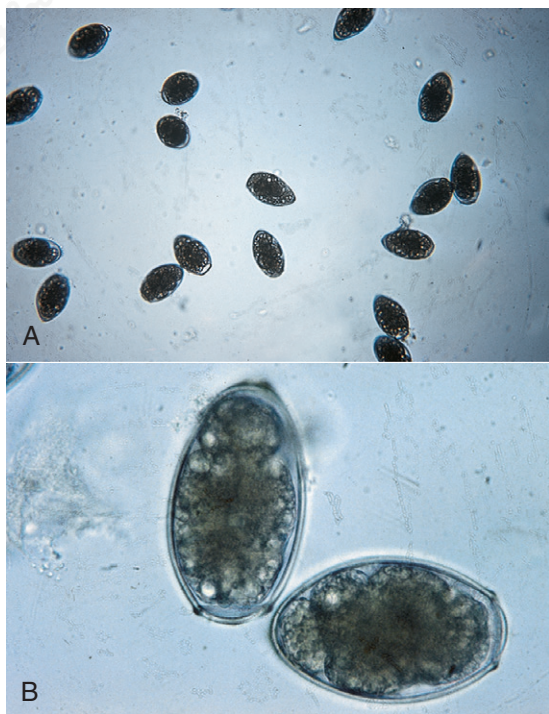


Fig. 8.14 The distinctly operculated eggs of *Paragonimus kellicotti* are yellowish-brown and 75 to $118\ \mu\text{m}$ $\times$ 42 to $67\ \mu\text{m}$. The shell at the pole opposite the operculum is somewhat thickened.

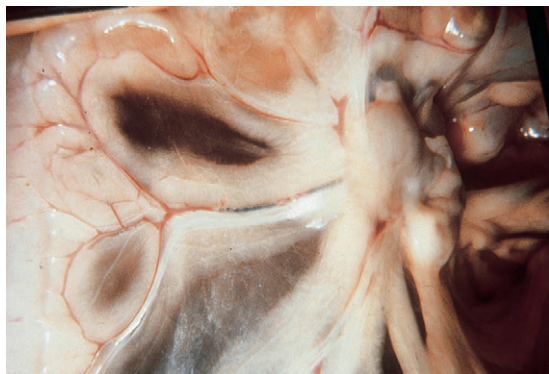


Fig. 8.15 Gross necropsy revealing adult *Heterobilharzia americana* in the mesenteric veins of a dog.

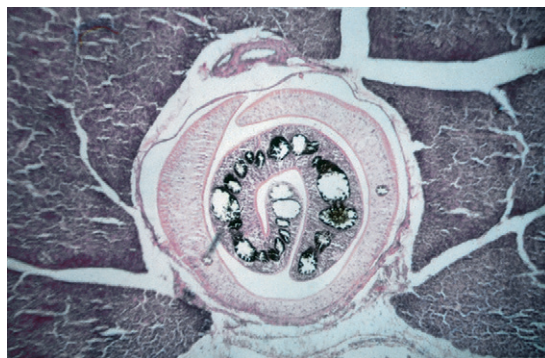


Fig. 8.16 Histopathology of adult *Heterobilharzia americana* in the mesenteric veins of a dog.



Fig. 8.17 Adult male and female *Heterobilharzia americana* recovered from the mesenteric veins of a dog.



Fig. 8.18 Thin-shelled egg of *Heterobilharzia americana*, approximately $80 \times 50\ \mu\text{m}$. Miracidium are sometimes observed within the egg.

Technician's Note



The canine schistosome does not use a second intermediate host. Instead, the cercariae leave the freshwater snail and enter the dog by penetration of the skin.

Box 8-1 A Few Words About Flukes of Humans

Parasite: *Schistosoma* (*Bilharzia*) species

Host: Humans

Location of Adult: Mesenteric veins of the small and large intestines and the urinary bladder

Intermediate Host: Freshwater snails

Distribution: Africa, the Middle East, the Caribbean

Derivation of Genus: Split body

Transmission Route: Cercariae enter through skin penetration

Common Name: Blood flukes of humans

Humans serve as definitive hosts for an important group of flukes called the *schistosomes*, or the *blood flukes*. These flukes are similar to *Heterobilharzia americana* and inhabit the blood vasculature of the mesenteric veins and the blood vasculature associated with major organs (large and small intestines and urinary bladder) of the abdominal cavity of humans. These flukes are members of the genus *Schistosoma* (also known

as *Bilharzia*) and are important parasites of humans in Africa, the Middle East, the Caribbean, and other areas of the world. These parasites are important in human medicine; however, other than this mention, they are beyond the scope of this textbook. The cercarial stage of this important fluke infects the definitive host by direct penetration of the skin of humans as they are wading or bathing in water. Some members of the genus *Schistosoma* infect the blood vasculature of the mesenteric and portal veins of cattle; however, these schistosomes occur in Africa, the Mediterranean, and the Middle East and are not usually associated with domesticated animals in North America. Schistosomes are species specific; that is, human schistosomes infect humans, and bovine schistosomes infect cattle. Schistosomes of domestic animals are not zoonotic. The veterinary technician who has an interest in the schistosomes of humans should consult a textbook on the parasitology of humans.

Box 8-2 A Few Words About Flukes of Wild Birds

Parasite: *Schistosoma* (*Trichobilharzia*, *Gigantobilharzia* species) and assorted other species found in birds

Host: Birds

Location of Adult: Blood vasculature

Intermediate Host: Freshwater snails

Distribution: North America

Derivation of Genus: Split body

Transmission Route: Cercariae enter through skin penetration

Common Name: Avian schistosomes

Avian schistosomes occur in the blood vasculature of many wild birds (particularly aquatic birds) that migrate across the North American continent along seasonal flyways. Migrating aquatic birds frequently rest in rivers and lakes of North America along their seasonal journeys. These birds are frequently infected with avian schistosomes in their blood vessels. The schistosomes produce eggs that pass to the external environment in the birds' feces. The eggs often make contact with water, hatch, and release the miracidia, the stage infective for the snail intermediate host. The miracidia penetrate aquatic snails and, within the snails, develop into the cercarial stage. The cercariae emerge from the snail and usually complete the life cycle by penetrating the skin of the appropriate avian definitive host. However, if the cercariae penetrate the skin of a human (who is swimming or playing in the lake, river, or

ocean), with repeated exposure, the cercariae can produce a severe papular or pustular dermatitis called *swimmer's itch* or **schistosome cercarial dermatitis** (Fig. 8-19). This pruritic dermatitis is one of the few zoonotic parasitic conditions/diseases found among the digenetic trematodes. The dermatitis is quite pruritic and can ruin a vacation at the lake or the seashore.



Fig. 8.19 Severe papular or pustular dermatitis (swimmer's itch, or schistosome cercarial dermatitis) in a human. This pruritic dermatitis is the only zoonotic digenetic trematode. (Courtesy James W. Berger T, Elston D: *Andrews' diseases of the skin*, 12th edition, St. Louis, 2015, Elsevier.)

Box 8-3 A Few Words About Flukes of Game Fish

Birds near a lake or seashore may have flukes that reside in the gastrointestinal tract. As with the avian schistosomes described in Box 8-2, these flukes produce eggs that pass to the external environment and often make contact with water. The eggs hatch, releasing the miracidia. The miracidia penetrate aquatic snails and, within the snails, develop into the cercarial stage. The cercariae emerge from the snails and normally penetrate the skin of fish. When the cercariae penetrate the skin of fish, they produce a metacercarial stage. The metacercaria is actually a juvenile fluke. Fish often react to the presence of metacercariae by depositing melanin (black) pigment around the organism, producing a condition called **black spot** (Fig. 8-20). Aquatic birds become infected with the fluke by ingesting the fish containing the metacercarial stage. Sometimes fishermen catch these fish and, during the cleaning process, may notice these conspicuous black metacercarial stages in the skin or in the muscles of the fish. If the fish is properly cooked, it is safe for human consumption. Humans are not harmed when they ingest these stages; humans cannot become infected with this avian fluke. Therefore this is not

a zoonotic condition; however, it may not be aesthetically pleasing! The unsightly appearance of these metacercarial spots in the fish's tissues may prevail over the hungry fisherman's appetite.



Fig. 8.20 Fish exhibiting black spot, deposition of melanin pigment in response to the presence of metacercariae.

Chapter Eight Test

MATCHING—Match the scientific term in the left hand column with the correct phrase or term in the right hand column.

A. <i>Dicrocoelium dendriticum</i>	1. Salmon-poisoning fluke of dogs
B. <i>Paramphistomum</i> and <i>Cotylophoron</i>	2. Canine schistosomes (blood flukes)
C. <i>Fasciola hepatica</i>	3. Liver fluke of cattle
D. <i>Fascioloides magna</i>	4. The lancet fluke of ruminants
E. <i>Platynosomum fastosum</i>	5. Rumen flukes
F. <i>Nanophyetus salmincola</i>	6. Melanin deposition in response to the presence of metacercariae
G. <i>Paragonimus kellicotti</i>	7. Schistosome cercarial dermatitis
H. <i>Heterobilharzia americana</i>	8. Liver fluke of white-tailed deer
I. Swimmer's itch	9. Lizard-poisoning fluke of cats
J. Black spot	10. Lung fluke of dogs and cats

Questions for Thought and Discussion

1. Discuss the zoonotic potential for the digenetic trematodes. In what way are trematodes zoonotic?

2. Trematodes are usually associated with the gastrointestinal tract or with some duct associated with the
- gastrointestinal tract. Which digenetic trematode is the exception to this rule?

3. Explain how schistosomes are different from other digenetic flukes.

Chapter

9

The Phylum Acanthocephala

OUTLINE

Common Acanthocephalans	129
Key Morphologic Features	129
Life Cycle of the Thorny-Headed Worm	130
Acanthocephalans of Importance in Veterinary Parasitology	131

LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Identify acanthocephalans relative to their morphology and egg type.
- Correctly spell *Macracanthorhynchus hirudinaceus*, the swine acanthocephalan. This parasite has the longest scientific name among all the parasites of wild and domesticated animals.

KEY TERMS

Acanthella	Cystacanth
Acanthocephalan	Tegument
Acanthor	

The phylum Acanthocephala consists of the “thorny-headed worms,” or “spiny-headed worms.” With regard to the number of **acanthocephalan** parasites that infect domesticated animals, the phylum Acanthocephala is very small.

Common Acanthocephalans

Most acanthocephalans are parasites of marine and freshwater fish and aquatic birds; their predilection site is within the small intestine of the definitive host. Only two species, *Macracanthorhynchus hirudinaceus*, the thorny-headed worm of swine, and *Oncicola canis*, the canine acanthocephalan, are important to veterinary medicine.

Technician's Note

Only two species of acanthocephalans are important to veterinary medicine. Most species parasitize marine fish, freshwater fish, and aquatic birds.

Key Morphologic Features

Members of the phylum Acanthocephala are important parasites of domesticated and wild animals. Adult acanthocephalans are internal parasites, living in the small intestine of their vertebrate hosts. Acanthocephalans are typically elongate, cylindric worms, tapered on both ends. One acanthocephalan (*M. hirudinaceus*) can measure up to 70 cm in length. Acanthocephalans are dioecious; that is, they have separate sexes. Female acanthocephalans are typically larger than their male counterparts. The colloquial names *thorny-headed worm* and *spiny-headed worm* are derived from the fact that acanthocephalans possess a retractable proboscis, or “nose,” on the anterior end (Fig. 9.1). This proboscis is covered with tiny backward-facing spines and serves as an organ of attachment (Fig. 9.2). The proboscis embeds in the small intestinal mucosa and allows the acanthocephalan parasite to attach to the host, similar to the scolex of the true tapeworm. It is in this enteric site that acanthocephalans feed; however, these are unusual parasites in that they lack a mouth. Instead, these strange-looking helminths have a trait that is similar to that of tapeworms: They do not possess an alimentary tract (a gut or intestinal tract). As a result, acanthocephalans must absorb nutrients through their body surface, or **tegument**.

Technician's Note

Acanthocephalans attach or embed in the small intestine of their host with a proboscis covered with tiny backward-facing spines. They absorb their nutrients through their body walls.

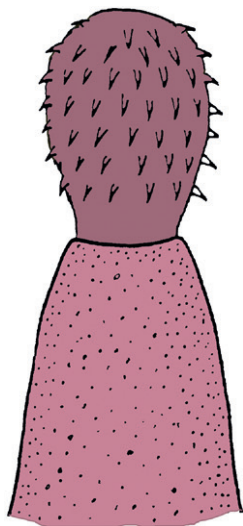


Fig. 9.1 Anterior end of *Macracanthorhynchus hirudinaceus*, the thorny-headed worm of swine. This colloquial name is derived from acanthocephalans' possession of a retractable proboscis, or nose, on the anterior end.



Fig. 9.2 The proboscis of *Macracanthorhynchus hirudinaceus* is covered with tiny backward-facing spines and serves as an organ of attachment.

Another important organ system in the acanthocephalan is the reproductive tract. As with all helminths, acanthocephalans have tremendous reproductive potential—one adult female worm can produce in excess of a quarter million eggs per day! These eggs pass out of the definitive host within its feces and embryonate in the external environment.

Life Cycle of the Thorny-Headed Worm

The typical acanthocephalan has a unique life cycle. Because adult acanthocephalans are found attached to the

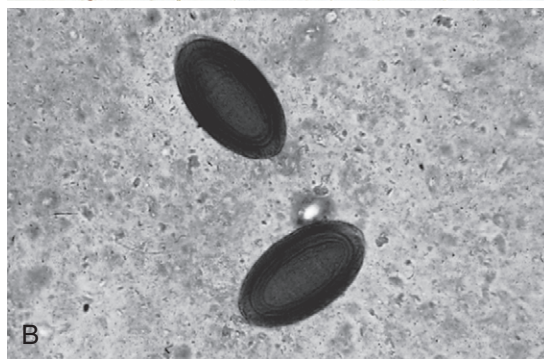
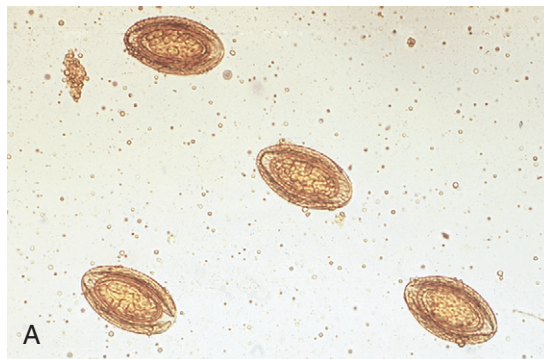


Fig. 9.3 The egg of *Macracanthorhynchus hirudinaceus* is spindle shaped and has a shell of three layers. The egg contains the larval acanthocephalan, or acanthor.

small intestinal mucosa, the eggs are voided in the feces of the definitive host. The egg is spindle shaped and has a shell of three layers (**Fig. 9.3**). This egg contains the larval acanthocephalan, or **acanthor**. The intermediate host, usually some type of arthropod (e.g., dung beetle), ingests the egg, and the acanthor larva hatches in that intermediate host. Within the intermediate host, the larva develops to the next stage, the **acanthella**. The acanthella develops into the **cystacanth** stage, which has an inverted proboscis. The definitive host ingests the arthropod intermediate host.

Within the intestine of the definitive host, the acanthella everts its proboscis and attaches to the wall of the small intestine. This juvenile acanthocephalan grows to the adult stage, and the life cycle begins again (Fig. 9.4).

Technician's Note

The adult female acanthocephalan can produce 250,000 eggs per day. The eggs are ingested by an arthropod and develop into an acanthor larva, then an acanthella to a cystacanth stage. The arthropod is ingested by the new host, and the acanthella everts its proboscis to embed in the intestinal mucosa.



Acanthocephalans of Importance in Veterinary Parasitology

M. hirudinaceus and *O. canis* are the acanthocephalans of importance in veterinary medicine.

Macracanthorhynchus hirudinaceus

Parasite: ❖ *Macracanthorhynchus hirudinaceus*

Host: Pigs

Location of Adult: Small intestinal mucosa

Intermediate Host: Dung beetle

Distribution: Worldwide

Derivation of Genus: Large thorny nose

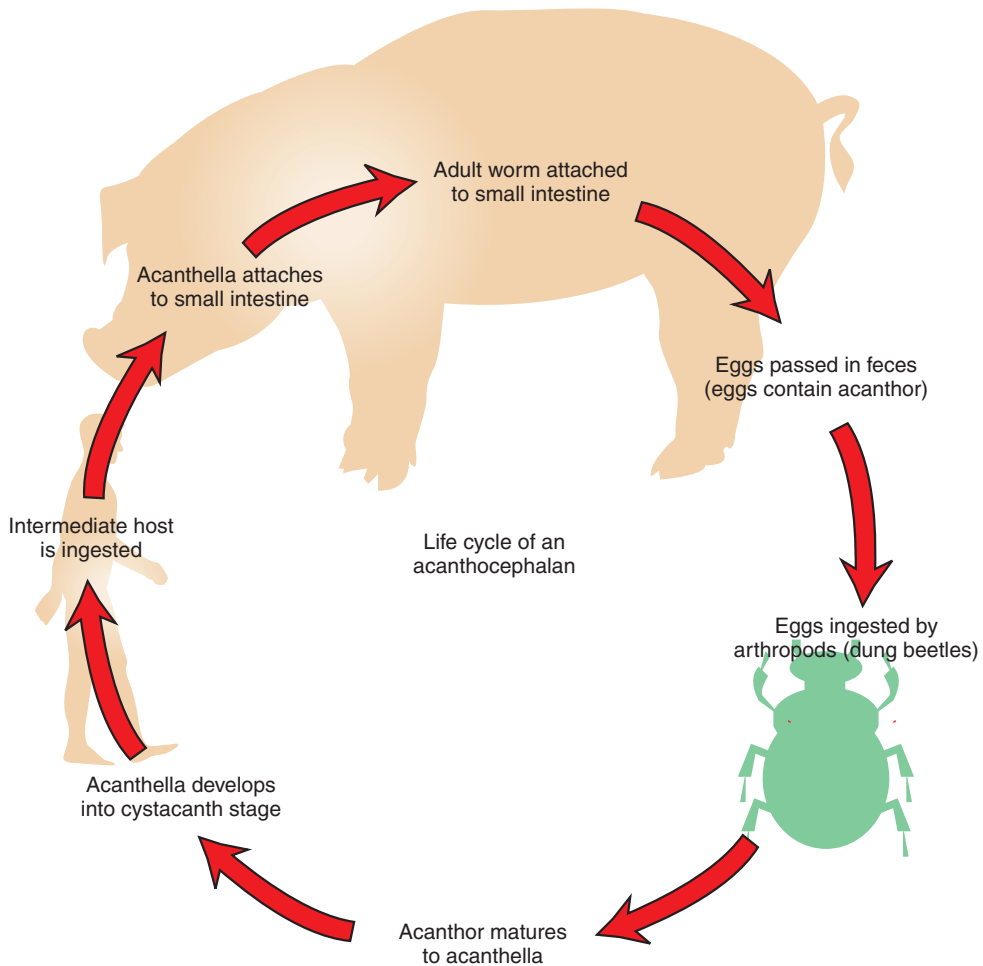


Fig. 9.4 Life cycle of the acanthocephalan.

Transmission Route: Ingestion of infective dung beetle

Common Name: Thorny-headed worm of swine

Zoonotic: Per the Companion Animal Parasite Council (CAPC), humans can be infected by ingesting an infective insect.

Macracanthorhynchus hirudinaceus, the thorny-headed worm of swine, is the acanthocephalan found attached to the lining of the small intestine of pigs (Fig. 9.5). Because of its attachment to the intestinal mucosa, the parasite has the potential to perforate the intestine, thus causing peritonitis and possible death. This parasite has the dubious distinction of having the longest scientific name among all the parasites of wild and domesticated animals. During postmortem examination, the prosector (pathologist) might, at first glance, make a diagnosis of swine roundworm, *Ascaris suum* (see Fig. 4.70). On closer examination, however, it is apparent that the parasite is firmly attached to the mucosa of the small intestine rather than free within the lumen. *A. suum* does not attach to the mucosa but remains within the lumen of the small intestine. *M. hirudinaceus* can grow up to 70 cm in length, although the males average up to 10 cm in length and the females up to 35 cm, and these worms are 4 to 10 mm thick. The proboscis is tiny and is covered with six rows of six hooks each. These backward-facing hooks are used to anchor the adult parasite to the mucosa. The eggs of *M. hirudinaceus* are 40 to 65 μm $\times$ 67 to 110 μm and have a three-layered shell; the second shell is brown and pitted (see Fig. 9.3) and can be found using standard fecal flotation procedures. Because humans seldom intentionally eat dung beetles (the intermediate host of *M. hirudinaceus*), this acanthocephalan is seldom identified as a zoonotic parasite.

Technician's Note



On postmortem examination, one may confuse *Macracanthorhynchus hirudinaceus* with the adult of *Ascaris suum*. On closer examination, *M. hirudinaceus* will be found to be firmly attached to the intestinal mucosal lining while *Ascaris suum* will be free within the intestinal lumen.

Oncicola canis

Parasite: *Oncicola canis*

Host: Dogs

Location of Host: Small intestinal mucosa

Intermediate Host: Dung beetle

Distribution: North and South America

Derivation of Genus: Strain mass

Transmission Route: Ingestion of infective dung beetle

Common Name: Thorny-headed worm of dogs

Zoonotic: No

Oncicola canis, the thorny-headed worm of dogs, is the acanthocephalan found attached to the lining of the small intestine of dogs. This is a tiny acanthocephalan, only 14 mm in length. The body is tapered posteriorly, and on the anterior end is the characteristic proboscis armed with hooks. As with *M. hirudinaceus*, these are backward-facing hooks used to anchor the adult parasite to the mucosa of the small intestine. With their proboscis embedded within the small intestinal wall, they often penetrate through to the peritoneum. Perforation of the intestinal wall, leading to peritonitis and death, is possible. The eggs of *O. canis* are brown and oval, approximately 65 $\times$ 45 μm , and can be found with standard fecal flotation procedures.

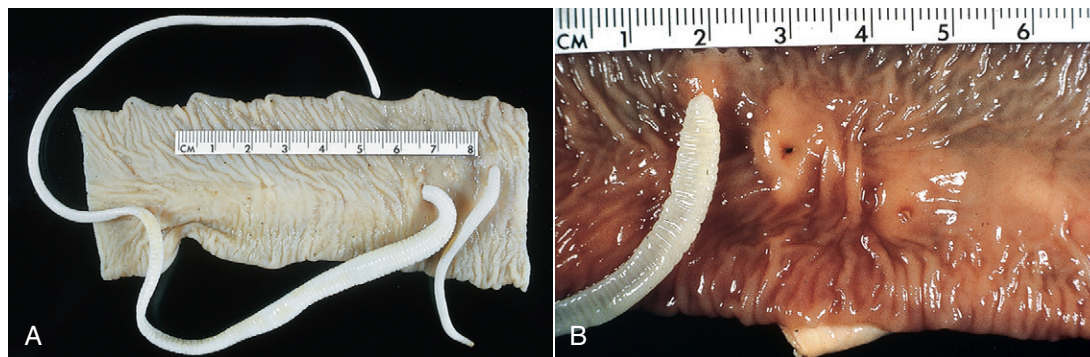


Fig. 9.5 *Macracanthorhynchus hirudinaceus*, the thorny-headed worm of swine, is found attached to the lining of the small intestine of pigs.

Technician's Note

Oncicola canis is an acanthocephalan, but it is very rare to find this parasite in the dog.

Although the phylum Acanthocephala is extremely small with regard to domesticated animals, veterinarians should understand its importance, especially with regard to the swine industry.

Chapter Nine Test

MATCHING—Match the scientific term in the left hand column with the correct phrase or term in the right hand column.

A. Acanthocephalans	1. Larval acanthocephalan stages within the intermediate host
B. Proboscid with backward-facing spines	2. Three-layered shell
C. Tegument	3. "Feeding organelle" that absorbs nutrients through the body surface
D. Dung beetle	4. Organ of attachment; holdfast organelle
E. Acanthocephalan egg	5. Larval acanthocephalan stage within the egg
F. Acanthor	6. Thorny-headed worm of dogs
G. Acanthella and cystacanth	7. Thorny-headed worm of swine
H. <i>Macracanthorhynchus hirudinaceus</i>	8. Thorny-headed or spiny-headed worms
I. <i>Oncicola canis</i>	9. Usual intermediate host for an acanthocephalan
J. Acanthocephalan pathology	10. Attachment to the wall of the small intestine

Questions for Thought and Discussion

- Macracanthorhynchus hirudinaceus*, the swine acanthocephalan, is often confused with *Ascaris suum*, the swine ascarid. Compare and contrast these two important swine parasites relative to their size, location within the host, pathologic findings/conditions, description of the eggs (ova), and life cycle.
- What two features or qualities do acanthocephalans have in common with true tapeworms?

Chapter

10

The Protozoans

OUTLINE

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Mastigophora (Flagellates)	134
Sarcodina (Amoebae)	135
Ciliophora (Ciliates)	136
Apicomplexa (Apicomplexans)	136

LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Identify the four basic types of protozoans.
- Describe how the four different groups of protozoans move.

KEY TERMS

Cilia	Protozoans
Ciliophoran	Pseudopodia
Flagellum	Sarcomastigophorans
Pathogenicity	Trophozoite

Only two kingdoms of living creatures have members that are true parasites of domesticated animals. These parasites belong to the kingdom Animalia and the kingdom Protista. Most of the parasites of domesticated animals belong to the Animalia kingdom (flukes, tapeworms, roundworms, thorny-headed worms, arthropods, and leeches). The rest of the animal parasites belong to the kingdom Protista. This kingdom contains the unicellular, or one-celled, organisms (better known as the **protozoans**).

Most protozoans are free-living organisms; however, those protozoans that are parasitic may produce significant pathology in domesticated animals and humans. Within the kingdom Protista are several phyla, which contain (1) flagellated protozoans, (2) ameboid protozoans, (3) apicomplexans, and (4) ciliated protozoans. These phyla contain the primary protozoans that may cause significant pathology in domesticated animals and humans.

Technician's Note



The parasitic protozoans are categorized in several phyla: **sarcomastigophorans** (subphylum flagellated and subphylum ameboid), apicomplexan, and ciliated (**ciliophoran**) protozoans.

Characteristics of the Protozoans

Protozoans are unicellular organisms; that is, they are one-celled organisms. Protozoans vary greatly in size, form, and structure; most are microscopic, and a very few are macroscopic, that is, visible to the naked eye. The kingdom Protista is divided into several phyla. These phyla differ in the manner in which the protozoans move within their tiny microenvironments. In veterinary parasitology, the most important phyla are Sarcomastigophora (containing the flagellates and amoebae), Ciliophora (containing the ciliates), and Apicomplexa (containing the coccidia, malarial organisms, and piroplasms).

Technician's Note



Protozoans are single-celled organisms that may be parasites of both humans and domesticated animals.

Mastigophora (Flagellates)

Kingdom: Protista

Phylum: Sarcomastigophora

Subphylum: Mastigophora (flagellates)

The flagellates are those protozoans that possess at least one **flagellum** (a long whip-like or lash-like appendage) in

their **trophozoite**, or moving form. This flagellum allows the protozoan to move about in a fluid medium. As a result of this activity, parasitic flagellates live in the liquid world of the host's blood, lymphatic fluid, or cerebrospinal fluid. Flagellates are often pear shaped or bullet shaped and are able to swim in their host's body fluids, meeting very little resistance. These flagellates vary greatly in **pathogenicity** (disease-causing potential). Some flagellates are highly pathogenic, whereas others appear to cause little or no harm to the host. Some important genera of parasitic flagellates of domestic animals are *Leishmania*, *Trypanosoma*, *Trichomonas*, *Histomonas*, and *Giardia* species. Fig. 10.1 is a diagram of a representative flagellate, *Tritrichomonas foetus*, a flagellated protozoan of the reproductive tract of cattle.

Sarcodina (Amoebae)

Kingdom: Protista

Phylum: Sarcomastigophora

Superclass: Sarcodina (amoebae)

The amoebae are protozoans that move via **pseudopodia** ("false feet"). Amoebae have two forms: the motile

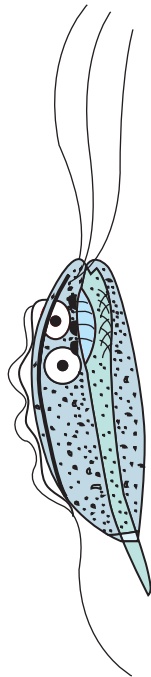


Fig. 10.1 Diagram of the representative flagellate, *Tritrichomonas foetus*, a flagellated protozoan of the reproductive tract of cattle. Note the three anterior flagella, undulating membrane, and trailing posterior flagellum.

trophozoite form and the resistant cyst form. In their motile trophozoite form, amoebae glide or flow along a solid surface, usually the surface at the bottom of the liquid medium. Amoebae are amorphous (poorly defined, or blob-like, in shape). As with the flagellates, the amoebae vary greatly in their pathogenicity. Some amoebae are highly pathogenic, whereas others appear to cause little or no harm to the host. Amoebae demonstrate a resistant cyst form that allows them to survive in adverse conditions in the external environment.

The most important parasitic amoeba of humans is *Entamoeba histolytica*. *Entamoeba coli*, a nonpathogenic amoeba, may also be found in humans and pigs. Fig. 10.2 is a diagram of the motile trophozoite stage of a representative amoeba, *E. histolytica*, an amoeboid protozoan. Fig. 10.3 is a diagram of the resistant cyst stage of *E. histolytica*.

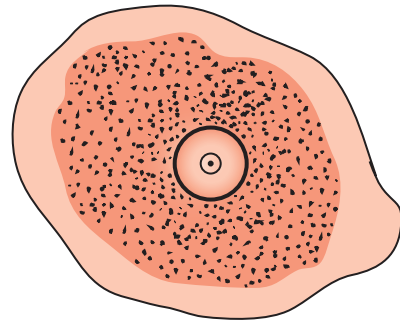


Fig. 10.2 Diagram of the motile trophozoite stage of a representative amoeba, *Entamoeba histolytica*, an amoeboid protozoan, with characteristic nucleus and bull's-eye nucleolus.

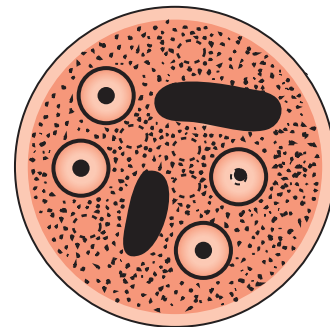


Fig. 10.3 Diagram of the resistant cyst stage of a representative amoeba, *Entamoeba histolytica*, with thick cyst wall, four nuclei, and dark chromatoid bodies.

Technician's Note

Entamoeba histolytica is the most important amebic protozoan in humans.

Technician's Note

Ciliates in the rumen of a cow are beneficial that they break down cellulose and assist in digestion.

Ciliophora (Ciliates)

Kingdom: Protista

Phylum: Ciliophora (ciliates)

Ciliates are protozoans that are covered with tiny, short hairs over most of their body surface. These tiny hairs are called **cilia**, thus the name ciliates. Ciliates move with these beating, undulating hairs. As with amoebae, ciliates demonstrate two forms: the motile trophozoite form and the resistant cyst form. In their trophozoite, or moving, form, ciliates dart and twirl speedily in liquid media. Ciliates come in a variety of sizes and shapes, but all are covered with these tiny hairs. Fig. 10.4 is a diagram of the motile trophozoite form of a representative ciliate, *Balantidium coli*, a ciliated protozoan of the intestinal tract of pigs. Some amoebae, such as *B. coli* and *Ichthyophthirius multifiliis*, are highly pathogenic to their hosts, whereas other ciliates, such as those in the rumen of the cow or sheep or the cecum of the horse, have beneficial roles. As with amoebae, ciliates demonstrate a resistant cyst form that allows them to survive in adverse conditions in the external environment. Fig. 10.5 is a diagram of the resistant cyst stage of *B. coli*. The ciliates are unique among the protozoans in that they possess two types of nuclei: a macronucleus and a micronucleus.

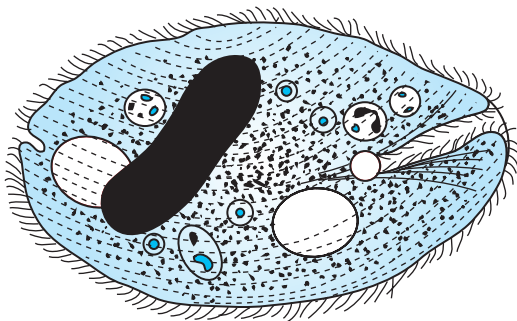


Fig. 10.4 Diagram of the motile trophozoite form of a representative ciliate, *Balantidium coli*, a ciliated protozoan of the intestinal tract of pigs.

Apicomplexa (Apicomplexans)

Kingdom: Protista

Phylum: Apicomplexa (apicomplexans)

Of the protozoans, the apicomplexans are the most diverse and the most complicated. The apicomplexans are parasites of almost every animal phylum. In domesticated animals, they are found primarily in the epithelium of the intestine, within blood cells, and within cells of the reticuloendothelial system. The life cycles of these protozoans vary among the genera that affect domesticated animals; however, they do have a common trait in that their life cycles are complex and intimately integrated into the physiology of the host's body. The locomotory organelles of the flagellates, amoebae, and ciliates (i.e., flagella, pseudopodia, and cilia, respectively) are discernible. In contrast, the locomotory organelles of the apicomplexans are not visible to the naked eye; their locomotory organelles are internal. The apicomplexans are often banana-, comma-, or boomerang shaped (Fig. 10.6) and move via undulations. Some of the most important genera of parasitic apicomplexans of domestic animals are *Eimeria*, *Cystoisospora*, *Toxoplasma*, *Sarcocystis*, *Cryptosporidium*, *Plasmodium*, *Haemoproteus*, *Leukocytozoon*, *Babesia*, *Theileria*, *Cytauxzoon*, and *Hepatozoon*. These protozoans are perhaps the most diverse, complicated members of the Protista kingdom.

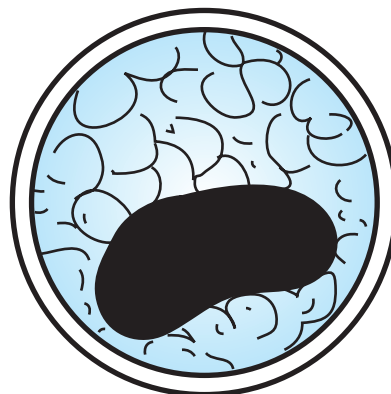


Fig. 10.5 Diagram of the resistant cyst stage of *Balantidium coli* with thick cyst wall and large, dark nucleus.

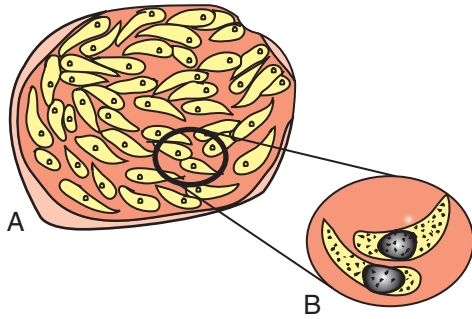


Fig. 10.6 A, Diagram of a cyst containing banana-, comma-, or boomerang shaped sporozoites typical of apicomplexans of domestic animals, for example, *Eimeria*, *Isospora*, *Toxoplasma*, *Sarcocystis*, *Cryptosporidium*, *Plasmodium*, *Haemoproteus*, *Leukocytozoon*, *Babesia*, and *Theileria* species. **B**, Note the enlarged banana-, comma-, or boomerang shaped sporozoites.

Technician's Note

The apicomplexan parasites do not have visible locomotory organelles but move via undulations. Some of the most commonly seen apicomplexans are *Eimeria* and *Cystoisospora*.

Chapter Ten Test

MATCHING—Match the scientific term in the left hand column with the correct phrase or term in the right hand column.

A. Protozoans	1. Tiny, short, moving hairs over most of the body surface
B. Sarcomastigophorans	2. Disease-causing potential
C. Ciliophorans	3. Organelles of internal movement, not visible to the naked eye
D. Apicomplexans	4. A long whip-like or lash-like appendage
E. Flagellum	5. <i>Balantidium coli</i> and <i>Ichthyophthirius multifiliis</i>
F. Trophozoite	6. Unicellular, or one-celled, organisms
G. Pathogenicity	7. Flagellates and amoebae
H. Pseudopodia	8. False feet of amoebae
I. Cilia	9. Moving or motile form
J. Locomotory organelles of apicomplexans and piroplasms	10. Coccidia, malarial organisms

Questions for Thought and Discussion

1. Discuss the different ways in which protozoans move.
2. Most of the parasites affecting domestic and wild animals are in the kingdom Animalia. Why do you think

that protozoans are included in a separate kingdom, Protista?

Common Protozoans That Infect Domestic Animals

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LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Remember the scientific names and the corresponding common names for the major protozoan parasites affecting domestic animals, laboratory animals, and fish.
- Recognize cyst and trophozoite forms of protozoans infecting the gastrointestinal tract when presented with a definitive host.
- Recognize intra- and extraerythrocytic forms of the hemoprotozoans when presented with a definitive host.
- Recognize the significance of protozoans that are zoonotic parasites.

KEY TERMS

Canine piroplasm	Ichthyophthiriosis
Cyst stage	Infectious enterohepatitis or blackhead
Endosome	Phlebotomine sand flies
Equine protozoal myeloencephalitis (EPM)	Ring form
Gamonts	Trophozoite
Hemoprotozoan	

This chapter is a continuation of [Chapter 10](#) in that it details the common protozoans that infect domestic animals. The parasitic protozoans are discussed in the same order as in [Chapter 10](#): flagellates, amoebae, ciliates, and apicomplexans. These parasites are discussed in the same system-by-system manner, that is, those infecting the gastrointestinal tract, the circulatory system and peripheral blood, and the urogenital system. These parasites are discussed in the following species of domesticated

animals: dogs and cats, ruminants (i.e., cattle and sheep), horses, pigs, pet and aviary birds, domestic fowl, rabbits, mice, rats, hamsters, guinea pigs, and fish.

Dogs and Cats

Gastrointestinal Tract

Protozoans that infect the gastrointestinal tract of dogs and cats are flagellates, amoebae, ciliates, and apicomplexans.

Flagellates

Parasite: ♦ *Giardia* species

Host: Dogs, cats, horses, ruminants, and exotic species

Location: Intestinal mucosa

Distribution: Worldwide

Derivation of Genus: Named after the famous protozoologist Alfred Giard

Transmission Route: Ingestion of oocysts

Common Name: *Giardia*

Zoonotic: *Giardia* assemblage A: yes; all other assemblages: no

Giardia species are flagellated protozoans often recovered from the feces of dogs and cats with diarrhea. They may also be recovered from animals with normal stools. These parasites occur in two morphologic forms: a rarely observed, motile feeding stage (the **trophozoite**) and a frequently observed, resistant **cyst stage**.

The motile trophozoite stage is pear shaped and dorsoventrally flattened and possesses four pairs of flagella. This stage is 9 to 21 μm $\times$ 5 to 15 μm . Two nuclei and a prominent adhesive disk are present on the anterior portion of the trophozoite, suggesting to the observer that a pair of eyes is "staring back." Fig. 11-1 presents the motile trophozoite form of the *Giardia* species.

The mature cysts of *Giardia* species are oval and are 8 to 10 μm $\times$ 7 to 10 μm . They have a refractile wall and four nuclei. Immature cysts, which represent recently encysted motile forms, contain only two nuclei. Fig. 11-2 presents a cyst of the *Giardia* species. In dogs, diarrhea may begin as early as 5 days after exposure to *Giardia*, with cysts first appearing in the feces at 1 week.

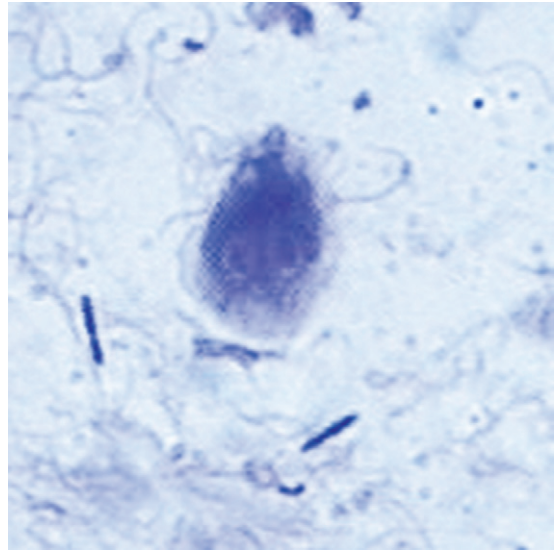


Fig. 11.1 The motile trophozoite of *Giardia* species is pear shaped and dorsoventrally flattened and possesses four pairs of flagella. Two nuclei and a prominent adhesive disk are present on the anterior portion of the trophozoite, suggesting a pair of eyes staring back.



Fig. 11.2 Mature cysts of *Giardia* species are oval and possess a refractile wall and four nuclei. Immature cysts, which represent recently encysted motile forms, contain only two nuclei.

Technician's Note



The trophozoites of *Giardia* species are typically seen in animals with diarrhea rather than animals with a formed stool.

Recent advances in molecular biology have changed the way *Giardia* species are named. Currently, *Giardia* is referred to in terms of assemblages rather than species. Assemblages A and B are associated with human beings, whereas assemblages C and D constitute the organisms found in dogs. Those organisms associated with cows,

sheep, goats, horses, and pigs are grouped in assemblage E. Assemblage F encompasses the forms found in cats, whereas assemblage G includes the organisms found in rodents. Although *Giardia* seems to be more species specific than once thought, assemblage A (that affecting humans) has been found in dogs and cats. This means there can still be a source of zoonotic infection from animals. However, it is more common that people are infected with *Giardia* by other people (Fig. 11-3).

Diagnosis of *Giardia* species is by standard fecal flotation. Zinc sulfate (specific gravity, 1.18) and Sheather sugar solution are considered the best flotation media for recovering cysts. Cysts are often distorted, with a semilunar appearance. The motile trophozoite occasionally can be found on direct smear of fresh feces (usually diarrhea) using isotonic saline. Lugol iodine stain may be used to visualize the internal structures of both cysts and trophozoites. Fecal immunodiagnostic tests are also frequently used. Using immunodiagnostic tests in conjunction with fecal flotation tests provides the best protocol for diagnosing *Giardia* infection.

Technician's Note



The cysts are hard to find in diarrheic samples; immunodiagnostic tests may thus be helpful with a definitive diagnosis.

Amoebae

Parasite: ♦ *Entamoeba histolytica*

Host: Canines, felines, primates, and humans

Location: Large intestines

Distribution: Worldwide but rare in the United States

Derivation of Genus: Internal amoeba

Transmission Route: Ingestion of cysts

Common name: Entamoeba

Zoonotic: Yes

Entamoeba histolytica, the etiologic agent that produces amebic dysentery (an extremely severe dysentery) in humans, may also produce sporadic infections in dogs. These cases usually have been acquired by association with infected humans. *E. histolytica* may produce acute or chronic diarrhea in dogs. Cats are rarely infected; most infections have been experimental.

E. histolytica occurs in two morphologic forms: a motile feeding stage (the trophozoite) and an environmentally resistant cyst stage. The motile trophozoite of *E. histolytica* ranges in size from 10 to 60 μm and has a single spherical nucleus that is 4 to 7 μm , with a tiny pinpoint center, a structure called an **endosome** (Fig. 11-4). The mature cysts are round and are 5 to 20 μm . They have a thin, refractile wall and may demonstrate as many as four nuclei, each with its own endosome. Immature cysts, which represent recently encysted motile forms, contain only one nucleus (Fig. 11-5).

CASE PRESENTATION 11-1

Setting Up the Scenario

Mr. Amazon brought his 8-year-old neutered-male German Shorthaired Pointer, Bougie, to the veterinary clinic for an annual physical examination and routine vaccinations. Dr. Joseph performed the examination and administered the necessary vaccinations while the veterinary technician performed a heartworm test and fecal centrifugation analysis. The technician reported finding *Giardia* assemblage C or D cysts in the stool sample. Dr. Joseph prescribed a 5-day course of fenbendazole followed by a 5-day course of metronidazole.

What Information Must the Veterinary Technician Convey to Mr. Amazon?

The technician educated Mr. Amazon on canine giardiasis.

"Mr. Amazon, Bougie has been diagnosed as having an intestinal protozoan parasite called *Giardia*. This is a one-celled parasite that lives in the small intestine and can cause diarrhea in dogs. You may remember the often-repeated story about traveler's diarrhea being contracted in Mexico by drinking contaminated water. This diarrhea is often referred

to as *Montezuma's revenge* and is often associated with *Giardia*, the protozoan parasite producing this illness. The parasite can be spread by a dog drinking water containing cysts of *Giardia* or ingesting cysts in soil contaminated by them. It is important that responsible dog owners clean up feces from the yard to prevent infection from their dog to any other dog that might become exposed.

"You should also know that dogs can serve as a reservoir for the *Giardia* species found in humans or in an assemblage or groupings of this parasite. Although the human form does not harm or cause disease to your dogs, dogs are capable of transmitting this parasite to you or to members of your family. Whenever anyone comes in contact with dog feces, that person's hands must be thoroughly washed with soap and hot water.

"Dr. Joseph is sending you home with two different antiprotozoals that will treat *Giardia*. Do you have any questions before you leave?"

The technician noted the discussion had taken place and that the zoonotic potential of the protozoan had been noted in the patient's record.

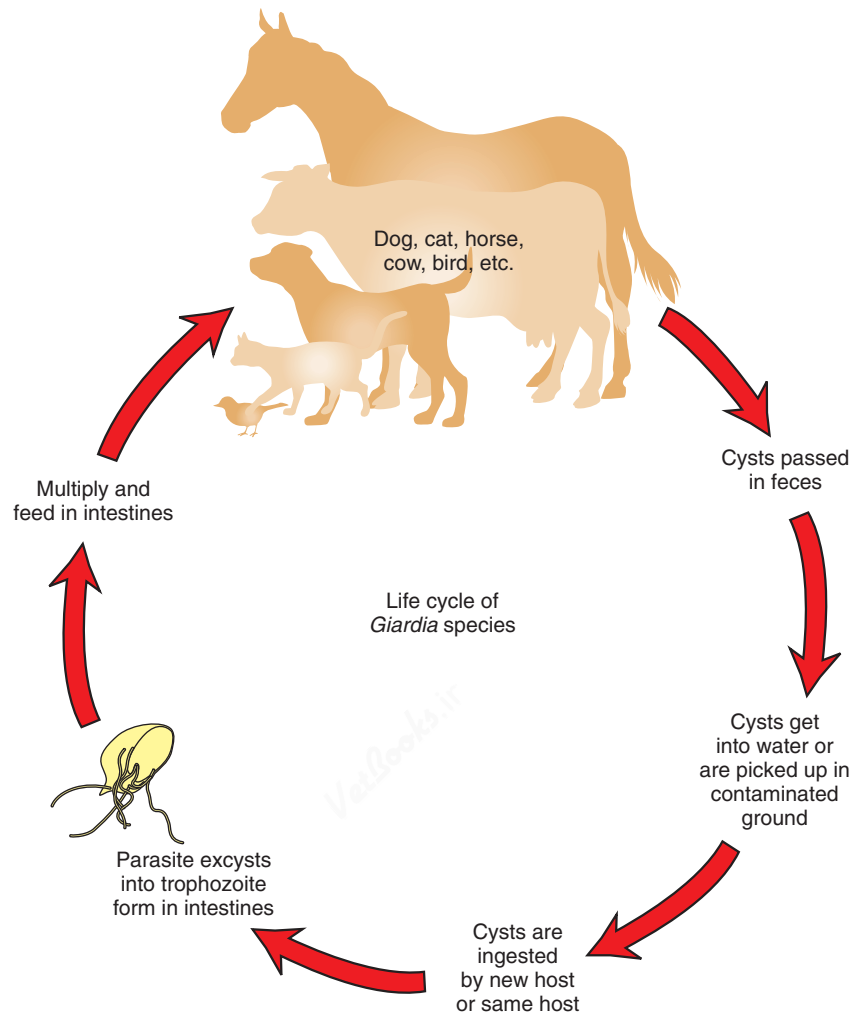


Fig. 11.3 Life cycle of *Giardia* species.



Fig. 11.4 Motile feeding stage of *Entamoeba histolytica*, the trophozoite stage. Note the single spherical nucleus with a tiny pinpoint center, or endosome.

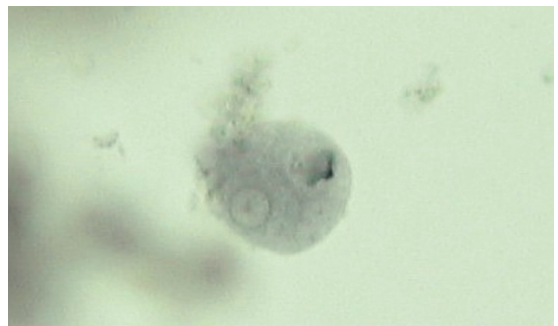


Fig. 11.5 Cyst of *Entamoeba histolytica*. The cyst may demonstrate as many as four nuclei. Immature cysts, which represent recently encysted motile forms, contain only one nucleus.

Technician's Note

Entamoeba histolytica is the parasite that causes amebic dysentery in humans.

Diagnosis of *E. histolytica* is by standard fecal flotation, which may be used to demonstrate both cyst and trophozoite forms. In a formed stool, the cyst form is usually found; however, in diarrhetic stool, both the cyst and the trophozoite forms may be observed. The direct smear technique may be used to observe motile forms in warm, freshly passed diarrhetic stools. Lugol iodine stain may be used to visualize the internal structures of both cysts and trophozoites. Zinc sulfate may be used to concentrate cysts. If infection with *E. histolytica* is suspected in a human, a human pathology laboratory should be consulted for assistance with diagnosis. Because *E. histolytica* is primarily a human pathogen, great care should be taken with suspect feces.

E. histolytica also can be a significant problem in primates such as monkeys and chimpanzees. Great care should be taken when handling suspect feces. Infection in monkeys has great public health significance.

Technician's Note

Entamoeba histolytica is primarily a human parasite.

Ciliates

Parasite: ♦ *Balantidium coli*

Host: Canines and swine

Location: Cecum and colon of canines and large intestine of swine

Distribution: Worldwide

Derivation of Genus: Small bag

Transmission Route: Ingestion of cysts

Common Name: Balantidium

Zoonotic: Yes (per *The Merck Veterinary Manual*)

Balantidium coli is the ciliated protozoan found occasionally in the cecum and colon of dogs. This parasite has been associated with diarrhea in dogs. *B. coli* is more intimately associated with pigs (see the section on swine protozoan parasites).

Apicomplexans

Parasite: *Cystoisospora* species (formerly *Isospora* species)

Host: Canines, felines, and swine

Location: Small intestines

Distribution: Worldwide

Derivation of Genus: Equal seeds; sac same spore

Transmission Route: Ingestion of oocysts

Common Name: Coccidia

Zoonotic: No

Cystoisospora species (coccidians) are protozoan parasites of the small intestine of dogs and cats. They produce a clinical syndrome known as *coccidiosis*, caused by inflammation of the intestine, one of the most commonly diagnosed protozoan diseases in puppies and kittens. It produces loose stool to a watery diarrhea. Coccidiosis is rarely a problem in mature animals. The oocyst is the diagnostic stage observed in a fecal flotation of fresh feces; it is unsporulated in fresh feces and varies in size and shape among the common *Cystoisospora* species. Fig. 11-6 shows an unsporulated oocyst, and Fig. 11-7 shows a sporulated oocyst. The canine coccidians and their measurements are *Cystoisospora canis*, 34 to 40 μm $\times$ 28 to 32 μm ; *Cystoisospora ohioensis*, 20 to 27 μm $\times$ 15 to 24 μm ;

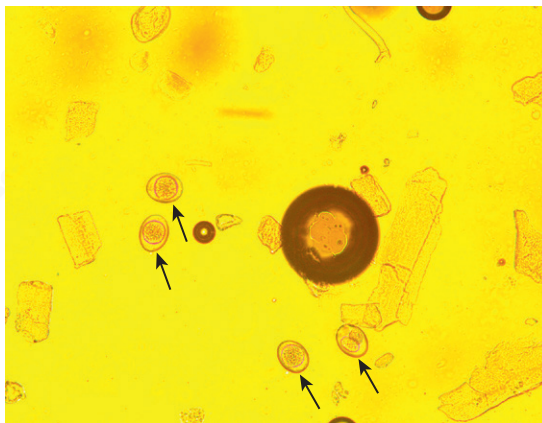


Fig. 11.6 Unsporulated oocysts of *Cystoisospora* species. *Cystoisospora canis* (large oocysts) and *Cystoisospora burrowsi* (small oocysts) are present.

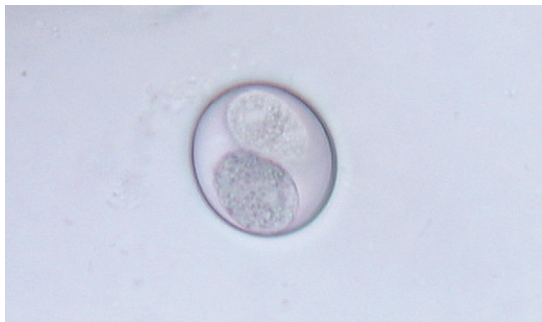


Fig. 11.7 Sporulated oocyst of *Cystoisospora rivolta* from older feces.

and *Cystoisospora burrowsi*, 10 to 14 $\mu\text{m} \times 7.5$ to 9 μm . The feline coccidians and their measurements are *Cystoisospora felis*, 38 to 51 $\mu\text{m} \times 27$ to 29 μm , and *Cystoisospora rivolta*, 21 to 28 $\mu\text{m} \times 18$ to 23 μm . Fig. 11-8 shows the life cycle of *Cystoisospora* species. The prepatent period varies among species, but it is usually 7 to 14 days.

Technician's Note

Cystoisospora species are some of the most commonly diagnosed parasites in puppies and kittens.



Parasite: ♦ *Toxoplasma gondii*

Host: Definitive host is the feline; can also occur in other animals and humans as an incidental parasite.

Location: Intestines

Distribution: Worldwide

Derivation of Genus: Bow body

Transmission Route: Ingestion of sporulated oocysts

Common Name: Toxoplasma

Zoonotic: Yes

Toxoplasma gondii is an intestinal coccidian of cats. Its oocysts are usually diagnosed using a standard fecal flotation solution. Oocysts of *T. gondii* are unsporulated in fresh

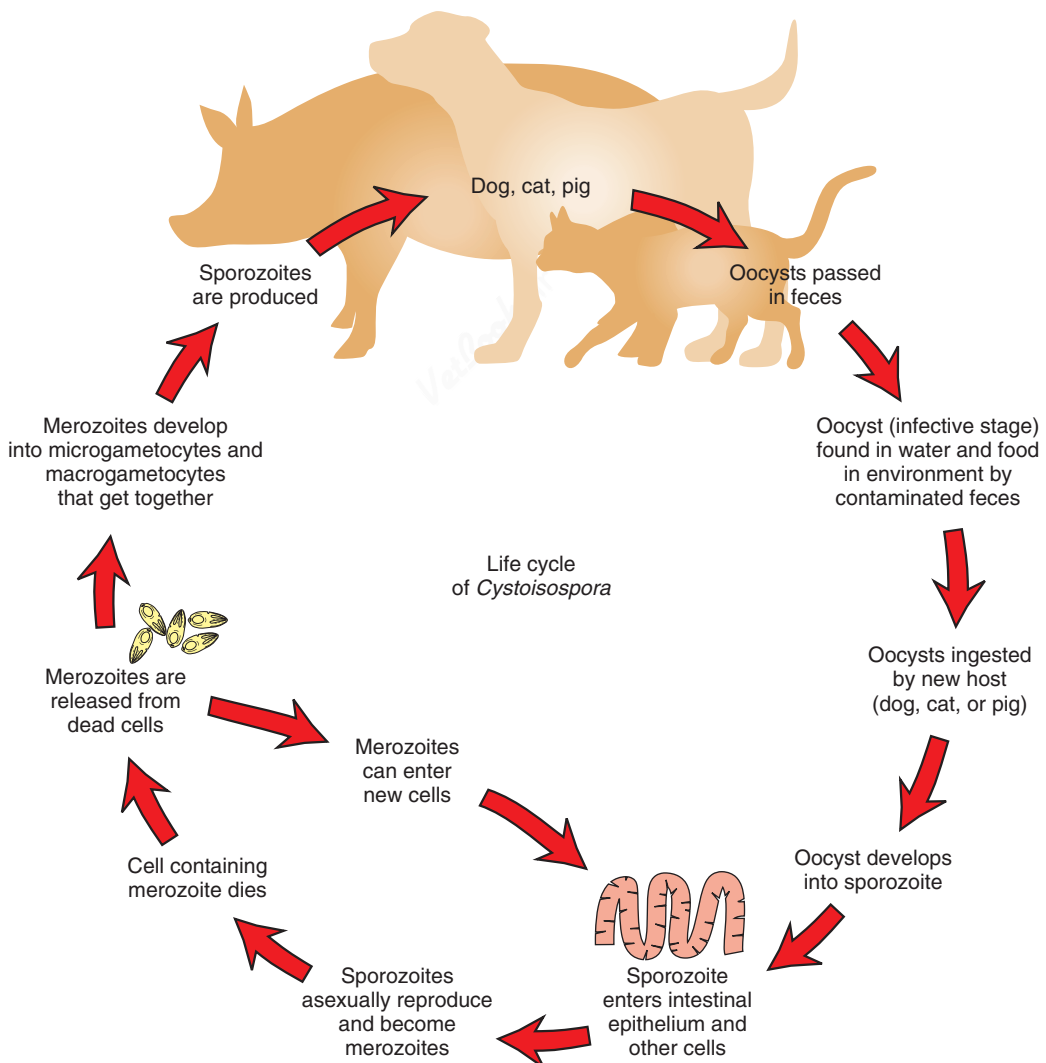


Fig. 11.8 Life cycle of *Cystoisospora* species.

CASE PRESENTATION 11-2

Setting Up the Scenario

Ms. Dunleavy brought her new 8-week-old female kitten, Clarisse, to her first kitten appointment for a thorough physical examination and routine vaccinations. The technician recorded the kitten's weight, collected a fecal sample, and trimmed Clarisse's nails. (Question: Can a kitten's nails be trimmed at 8 weeks?) Dr. Dundee performed a physical examination and administered first vaccinations to Clarisse while the technician performed the fecal centrifugation analysis. The technician reported finding oocysts of *Cystoisospora felis* in the fecal sample. Dr. Dundee diagnosed Clarisse as having coccidia and prescribed an effective antiprotozoal compound.

What Information Must the Veterinary Technician Convey to Ms. Dunleavy?

The technician explained the following to Ms. Dunleavy: "Clarisse has been diagnosed as having protozoans commonly called *coccidia*. Dr. Dundee is sending you home with an effective antiprotozoal for Clarisse. Coccidia, or *C. felis*, are common protozoan (single-celled) parasites found in young kittens and puppies. Coccidia commonly cause diarrhea, but this particular feline protozoan is not a parasite that humans can get from cats. This parasite is usually controlled by your kitten's body, but it will take time for Clarisse to develop immunity to the parasite. Therefore Dr. Dundee is going to treat the parasite so that Clarisse will not have diarrhea. The antiprotozoal agent should clear up the parasitic infection very quickly.

"Do you have any questions regarding *C. felis*?"

The technician noted in the patient's record that the discussion had taken place and that the protozoan parasite lacked zoonotic potential.

feces and measure $10 \times 12 \mu\text{m}$ (Fig. 11-9). Several immunodiagnostic tests using whole blood or serum are available for diagnosis of *T. gondii*. The prepatent period is highly variable, ranging from 5 to 24 days, and depends on the infection route. Fig. 11-10, A, shows the life cycle of *T. gondii* in the feline host, and Fig. 11-10, B, shows the life cycle in the nonfeline host. Because this parasite can use humans (and many other warm-blooded vertebrates) as intermediate hosts, *T. gondii* is a very important zoonotic parasite.

T. gondii can be a significant pathogen in humans (particularly the pregnant woman and her developing fetus). It is important to discuss this parasite with clients. Great care should be taken when handling suspect feces. Infection in cats has great public health significance.



Fig. 11.9 Unsporulated oocyst of *Toxoplasma gondii*, an intestinal coccidian of cats, from fresh feline feces. Its oocysts measure $10 \times 12 \mu\text{m}$.

CASE PRESENTATION 11-3

Setting Up the Scenario

Ms. Vance came into the veterinary clinic with her cat, and she was crying. Ms. Vance had come to the clinic to have her cat euthanized. Jerry is a 3-year-old neutered-male domestic shorthaired cat. Ms. Vance was led into the examination room and questioned regarding her cat's "medical problem." Ms. Vance replied that she recently found out she was expecting a baby and that her obstetrician had informed her that she needed to get rid of Jerry because the cat might transmit the deadly protozoan parasite *Toxoplasma gondii* to her unborn baby. Dr. Cotton had the technician run a fecal flotation and performed a physical examination on Jerry. The technician reported that there were no protozoan oocysts or helminth ova observed during the analysis of the fecal specimen.

Dr. Cotton told Ms. Vance to remain calm and that there were a few preventive measures that she might implement so that Jerry could remain in her home and not have to be euthanized. Dr. Cotton had the technician explain the life cycle of toxoplasmosis to Ms. Vance and detail the measures that might be taken to prevent human infection.

What Information Must the Veterinary Technician Convey to Ms. Vance?

The technician explained the following to Ms. Vance:

"*T. gondii* is a protozoan parasite that causes toxoplasmosis, a disease that can be transmitted to humans, especially during pregnancy. Your physician is right to be so worried about the possibility of this disease being transmitted to you from your

Continued

CASE PRESENTATION 11-3—cont'd

cat. Only cats can serve as definitive hosts, capable of transmitting the parasite to other animals. However, cats pass the parasite only during about a 2-week time period in their lives. We did not observe any protozoan oocysts or helminth eggs during the examination of Jerry's stool sample. Although it is true that a mother being exposed for the first time during pregnancy can have problems, this is not a common occurrence. Most humans have already been exposed to the parasite, and their immune systems are programmed to prevent further infection. In addition, there are several techniques that might be used to prevent exposure to this parasite.

1. Have someone else (for example, your husband or other family members or friends) clean and empty the litter box. If this is not possible, you should wear gloves while cleaning the litter box. The litter box should be cleaned daily to remove any developing oocysts from the home environment. It takes approximately 48 hours for the oocysts to become infective to animals, including humans; the oocysts are undergoing a process called *sporulation*. If the litter box is changed daily, the oocyst will not develop in the presence of a pregnant woman, and the feces will not become infective for toxoplasmosis.
2. Hands should be thoroughly washed with soap and warm water, especially after the litter box has been cleaned, after working in garden soil, and after playing with children in a sandbox. Outdoor cats prefer flower and vegetable gardens and sandboxes as sites in which to defecate. Even if there are no cats residing in the household, one can still become exposed to toxoplasmosis during normal day-to-day activities. Precautions should always be taken to avoid infection.
3. If Jerry is kept inside the house, away from mice and rats, it will not be possible for him to become exposed

to this parasite. Cats enjoy preying on rodents and other small creatures that are capable of serving as intermediate hosts when they are eaten by the cat.

4. Sandboxes must be covered after each and every episode of use to prevent cats from using the play area as their litter box. Gardens should be securely fenced and patrolled for the same reason. Both of these options may prove difficult, but precautions must be taken to prevent exposure.
5. Hands should be thoroughly washed with soap and warm water during the food-preparation process, especially after handling raw meat. Raw muscle may contain one of the life-cycle developmental stages of *Toxoplasma* that can become encysted within animal muscle (and therefore become contagious to people).
6. Another way that humans can become infected with *T. gondii* is by ingesting poorly cooked meat. Although cats are the only animals that shed the oocysts in their feces, other animals can become infected by ingesting the tissue stages within meat. This infective encysted form in the muscle can easily be transmitted in raw meat. Make sure that meat is not consumed in either a raw or undercooked state. Cats should never be fed raw or undercooked meat.
7. The kitchen and dining room should never be considered an acceptable place to locate a cat's litter box. Cat feces should never be in close proximity to food preparation/consumption areas.

"Do you have any other questions regarding *T. gondii*?"

Ms. Vance left the clinic with a big smile on her face and Jerry in his cat carrier. The technician noted that the discussion regarding this pathogenic protozoan had taken place and that the zoonotic potential had been noted in the patient's record.

Technician's Note



The feline sheds *Toxoplasma gondii* oocysts for only up to 2 weeks of its life unless cat become immunocompromised.

Parasite: ♦ *Cryptosporidium* species

Host: Canines, felines, bovines, ovines, swine, avians, guinea pigs, snakes, and mice

Location: Small intestine

Distribution: Worldwide

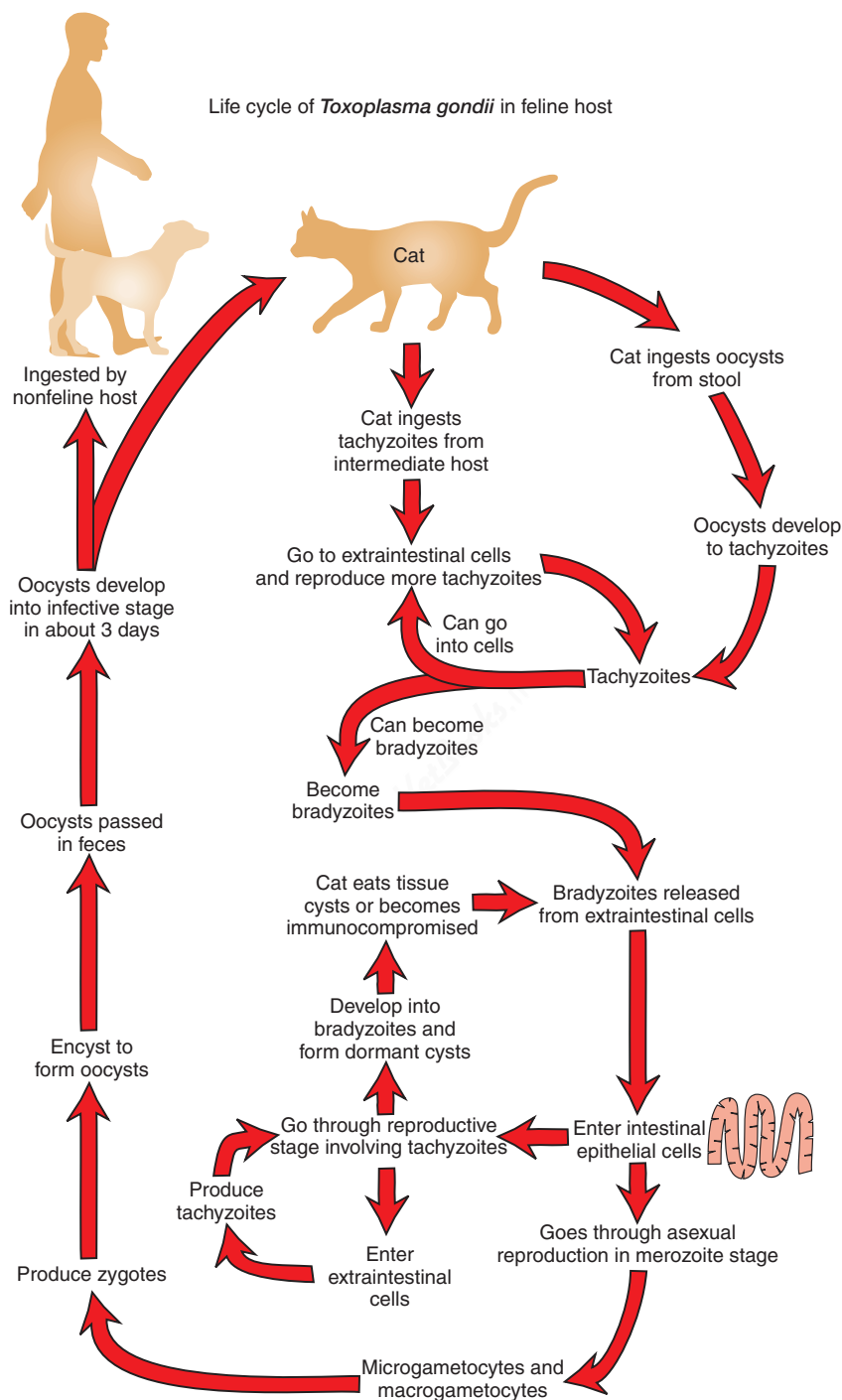
Derivation of Genus: Hidden small seeds

Transmission Route: Ingestion of oocysts

Common Name: *Cryptosporidia*, "Crypto"

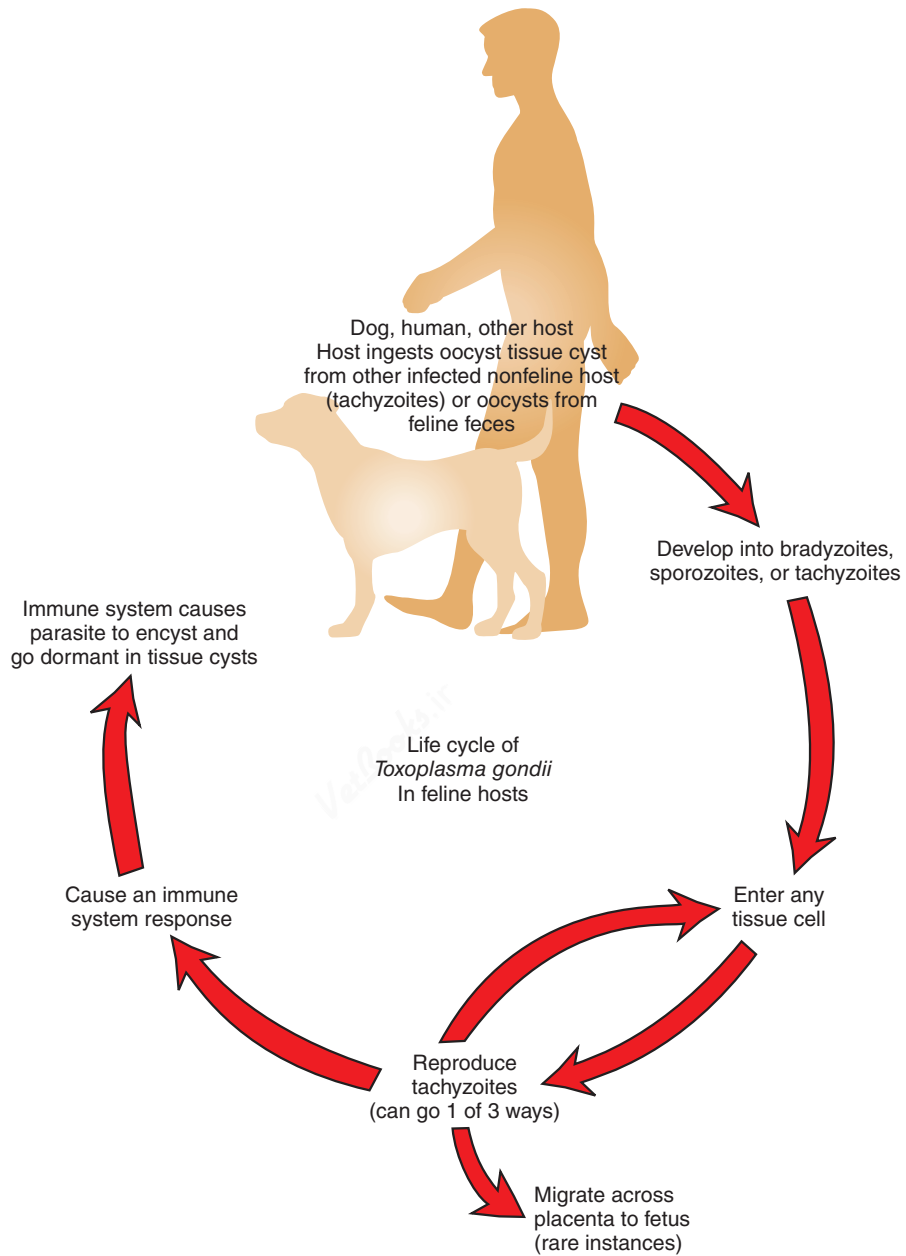
Zoonotic: Yes

Cryptosporidium species is another coccidian-like parasite that parasitizes the mucosal cells of the small intestine of a variety of animals and causes inflammation of those cells. These animals include cows, pigs, dogs, cats, birds, and guinea pigs. *Cryptosporidium* species in snakes and mice and some species in cows parasitize the stomach and abomasum (cows). There is also a species of *Cryptosporidium* that parasitizes humans. In most cases of infection, diarrhea is the major clinical sign. The sporulated oocysts in the feces are oval to spherical and measure only 4 to 6 μm . Diagnosis is by standard fecal flotation. The oocysts are extremely small and may be observed just under the coverslip, not in the same plane of focus as other oocysts and parasite ova (Fig. 11-11). Examination of fresh fecal smears using special stains (modified acid-fast stain) is also helpful. Enzyme-linked immunoassay (ELISA) tests are also being used to diagnose this parasite.



A The cat is the only animal species that sheds oocysts of *T. gondii* in its feces

Fig. 11.10 A, Life cycle of *Toxoplasma gondii* for feline hosts.



B

T. gondii will not produce oocysts in a nonfeline hostFig. 11.10, Cont'd B, Life cycle of *T. gondii* for nonfeline hosts.

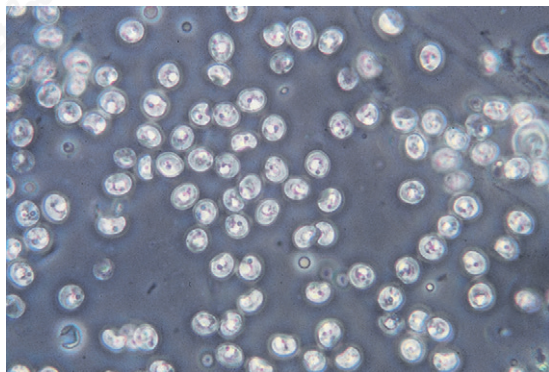


Fig. 11.11 Numerous oocysts of *Cryptosporidium*, a coccidian parasite that parasitizes the small intestine of dogs and cats. Sporulated oocysts in feces are oval to spherical and measure 3 to 5 μm . Diagnosis is by standard fecal flotation. Oocysts are extremely small and may be observed just under the coverslip, not in the same plane of focus as other oocysts and parasite ova. Examination of fresh fecal smears using special stains (modified acid-fast stain) is also helpful.

Because humans may become infected with *Cryptosporidium* species, feces suspected of harboring this protozoan should be handled with great care. *Cryptosporidium* is a zoonotic parasite. *Cryptosporidium parvum* is the most common zoonotic species. However, *Cryptosporidium canis*, *Cryptosporidium felis*, *Cryptosporidium meleagridis* (birds), *Cryptosporidium muris* (mice), and *Cryptosporidium suis* (pigs) have been seen in humans.

Technician's Note

Feces suspected of containing *Cryptosporidium* oocysts should be handled with great care.

Parasite: *Sarcocystis* species

Host: Canines and felines

Location: Small intestine

Distribution: Worldwide

Derivation of Genus: Flesh cyst

Transmission Route: Ingestion of the muscle of horses, pigs, and ruminants

Common Name: Sarcocystis

Zoonotic: No

Sarcocystis species are the final coccidian parasites cited here that are found in the small intestine. Several species infect dogs and cats, and identification of an individual species can be quite difficult. The oocysts of *Sarcocystis* species are sporulated when passed in the feces. Each oocyst contains

two sporocysts, each with four sporozoites. These individual oocysts measure 12 to 15 μm $\times$ 8 to 12 μm and may be recovered in standard fecal flotation of fresh feces. The oocysts are ingested by a ruminant, horse, or pig, depending on the specific species of *Sarcocystis*. The oocysts excyst and go through multiple asexual reproductive stages before encysting in the muscles of the intermediate host. The muscle tissue of the intermediate host must be ingested to complete the maturation to the oocyte stage in the final host species, canine or feline.

Technician's Note

There are seven species of *Sarcocystis* that infect dogs and five species that infect cats. Each of the species has a different intermediate host.

Circulatory System and Blood

Protozoans that infect the circulatory system and blood of dogs and cats are flagellates and apicomplexans.

Flagellates

Parasite: ♦ *Trypanosoma cruzi*

Host: Humans and occasionally canines

Location: Peripheral blood

Distribution: Primarily in Central and South America but occasionally in the southern United States

Derivation of Genus: Borer body

Transmission Route: Ingestion of intermediate host, reduviid bug, or feces of reduviid bug left on mucous membranes of the final host

Common Name: Trypanosome

Zoonotic: Yes

Trypanosoma cruzi is a **hemoprotozoan** (a protozoan found circulating in the peripheral blood). It is found primarily in Central and South America; however, it is occasionally reported in dogs in the southern half of the United States. This trypanosome is extracellular; it is not found within the red blood cell (RBC) itself. It “swims” within the blood. This swimming stage is called a *trypomastigote* and is 16 to 20 μm in length, approximately 3 to 10 times as long as an RBC is wide. It is banana shaped and possesses a lateral, undulating membrane and a thin whip-like tail (the flagellum) that is used for swimming. These parasites are also transmitted by blood-feeding arthropods called *reduviid bugs*, or “kissing bugs” (see [Chapter 13](#)). *T. cruzi* also has a resting cyst stage (the amastigote stage) that may be found encysted within cardiac muscle and other tissues such as the esophagus. The encysted amastigote

stage lacks the undulating flagellum of the swimming trypomastigote stage.

The trypomastigote stage of *T. cruzi* may be found swimming within the peripheral blood and may be demonstrated in direct blood smears. The amastigote stage must be confirmed using histopathologic sectioning. Suspect tissues should be submitted to a histopathology laboratory for diagnosis by a veterinary pathologist or parasitologist.

Technician's Note



The trypomastigote stage of *Trypanosoma cruzi* may be found in a peripheral blood smear.

Parasite: ♦ *Leishmania* species

Host: Canines

Location: Reticuloendothelial cells of the capillaries and spleen, as well as other internal organs and white blood cells (WBCs)

Distribution: Worldwide but rarely seen in North America

Derivation of Genus: Named after the famous physician William Leishman

Transmission Route: Bite by an infective intermediate host, phlebotomine sand flies

Common Name: *Leishmania*

Zoonotic: Yes

Leishmania species is another hemoprotozoan (blood protozoan). The parasite is found primarily in areas other than North America; however, it is occasionally reported in dogs that have traveled or were born overseas. It is rarely diagnosed in dogs that have never left the United States. This flagellate is intracellular and found within reticuloendothelial cells of the capillaries, spleen, and other internal organs and in monocytes, polymorphonuclear leukocytes, and macrophages. Instead of having a flagellum and being called the *trypomastigote stage*, as with *T. cruzi*, this parasite lacks the flagellum and is called the *amastigote stage*. *Leishmania* is transmitted by blood-feeding arthropods called **phlebotomine sand flies** (see [Chapter 13](#)).

The amastigote stage of *Leishmania* must be confirmed using histopathologic sectioning of infected organs. Suspect tissues should be submitted to a histopathology laboratory for diagnosis by a veterinary pathologist or parasitologist.

Technician's Note



Leishmania species are rarely seen in dogs in North America.

Apicomplexans

Parasite: *Babesia canis*

Host: Canine

Location: Within RBCs

Distribution: Europe, Africa, Asia, North and South America

Derivation of Genus: Named after the famous bacteriologist Victor Babès

Transmission Route: Bite of an infective intermediate host, tick

Common Name: Babesia or canine piroplasm

Zoonotic: No

Babesia canis is an intracellular parasite found within the RBCs of dogs. It has been referred to as the **canine piroplasm**. The parasite demonstrates pear shaped organisms within canine RBCs. This protozoan parasite is spread by the bite of infected ticks. Diagnosis is by observing basophilic, pear shaped organisms within RBCs in stained blood smears ([Fig. 11-12](#)). This parasite causes damage by residing within the RBCs. Common symptoms include pale mucous membranes, icterus, hemoglobinuria, depression, hemoglobine-mia, weakness, splenomegaly, fever, and anorexia.

Technician's Note



Babesia canis can be broken down into three subspecies that denote in which country the species is found. *Babesia canis canis* is found in Europe, *Babesia canis vogeli* is found in Northern Africa and North America, and *Babesia canis rossi* is found in Southern Africa (Bowman, 2009).

Parasite: *Cytauxzoon felis*

Host: Feline

Location: Within RBCs

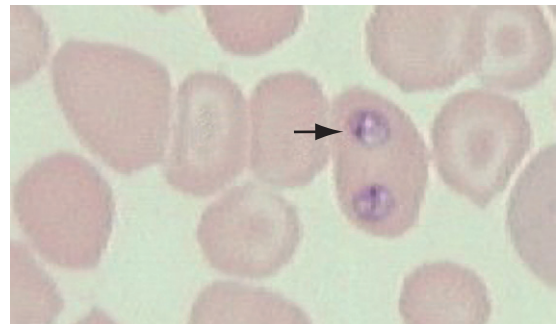


Fig. 11.12 Trophozoites of *Babesia canis* within canine red blood cells.

Distribution: Africa and the United States

Derivation of Genus: Hollow vessel-increasing animal

Transmission Route: Bite from an infective intermediate host, tick

Common Name: Cytauxzoon

Zoonotic: No

Cytauxzoon felis is another intracellular parasite that has been reported in the RBCs of cats in sporadic sites (Missouri, Arkansas, Georgia, and Texas) throughout the United States and Africa. It also produces piroplasms; however, these bodies have been described as being in the shape of a “bejeweled ring” and are referred to as the **ring form** in stained blood smears (Fig. 11-13). This disease is spread by ticks, and its prognosis is poor. Diagnosis is made by observing the bejeweled-ring piroplasms within the RBCs in stained blood smears. Common symptoms include fever, icterus, anemia, dehydration, and death. As with *B. canis*, *C. felis* causes damage by inflammation within the RBCs.

Technician's Note



Cytauxzoon felis is diagnosed by finding the jewel-like ring form in the RBCs in stained blood smears.

Parasite: *Hepatozoon canis* and *Hepatozoon americanum*

Host: Canines

Location: Gamonts are found within WBCs, whereas schizonts are found in the endothelial cells of the spleen, bone marrow, and liver.

Distribution: United States, Africa, Asia, and southern Europe

Derivation of Genus: Liver animal

Transmission Route: Ingestion of infective intermediate host, *Rhipicephalus sanguineus* tick for *H. canis* and *Amblyomma maculatum* tick for *H. americanum*

Common Name: Hepatozoon

Zoonotic: No

Hepatozoon canis and *Hepatozoon americanum* are intracellular, malaria-like parasites affecting dogs. The blood forms (the **gamonts**) of these protozoan parasites are found in the leukocytes. (Leukocytes containing gamonts of *H. canis* are common in peripheral blood smears, whereas those of *H. americanum* are rare.) Schizonts are found in the endothelial cells of the spleen, bone marrow, and liver. The gamonts are surrounded by a delicate capsule and stain pale blue with a dark-reddish-purple nucleus. Numerous pink granules are found in the cytoplasm of the leukocyte. The “onionskin” tissue cysts of *H. americanum* are found in the skeletal muscle of dogs (Fig. 11-14). This is an unusual parasite in that the dog becomes infected by ingestion of an infected tick, *Amblyomma maculatum*. *H. canis* is well adapted to its canine host and varies from being subclinical to producing mild disease. *H. americanum* produces a violent and frequently fatal course of disease; it is theorized to have crossed the species barrier from a wild animal host to the domestic dog.

Technician's Note



Almost all intracellular malaria-like parasites are transmitted by the bite of an arthropod (a mosquito or a mite), but *Hepatozoon* species are spread by the ingestion of an arthropod.

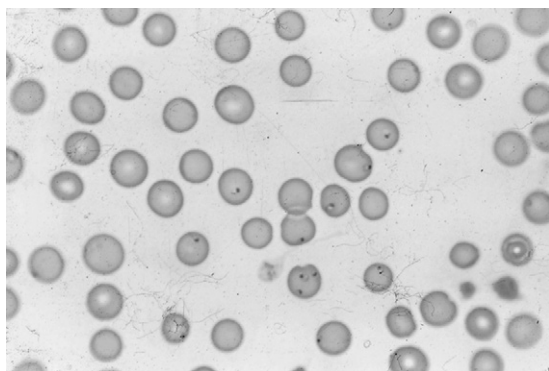


Fig. 11.13 Ring form of *Cytauxzoon felis* in stained feline red blood cells.

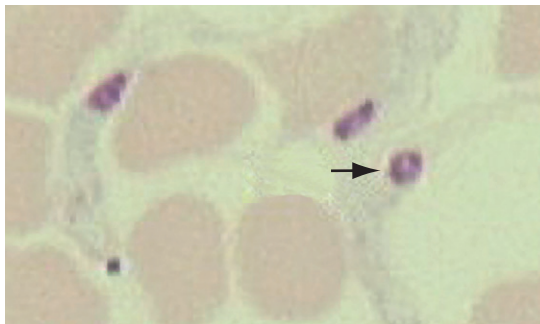


Fig. 11.14 The onionskin tissue cysts of *Hepatozoon americanum* are found in the skeletal muscle of dogs.

Ruminants (Cattle and Sheep)

Gastrointestinal Tract

Protozoans that infect the gastrointestinal tract of ruminants are ciliates and apicomplexans.

Ciliates

Nonpathogenic ciliates live in the rumen of all ruminants, including cattle and sheep. These are mutualists; in this type of symbiotic relationship, both individuals benefit from the association. The cow or sheep provide a warm, moist, particulate medium in which the ciliates live; the ciliates, in exchange, aid in digestion by breaking down cellulose. Sometimes ciliates may be observed in the diarrheic feces of cattle and sheep. These ciliates may be recovered on fecal flotation. Similar ciliates occur in the cecum of the horse and are often recovered from diarrheic feces.

Apicomplexans

Parasite: *Eimeria* species, *Eimeria bovis*, and *Eimeria zuernii*

Host: Ruminants

Location: Cecum and colon

Distribution: Worldwide

Derivation of Genus: Named after the famous zoologist Gustav Eimer

Transmission Route: Ingestion of oocysts

Common Name: Coccidia

Zoonotic: No

Ruminants serve as host to many species of the coccidian parasite *Eimeria*. It is often difficult to identify the individual species of *Eimeria* because their oocysts are similar in size and shape. The life cycle is similar to that of *Cystoisospora* species (see Fig. 11-8) and causes damage by inflammation of the intestinal cells. The two most common species of coccidia in cattle are *Eimeria bovis* and *Eimeria zuernii*; they can be differentiated on standard fecal flotation. The oocysts of *E. bovis* are oval, have a micropyle (opening), and measure $20 \times 28 \mu\text{m}$; the oocysts of *E. zuernii* are spherical, lack the micropyle, and measure $15 \text{ to } 22 \mu\text{m} \times 13 \text{ to } 18 \mu\text{m}$. When oocysts are recovered on fecal flotation, the observation is usually noted as coccidia. The coccidian oocysts of ruminants can be partially differentiated by size and appearance and cause diarrhea and possibly neurologic signs, such as muscle tremors, convulsions, and blindness (Fig. 11-15).

Technician's Note

Individual species of *Eimeria* can be partially differentiated by oocyst size and appearance.



Fig. 11.15 Unsporulated oocysts of *Eimeria* species recovered from fresh goat feces.

Parasite: ♦ *Cryptosporidium* species (discussed in greater detail in canine and feline section)

Host: Canines, felines, bovines, swine, avians, guinea pigs, snakes, and mice

Location: Small intestine

Distribution: Worldwide

Derivation of Genus: Hidden small seeds

Transmission Route: Ingestion of sporulated oocyst

Common Name: *Cryptosporidium*; Crypto

Zoonotic: Yes

The *Cryptosporidium* species is another coccidian that parasitizes the small intestine of a variety of animals, including cattle, sheep, and goats. The sporulated oocysts in the feces are colorless and transparent and measure only 3 to 5 μm . Diagnosis is by standard fecal flotation and stained fecal smears. Because humans may become infected with *Cryptosporidium* species, feces suspected of harboring this protozoan should be handled with great care. These oocysts are often recovered using Sheather sugar solution. (See Fig. 11-11 for features of the oocysts of *Cryptosporidium* species.)

Technician's Note

Feces suspected of being infected with *Cryptosporidium* should be handled with great care because of the potential for zoonosis.

Circulatory System and Blood

Protozoans that infect the circulatory system and blood are flagellates and apicomplexans.

Flagellates

Parasite: ♦ *Trypanosoma* species (see general discussion in canine and feline section)

Host: Ruminants

Location: Peripheral blood

Distribution: Primarily in Central and South America but occasionally in the southern United States

Derivation of Name: Borer body

Transmission Route: Bite of infective fly

Common Name: Trypanosome

Zoonotic: Yes

Trypanosoma species are hemoprotozoans found in the peripheral blood of many ruminants. This trypanosome has a long and narrow body, a dark nucleus, an anterior flagellum, and a sail-like undulating membrane (Fig. 11-16). These protozoans may be observed among the RBCs in a thin blood smear. *Trypanosoma* species are not pathogenic and are very common but are seldom seen in a routine smear.

Technician's Note



These nonpathogenic parasites are very common in ruminants but are rarely seen in a routine blood smear.

Apicomplexans

Parasite: *Babesia bigemina*

Host: Bovines

Location: Within RBCs

Distribution: Europe, Africa, Asia, North and South America

Derivation of Genus: Named after the famous bacteriologist Victor Babès

Transmission Route: Bite of an infective *Rhipicephalus* (formerly *Boophilus*) *annulatus* tick

Common Name: Babesia

Zoonotic: No



Fig. 11.16 *Trypanosoma* species in bovine blood smear. (From Bowman DD: *Georgis' parasitology for veterinarians*, ed 10, St Louis, 2013, Elsevier.)

Babesia bigemina is an intracellular parasite found within the RBCs of cattle. This parasite is a large piroplasm that causes damage by residing within the RBC, is 4 to 5 μm in length $\times$ about 2 μm wide, and can be observed in a stained blood smear. These piroplasms are characteristically pear shaped and lie in pairs, forming an acute angle within the erythrocyte (Fig. 11-17). The intermediate host for this protozoan parasite is the tick *Rhipicephalus* (formerly *Boophilus*) *annulatus* (see Chapter 13). Common symptoms include fever, depression, icterus, anorexia, hemoglobinuria, pale mucous membranes, weakness, and splenomegaly.

Technician's Note



If *Babesia bigemina* is diagnosed, both the protozoan and its tick intermediate host should be reported to state and federal authorities.

Urogenital System

Parasite: *Tritrichomonas foetus*

Host: Bovine

Location: Prepuce of bulls; vagina, cervix, and uterus of cows
Distribution: Worldwide but becoming rare where artificial insemination is used

Derivation of Genus: Three-hair unit

Transmission Route: Sexual transmission

Common Name: Trichomonas

Zoonotic: No

Tritrichomonas foetus is a protozoan parasite residing in the reproductive tract of cattle. These protozoans reside in the prepuce of infected bulls and in the vagina, cervix, and uterus of infected cows. In the cow, the parasite causes physiologic disturbance leading to abortion. *T. foetus* is pear shaped and approximately 10 to 25 μm long, with a sail-like undulating membrane and three rapidly moving, anterior whip-like flagella (Fig. 11-18). In fresh specimens,

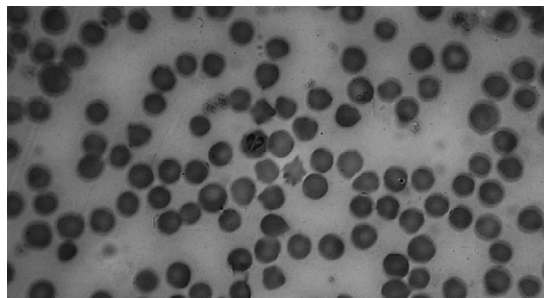


Fig. 11.17 Trophozoites of *Babesia bigemina* within bovine red blood cells. Piroplasms are characteristically pear shaped and lie in pairs, forming an acute angle within the erythrocyte.

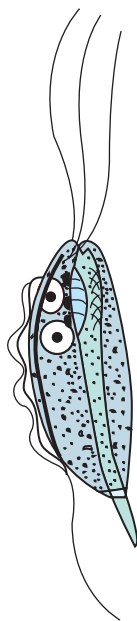


Fig. 11.18 Diagram of *Tritrichomonas foetus*. This flagellated protozoan is pear shaped and approximately 10 to 25 μm long, with a sail-like undulating membrane, a trailing posterior flagellum, and three rapidly moving anterior whip-like flagella.

they move actively with a jerky movement. Diagnosis is by finding these protozoans in fluid freshly collected from the stomach of an aborted fetus, from uterine discharge, or from washing of the vagina and prepuce. Fluid material should be centrifuged at 2000 rpm for 5 minutes. The supernatant is then removed and a drop of sediment transferred to a glass slide for microscopic examination for the moving organisms. Several slides should be examined. For more accurate diagnosis, fluid material from the sources just mentioned can be cultured in special media. A specialized parasitology laboratory should be consulted for information on these techniques.

Tritrichomonas blagburni is a species of trichomonad closely related to *T. foetus* in cattle. It resides in the colon and cecum of young cats. Motile trophozoites are usually found in cats with diarrhea. Cats are usually asymptomatic and do not show clinical sign of infection, however some may demonstrate chronic loose stools with blood or mucus. The parasite is often seen in cat colonies and can be confused with *Giardia*. Infection of the urogenital tract in cats with long-standing colonic infections is rare. This trichomonad may be the same species as *T. foetus* of cattle, however infection of the urogenital tract in cats is rare. The life cycle, mode of transmission, and range of hosts are unknown. There is no approved treatments for feline trichomoniasis. *T. blagburni* is not considered a zoonotic agent.

Technician's Note

Tritrichomonas foetus is typically spread through a herd by the bull.

Horses

Gastrointestinal Tract

Protozoan parasites that infect horses are flagellates, ciliates, and apicomplexans.

Flagellates

Parasite: *Giardia* assemblage E (*Giardia* is discussed in the canine and feline section)

Host: Horses, cows, sheep, goats, and pigs

Location: Small intestine

Distribution: Worldwide

Derivation of Name: Named after the famous biologist Alfred Giard

Transmission Route: Ingestion of oocysts

Common Name: *Giardia*

Zoonotic: No (only assemblage A is zoonotic)

Giardia assemblage E is a flagellated protozoan of low incidence in horses. The trophozoites and cysts of this parasite are morphologically similar to those of the species found in dogs and cats (see Fig. 11-1). *Giardia* invades the small intestine and causes chronic diarrhea. Normal flotation techniques rarely detect *Giardia*, but zinc sulfate and Sheather sugar solution will float the cysts.

Ciliates

As with the rumen ciliates of cattle and sheep, nonpathogenic ciliates live in the cecum of the horse. These mutualists live in the warm, moist, particulate-rich medium of the cecum. Sometimes ciliates may be observed in the diarrheic feces of horses and are often recovered on fecal flotation.

Apicomplexans

Parasite: *Eimeria leuckarti*

Host: Equine

Location: Small intestine

Distribution: Worldwide

Derivation of Genus: Named after the German zoologist Gustav Eimer

Transmission Route: Ingestion of oocysts

Common Name: Coccidia

Zoonotic: No

Eimeria leuckarti is the coccidian found in the small intestine of horses, particularly young ones, in the United States. Infections are usually asymptomatic and self-limiting but



Fig. 11.19 Unsporulated oocyst of *Eimeria leuckarti* (350×).

can cause inflammation of the intestinal cells. Horses rapidly become immune to further infection. This protozoan demonstrates unique oocysts that are quite large, 80 to 87 μm $\times$ 55 to 60 μm , and dark brown, with a thick wall and a distinct micropyle at the narrow end (Fig. 11-19). These oocysts can be recovered on fecal flotation using saturated sodium nitrate (1:360) and saturated sugar solution (1:320); however, they also may be easily recovered using fecal sedimentation. The oocysts of *E. leuckarti* are the largest coccidian oocysts. They are frequently described in histopathologic examination.

Technician's Note



Eimeria leuckarti infections are typically asymptomatic and self-limiting in horses.

Circulatory System and Blood

Apicomplexans are the protozoans that infect the circulatory system and blood of horses.

Apicomplexans

Parasite: *Theileria* (formerly *Babesia*) *equi* and *Babesia caballi*

Host: Equine

Location: Within RBCs

Distribution: Europe, Africa, Asia, North and South America

Derivation of Genus: Named after the famous bacteriologist Victor Babès

Transmission Route: Bite by infective tick

Common Name: Equine piroplasm

Zoonotic: No

Theileria equi and *Babesia caballi* are intracellular parasites found within the erythrocytes of horses. They are

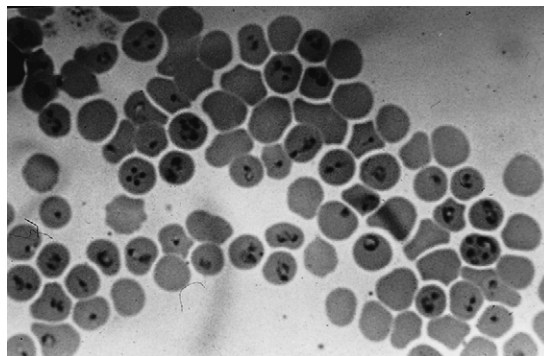


Fig. 11.20 Basophilic, pear shaped trophozoites of *Babesia equi* in red blood cells in stained equine blood smear. Trophozoites of *B. equi* may be round, ameboid, or pyriform (pear shaped). Four organisms may be joined, giving the effect of a Maltese cross. Individual organisms are 2 to 3 μm long.

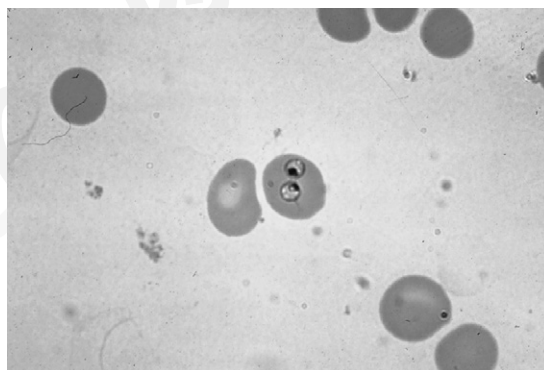


Fig. 11.21 Trophozoites of *Babesia caballi* in red blood cells in stained equine blood smear. These piroplasms are pyriform, round, or oval, and 2 to 4 μm long. They occur characteristically in pairs at acute angles to each other.

also referred to as the *equine piroplasms*. The parasites cause damage by residing in the RBCs. These parasites are spread by the bite of infected ticks. Diagnosis is by observing basophilic, pear shaped trophozoites in RBCs in stained blood smears. Trophozoites of *T. equi* may be round, ameboid, or pyriform (pear shaped). Four organisms may be joined, giving the effect of a Maltese cross (Fig. 11-20). Individual organisms are 2 to 3 μm long. Trophozoites of *B. caballi* are pyriform, round, or oval and 2 to 4 μm long. They occur characteristically in pairs at acute angles to each other (Fig. 11-21). Common symptoms include fever, depression, icterus, anorexia, hemoglobinuria, pale mucous membranes, weakness, and splenomegaly.

Technician's Note

Babesia and *Theileria* use different tick intermediate hosts.

Urogenital System

The protozoans that infect the urogenital system of horses are apicomplexans.

Apicomplexans

Parasite: *Klossiella equi*

Host: Equine

Location of Adult: Kidneys

Distribution: Worldwide

Derivation of Genus: Little organism; named after a parasitologist, Kloss

Transmission Route: Ingestion of oocysts in urine

Common Name: *Klossiella*

Zoonotic: No

Klossiella equi is a nonpathogenic coccidian infecting the kidney of horses. Oocysts can occasionally be found during histopathologic examination of the kidney and in urine sediment. There is no marked inflammatory response to infection with *Klossiella* in the horse.

Technician's Note

Pathologic effects resulting from inflammation due to *Klossiella equi* have been reported only in immune-compromised horses.

Nervous System

Apicomplexans are the protozoans that infect the nervous system of horses.

Apicomplexans

Parasite: *Sarcocystis neurona*

Host: Equine

Location: Schizogonous, or asexual, stage found in the nervous system

Distribution: North, Central, and South America

Derivation of Genus: Flesh cyst

Transmission Route: Ingestion of oocysts from opossum feces

Common name: (Sarcocystis)

Zoonotic: No

Sarcocystis neurona is sporadically found in the asexual, or schizogonous, stage of development in the nervous system, particularly the spinal cord, of horses. This stage can invade the central nervous system, producing a condition called **equine protozoal myeloencephalitis (EPM)**. This disease most often affects Standardbreds and Thoroughbreds. Clinical signs are caused mainly by destruction of neurons. Clinical signs are ataxia, weakness, stumbling, muscle wasting, and disorientation. *S. neurona* oocysts are ingested from food or water that has been contaminated with opossum feces. EPM can resemble many other equine neurologic diseases, including wobbler syndrome, the neurologic form of herpesvirus infection, rabies, West Nile virus infection, and other equine viral encephalitis diseases (e.g., Eastern and Western equine encephalitis). These developmental stages cannot be seen antemortem. Diagnosis of this parasite is by histopathologic examination. Tissues suspected of harboring developmental stages of *S. neurona* should be submitted to a histopathology laboratory for diagnosis by a veterinary pathologist or parasitologist.

S. neurona causes encephalomyelitis in many species of mammals and is the most important cause of neurologic disease in horses. Its complete life cycle is unknown, particularly its development and localization in the opossum intermediate host or the equine aberrant host.

Technician's Note

Sarcocystis neurona can invade the central nervous system of the horse and cause equine protozoal myeloencephalitis.

Swine**Gastrointestinal Tract**

Protozoans that infect the gastrointestinal tract of swine are ciliates and apicomplexans.

Ciliates

Parasite: ❖ *Balantidium coli* (also see discussion in canine section)

Host: Swine and occasionally canines

Location: Large intestine

Distribution: Worldwide

Derivation of Name: Small bag

Transmission Route: Ingestion of oocysts

Common Name: *Balantidium*

Zoonotic: Yes (per *The Merck Veterinary Manual*)

B. coli is the ciliated protozoan found in the large intestine of swine. Although it is often observed during microscopic examination of fresh diarrheic feces, it is generally considered to be nonpathogenic. Two morphologic stages can be found in feces: the cyst stage and the trophozoite stage. Both stages may vary in size. This is a very large protozoan parasite. The trophozoites may be $150 \times 120 \mu\text{m}$, with a sausage- to kidney shaped macronucleus. *B. coli* is covered with numerous rows of cilia and moves about the field with lively motility. The cyst is spherical to ovoid, 40 to 60 μm in diameter, and has a slight greenish-yellow color. Both of these stages may be easily recognized by microscopic examination of the intestinal contents of fresh, diarrheic feces by fecal flotation and fecal direct smear. Fig. 11-22 demonstrates the trophozoite stage of *B. coli* recovered on fecal flotation, and Figs. 11-23 and 11-24 demonstrate *B. coli* in histopathologic sections.

Apicomplexans

Parasite: *Cystoisospora suis* (see also discussion of *Cystoisospora* spp. in the canine and feline section)

Host: Swine

Location: Small intestine

Distribution: Worldwide

Derivation of Genus: Bladder same spore

Transmission Route: Ingestion of oocysts

Common Name: Coccidia

Zoonotic: No

Cystoisospora suis is the coccidian that parasitizes the small intestine of swine, especially young piglets. The merozoite stage causes inflammation in the small intestine. Oocysts

are usually found on flotation of fresh feces. They are subspherical, lack a micropyle, and measure 18 to 21 μm . Common symptoms include diarrhea, dehydration, and weight loss. Postmortem diagnosis in piglets exhibiting clinical signs but not shedding oocysts can be achieved by direct smear of the jejunum stained with Diff-Quik. Diagnosis is by observation of the banana shaped merozoites. The prepatent period is 4 to 8 days. (Fig. 11-25 shows features of the oocyst of *C. suis*.)

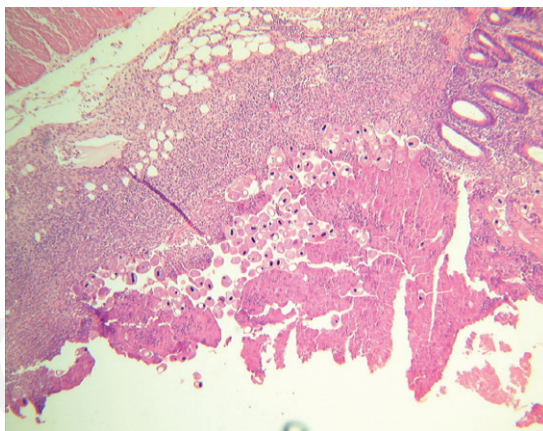


Fig. 11.23 *Balantidium coli* of swine in histopathologic section. This photomicrograph was taken at low magnification. Note that *B. coli* is quite large and easily visible (arrows).

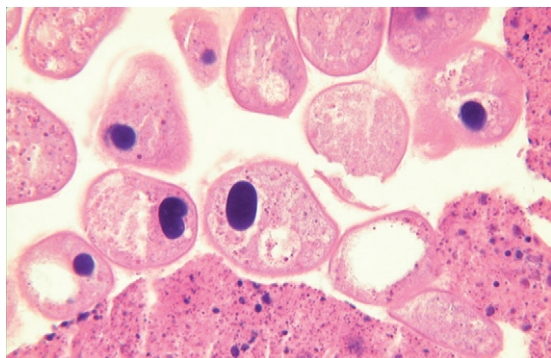


Fig. 11.22 Motile trophozoite stage of *Balantidium coli*, a ciliated protozoan found in the large intestine of swine, is often observed during microscopic examination of fresh diarrheic feces. It is covered with numerous rows of cilia and moves about the field of view with lively motility.

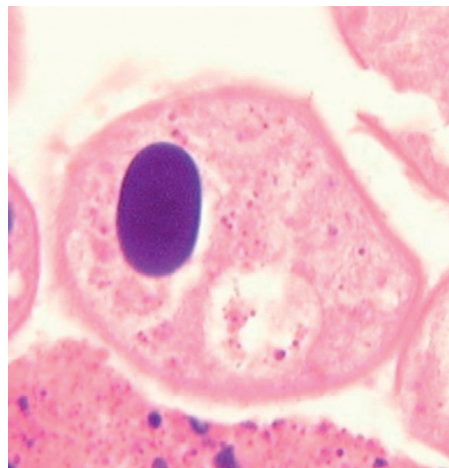


Fig. 11.24 *Balantidium coli* of swine in histopathologic section. This photomicrograph was taken at higher magnification than Fig. 11-23.

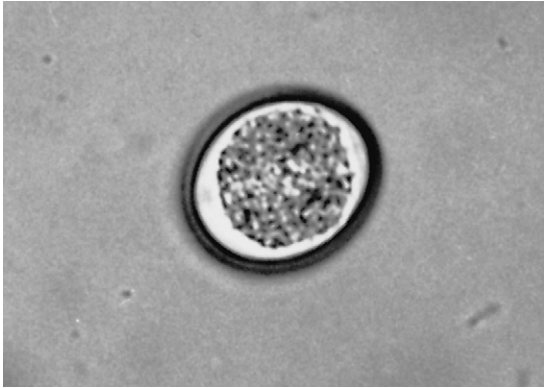


Fig. 11.25 Unsporulated oocyst of swine coccidian, *Cystoisospora suis*, recovered from swine feces (560x).

Technician's Note



The prepatent period for *Cystoisospora suis* is a short 4 to 8 days.

Parasite: ♦ *Cryptosporidium* species (also see discussion in canine and feline section)

Host: Canines, felines, bovines, swine, avians, guinea pigs, snakes, and mice

Location: Small intestine

Distribution: Worldwide

Derivation of Genus: Hidden small seeds

Transmission Route: Ingestion of oocyst

Common Name: *Cryptosporidium*, Crypto

Zoonotic: Yes

The *Cryptosporidium* species is another coccidian that parasitizes the small intestine of a variety of animals, including swine. The sporulated oocysts in the feces are colorless and transparent and measure only 3 to 5 μm . Diagnosis is by standard fecal flotation and stained fecal smears. Because humans may become infected with *Cryptosporidium* species, feces suspected of harboring this protozoan should be handled with great care. (See Fig. 11-11 for features of the oocysts of *Cryptosporidium* species.)

Technician's Note



Cryptosporidium species are transferred from host to host by ingestion of oocysts. Because humans are hosts, pig feces suspected of containing the oocysts should be handled with great care.

Pet and Aviary Birds and Other Domestic Fowl

Gastrointestinal Tract

Protozoans that infect the gastrointestinal tract of birds are flagellates and apicomplexans.

Flagellates

Parasite: *Giardia psittaci* (see also discussion at beginning of chapter)

Host: Avians

Location of Adults: Intestinal mucosa

Distribution: Worldwide

Derivation of Genus: Named after the famous protozoologist Alfred Giard

Transmission Route: Ingestion of oocysts

Common Name: *Giardia*

Zoonotic: No (only assemblage A is zoonotic)

Giardia psittaci is the most common protozoan seen in pet bird practices. This flagellated parasite is most often found in cockatiels, budgerigars, and lovebirds. The feces of affected birds often become voluminous and chunky, with a pea-soup consistency. Fresh saline mounts can demonstrate the motile trophozoites, with the characteristic “falling leaf” motility. Allergic skin conditions may be associated with giardiasis in cockatiels. It may be difficult to demonstrate *Giardia* in some of these cases.

The fecal trichrome stain can enhance visualization of *Giardia* species (Fig. 11-26). Other stains used to enhance visualization of this flagellate include Lugol iodine, Gram iodine, and Wright stain. Other stains, such as acid-fast stain or Gram stain, may incidentally demonstrate trophozoites (Fig. 11-27).

Parasite: *Histomonas meleagridis*

Host: Turkeys, peafowl, chickens, and pheasants

Location: Liver

Distribution: Worldwide

Derivation of Genus: Tissue unit

Transmission Route: Ingestion of intermediate host ova, *Heterakis gallinarum*, or direct ingestion of ova

Common Name: “Blackhead”

Zoonotic: No

Histomonas meleagridis infects turkeys, chickens, pheasants, and peafowl, causing a fatal liver disease called **infectious enterohepatitis**, or **blackhead**. The oocysts are ingested directly from infective feces or within the intermediate host ova, *Heterakis gallinarum*. *H. gallinarum* ova can survive for extended periods of up to years in the

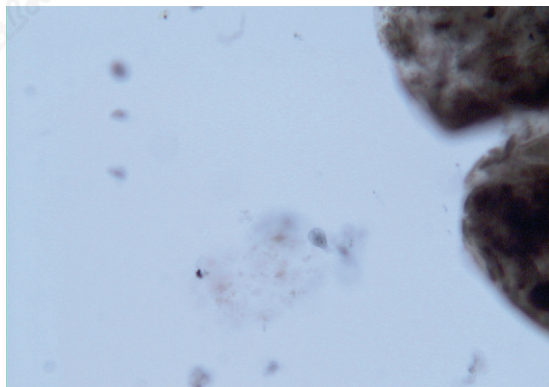


Fig. 11.26 *Giardia* trophozoites (trichrome stain) from feces of a cockatiel.

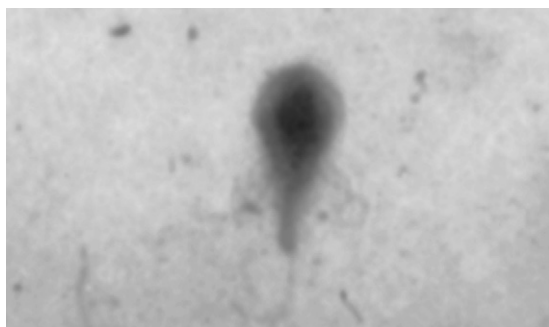


Fig. 11.27 *Giardia* trophozoite showing flagellar detail in Gram-stained fecal smear. This was an incidental finding because Gram stain is not the stain of choice for flagellates.

environment. Within several days of being ingested, the oocysts are released by the intermediate host ova, reproduce in the cecum, and migrate to the liver, where they cause inflammation and necrosis of liver cells. Diagnosis is usually by necropsy and histopathologic examination of the liver. Suspect tissues should be submitted to a histopathology laboratory for diagnosis by a veterinary pathologist or parasitologist. Suspicion of infection is increased by finding on fecal flotation the eggs of the cecal worm, *H. gallinarum*, which serves as the intermediate host for this parasite.

Technician's Note



If *Heterakis gallinarum* ova are found on fecal flotation, *Histomonas meleagridis* should also be suspected.

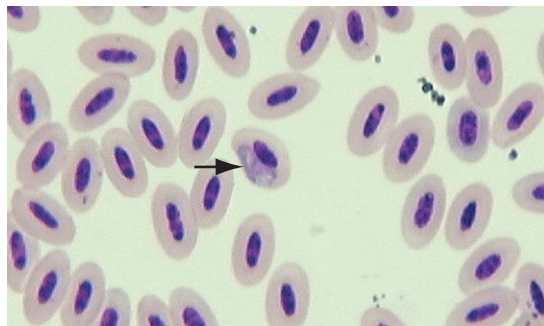


Fig. 11.28 *Trichomonas gallinae* in the crop wash from a dove.

Parasite: *Trichomonas gallinae*

Host: Pigeons, doves, poultry, and raptors that feed on pigeons

Location of Adult: Crop

Distribution: North America and countries with doves and pigeons

Derivation of Genus: Hair unit

Transmission Route: Direct contact with contaminated water or an infected bird

Common Name: Trichomonas

Zoonotic: No

Trichomonas gallinae is frequently found in crop washes and crop swabs of pigeons, doves, and poultry. Occasionally, this parasite is associated with mortality in finches. In North America, trichomoniasis appears to be rare in psittacine birds but has been reported in budgerigars. *T. gallinae* does not produce oocysts, so only direct contact with contaminated water from an infected bird or direct contact with an infected bird from fighting or feeding will result in transfer of the parasite. *T. gallinae* produces nodules in the crop that can cause cell death and obstructions. The parasite is best demonstrated by a direct saline smear of crop contents and is characterized by four anterior flagella. An air-dried smear can be stained with Wright stain. The parasite assumes an oval shape, staining blue with a red axostyle (Fig. 11-28).

Technician's Note



A severe infection of *Trichomonas gallinae* can result in the parasite spreading to the esophagus and even to the liver.

Apicomplexans

Coccidial infections are rare in pet birds, although *Cystoisospora* and *Eimeria* have been reported. Coccidia are

often observed in poultry and pigeons. A common error made by inexperienced veterinary technicians is to mistake normal urate crystals for coccidia. The *Cryptosporidium* species has been reported in cockatiels. This tiny apicomplexan parasite is difficult to visualize in fecal samples and is usually diagnosed by histopathologic examination of the small intestine. Suspect tissues should be submitted to a histopathology laboratory for diagnosis by a veterinary pathologist or parasitologist.

Circulatory System and Blood

Protozoans that infect the circulatory system and blood of birds are flagellates and apicomplexans.

Flagellates

Parasite: ♦ *Trypanosoma* species (see discussion in canine and feline section)

Host: Cockatoos

Location of Adult: Peripheral blood

Distribution: Worldwide

Derivation of Genus: Borer body

Transmission Route: No definitive intermediate hosts have been identified for birds

Common Name: Trypanosome

Zoonotic: Yes

Trypanosoma species is occasionally found in cockatoos and rarely produces clinical disease. As with the trypanosomes of mammals, this swimming, flagellated protozoan does not infect the RBCs. It has a very distinctive appearance, with a posterior flagellum and an undulating membrane (Fig. 11-29).

Technician's Note

Trypanosoma species are not a major concern in cockatoos because they rarely produce clinical disease.

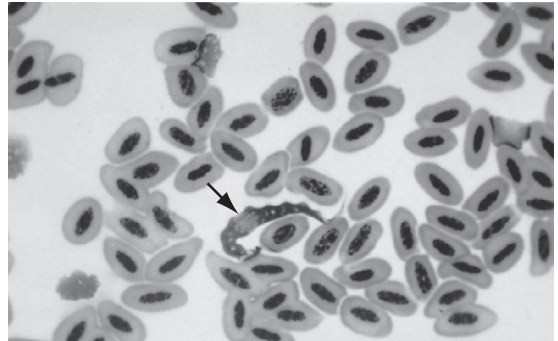


Fig. 11.29 *Trypanosoma* species in the blood of a cockatoo.

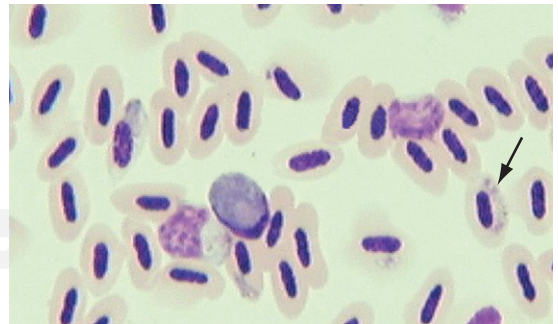


Fig. 11.30 *Haemoproteus* is normally seen as a sausage shaped body within the cytoplasm of the avian red blood cell.

Haemoproteus species is often found within the RBCs of the white species of cockatoos, green-winged macaws, and some species of conures. This blood parasite is rarely associated with clinical disease such as anemia but can destroy RBCs if anemia is associated with the clinical disease. *Haemoproteus* is characterized by a bluish, sausage shaped body in the cytoplasm of the RBC; sometimes the body is overlain with blue dots (Fig. 11-30). It infects a variety of wild waterfowl and can cause death in these birds.

Technician's Note

Some species of *Haemoproteus* infect turtles and lizards.

Apicomplexans

Parasite: *Haemoproteus* species

Host: Cockatoos, green-winged macaws, and some species of conures

Location: Within RBCs

Distribution: Worldwide

Derivation of Genus: Many forms in the blood

Transmission Route: Bite by an infected *Culicoides* species or *Chrysops* species of fly

Common Name: *Haemoproteus*

Zoonotic: No

Parasite: *Plasmodium* species

Host: Avians

Location: Within RBCs

Distribution: Worldwide

Derivation of Genus: Anything formed

Transmission Route: Bite of infected mosquito

Common Name: Avian malaria

Zoonotic: No

Plasmodium species is the etiologic agent of avian malaria. It can cause mortality in canaries in some parts of the United States. This may be the result of the transmission of a local passerine strain by the mosquito intermediate host to susceptible canaries. The organism may not be observable in the peripheral blood cells; many of the developmental stages of *Plasmodium* species occur in internal organs, such as the liver and spleen, and can cause inflammation in these organs. A “signet ring” form, in which the body of the organism displaces the nucleus of the RBC, is the most frequently observed form (Fig. 11-31), which can cause cell destruction leading to anemia. Diagnosis of infections with *Plasmodium* species is also by organ impression smears and histopathologic examination of the liver and the spleen. Tissues suspected of harboring developmental stages of *Plasmodium* should be submitted to a histopathology laboratory for confirmation by a veterinary pathologist or parasitologist. Polymerase chain reaction tests have also been developed for testing of *Plasmodium* species.

Parasite: *Leucocytozoon* species

Host: Raptors

Location: Within WBCs

Distribution: Worldwide

Derivation of Genus: White cell organism

Transmission Route: Bite of infected black flies, *Simulium* species

Common Name: *Leucocytozoon*

Zoonotic: No

Leucocytozoon species infects the WBCs of raptors—birds of prey such as owls, hawks, and falcons. The presence of this large protozoan organism greatly distorts the shape and

appearance of the WBC. A variety of forms can be present and can be associated with occasional leukocytosis and disease. The most common morphology of this protozoan is the fusiform, or spindle shape (Fig. 11-32). Most infections are subclinical, but deaths have been reported.

Technician's Note



The *Leucocytozoon* parasite distorts the white blood cells to the point that it may not be recognized as such.

Parasite: *Aegyptianella* species

Host: Pet birds

Location of Adult: Within RBCs

Distribution: Primarily in the Mediterranean areas

Derivation of Genus: Little organism from Egypt

Transmission Route: Bite of an argasid tick

Common Name: *Aegyptianella*

Zoonotic: No

Aegyptianella species is occasionally found in pet birds such as the African gray parrot. This protozoan causes few clinical problems. The organism infects the RBCs, appearing as a margined dot on the cells.

Respiratory System

The protozoans that infect the respiratory system of birds are apicomplexans.

Apicomplexans

Parasite: *Cystoisospora serini*

Host: Canaries and finches

Location: Lung, liver, and spleen

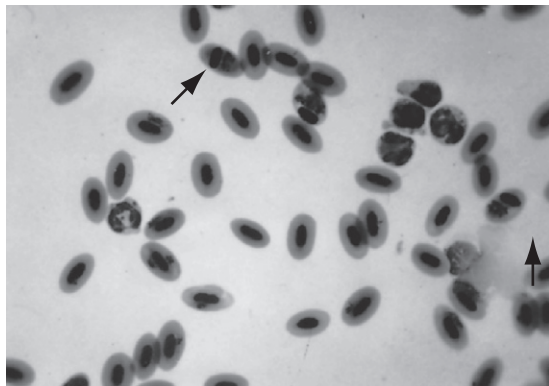


Fig. 11.31 *Plasmodium* displacing the nucleus of an erythrocyte in the blood of a canary.

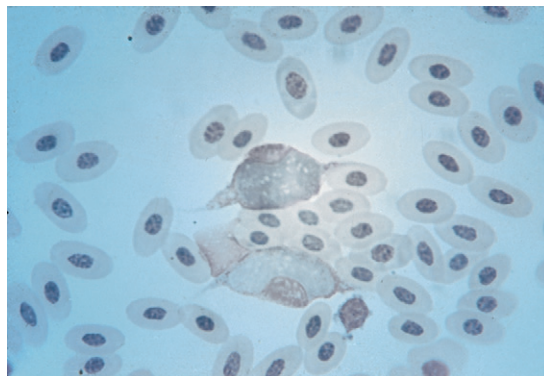


Fig. 11.32 *Leucocytozoon* species in an avian peripheral blood smear.

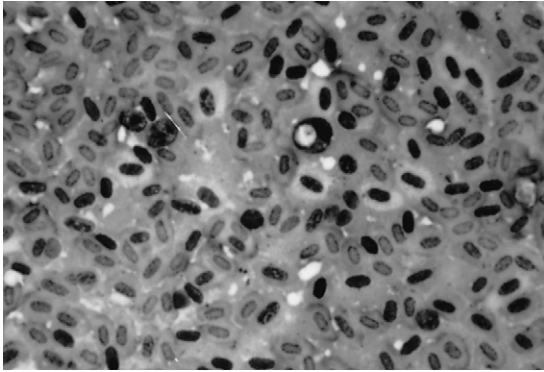


Fig. 11.33 *Cystoisospora* (formerly *Atoxoplasma*) *serini* in a mononuclear cell on a lung impression smear from a canary (Wright stain).

Distribution: Worldwide

Derivation of Genus: Same bladder organism

Transmission Route: Ingestion of oocyst during sexual stage

Common Name: Coccidia or atoxoplasmosis

Zoonotic: No

Cystoisospora (formerly *Atoxoplasma*) *serini* is a protozoan coccidial parasite of canaries and finches (Fig. 11-33). *C. serini* can affect several organs, causing respiratory signs related to inflammation of those organs. The parasite goes through a sexual cycle in the intestinal mucosa, at which time oocysts can be passed in the feces. However, few oocysts are typically seen after the sexual cycle has passed. An asexual cycle occurs in the liver, lungs, and spleen, causing inflammation to these organs. This parasite is best visualized on organ impression smears of the lung, liver, and spleen.

Technician's Note

Cystoisospora serini causes atoxoplasmosis in canaries and finches.

Rabbits

Gastrointestinal Tract

The protozoans that infect the gastrointestinal tract of rabbits are apicomplexans.

Apicomplexans

Parasite: *Eimeria irresidua*, *Eimeria magna*, *Eimeria media*, and *Eimeria perforans*

Host: Lagomorph (rabbit)

Location: Small intestine; *E. media* also affects the large intestine

Distribution: Worldwide

Derivation of Genus: Organism named after German zoologist Gustav Eimer

Transmission Route: Ingestion of oocysts

Common Name: Coccidia of rabbits

Zoonotic: No

Numerous species of *Eimeria* can infect rabbits. Most infect the intestine, causing intestinal coccidiosis, and one species, *Eimeria stiedae*, affects the bile ducts within the liver. The more pathogenic varieties of *Eimeria* species that affect the intestine are discussed in this section, and *E. stiedae* is considered separately. The intestinal coccidia of rabbits include *Eimeria irresidua*, *Eimeria magna*, *Eimeria media*, and *Eimeria perforans*. All species of *Eimeria* infect the small intestine; *E. media* may also affect the large intestine.

The oocysts of *E. irresidua* are $38 \times 26 \mu\text{m}$ and ovoid. The wall of the oocyst is smooth and light yellow. There is a wide micropyle, with no polar granules or residuum. Sporocysts within the oocyst are also ovoid, with both a body and a residuum. Antemortem diagnosis depends on recognition of the mature oocyst along with clinical signs, which may include severe hemorrhagic diarrhea, excessive thirst, and dehydration caused by inflammation of the intestines. Postmortem indications include inflammation of the intestines and sloughing of the lining of the intestine.

Technician's Note

Eimeria irresidua, *Eimeria magna*, *Eimeria media*, and *Eimeria perforans* all infect the small intestine, whereas *Eimeria stiedae* infects the bile ducts.

The mature oocyst of *E. magna* is $35 \times 24 \mu\text{m}$ and ovoid, with a distinctive dark-yellow-brown wall (Fig. 11-34). A wide micropyle appears built up around the rim, with no micropyle cap. Oocysts and sporocysts contain a residuum (Fig. 11-35). The sporocysts are ovoid and have a body. *E. magna*, like *E. irresidua*, is highly pathogenic. Clinical signs include weight loss, anorexia, and mucoid diarrhea. Necropsy signs include inflammation and sloughing of the lining of the intestine.

E. media oocysts are ovoid and $31 \times 18 \mu\text{m}$, with a smooth wall and a light-pink color. There is a micropyle and a residuum. Sporocysts within the mature oocyst are

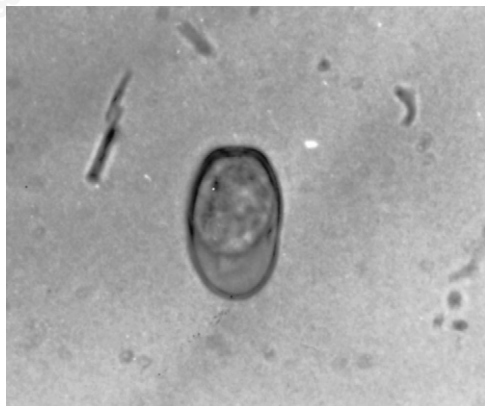


Fig. 11.34 Unsporulated oocyst of the rabbit intestinal coccidian *Eimeria magna*.

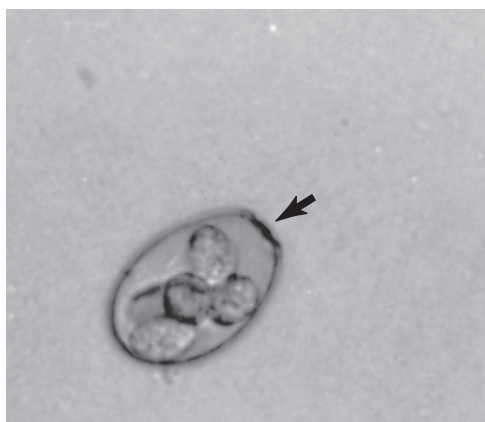


Fig. 11.35 Oocyst of *Eimeria magna* after sporulation. Arrow indicates a micropyle. The round, darkened body in the center of the oocyst is a residuum. The four lighter oval bodies are sporocysts.

ovoid, with a body and a residuum. *E. media* is moderately pathogenic and may cause enteritis and diarrhea as a result of inflammation of the intestines. At necropsy, the intestinal wall may be edematous and contain gray foci of necrosis.

Parasite: *Eimeria stiedae*

Host: Lagomorph (rabbit)

Location: Bile ducts

Distribution: Worldwide

Derivation of genus: Organism named after German zoologist Gustav Eimer

Transmission Route: Ingestion of oocysts

Common Name: Coccidia of rabbits

Zoonotic: No

E. stiedae is a highly pathogenic coccidian that affects the bile ducts of rabbits. It causes variable mortality, which is highest in young rabbits. The oocysts of *E. stiedae* are $35 \times 20 \mu\text{m}$ and ovoid, with a flattened pole at the micropyle end. The wall is smooth and yellow. There is no polar granule or residuum. Sporocysts are ovoid, with a body and a residuum.

Light infections with *E. stiedae* usually produce no clinical signs. Heavier infections may cause blockage of the bile ducts and impaired liver function, resulting in icterus and a distended abdomen caused by liver enlargement. Diarrhea or constipation and anorexia may be noted. At necropsy, white, dilated nodules are likely to be seen in the liver. Hyperplastic bile ducts contain a yellow-green creamy material in which oocysts may be seen in impression smears when examined microscopically. Transmission of *E. stiedae* is by ingestion of sporulated oocysts passed in the feces. The prepatent period is 15 to 18 days. As in all *Eimeria* species, there is no cross-species contamination or public health significance.

Technician's Note



Eimeria stiedae is a common highly pathogenic coccidian of rabbits.

Mice

Gastrointestinal Tract

Protozoans that infect the gastrointestinal tract of mice are flagellates and apicomplexans.

Flagellates

A few flagellates may be found by direct smear or fecal flotation from the mouse. They include *Giardia* assemblage G, *Spironucleus muris*, *Tetratrichomonas microti*, and *Tritrichomonas muris*.

Parasite: *Tetratrichomonas microti* and *Tritrichomonas muris*

Host: Mouse

Location: Small intestine, cecum, and colon

Distribution: Worldwide

Derivation of Genus: Four-hair unit, three-hair unit

Transmission Route: Ingestion of oocysts

Common Name: Flagellates of mice

Zoonotic: No

T. microti and *T. muris* are generally considered nonpathogenic in the mouse. Tritrichomonads and tetratrichomonads have three and four anterior flagella, respectively. Both

genera have a trailing caudal flagellum. These trichomonads are frequently found in the small intestine, cecum, and colon of the mouse. Mice with diarrhea, regardless of the cause, often have numerous tritrichomonads and tetratrichomonads on fecal smear and flotation because the diarrheic fluid medium secondarily provides an optimal habitat for the multiplication of these intestinal protozoans. Transmission of these trichomonads is by ingestion of organisms passed in the feces. *T. microti* is approximately $22 \times 10 \mu\text{m}$, and *T. muris* is approximately $7 \times 5 \mu\text{m}$.

Technician's Note



Tetratrichomonas microti and *Tritrichomonas muris* are commonly found in diarrhea because diarrheic supplies an optimal habitat for multiplication.

Parasite: *Giardia* assemblage G and *Spironucleus muris*

Host: Rodents (*Giardia* assemblage G), mice

Location: Proximal small intestine

Distribution: Worldwide

Derivation of Genus: Named after the famous biologist Alfred Giard (*Giardia*)

Transmission Route: Ingestion of oocyst

Common Name: *Giardia* (*Giardia* spp.), flagellates of mice (*S. muris*)

Zoonotic: No (only assemblage A is zoonotic)

Giardia and *Spironucleus muris* are the most common mouse flagellates and demonstrate the greatest potential for pathogenicity. Both *S. muris* and *Giardia* occur in the proximal small intestine and can produce enteritis related to inflammation, particularly in young weanling mice. The location of these flagellates in the intestines is proportional to the severity of the enteritis produced; the more severe the enteritis, the farther back (more distally) in the intestinal tract they are found. *Giardia* assemblage G appears similar to other *Giardia* species. The trophozoite is pyriform (pear shaped), with two nuclei at the anterior end. Eight flagella emerge in symmetric pairs from different locations cranially to caudally in the organism. *Giardia* species may be suspected when motile forms are observed on a direct smear at 100 $\times$ (high-dry) magnification. *Giardia* species are identified by staining the direct fecal smear with Lugol iodine, which enhances the detail of the cranial nuclei and flagella.

Transmission of *Giardia* is by ingestion of cysts that have been passed in the feces. *Giardia* has also been found in the rat and hamster; therefore the owner of multiple species should be made aware of the possibility of cross contamination. Although other species of *Giardia* are pathogenic to humans, the *Giardia* species found in rodents and rabbits have no known zoonotic potential.

S. muris appears somewhat similar to *Giardia* species except that the trophozoite of *S. muris* is uniformly slender, unlike the widened anterior end of *Giardia* species. *S. muris* has two anterior nuclei. There are three pairs of anterior flagella and one pair of trailing caudal flagella.

Technician's Note



Spironucleus muris appears similar to *Giardia* assemblage G on fecal flotation, but the trophozoite is uniformly slender compared with the widened anterior end of *Giardia* species on direct smear.

Apicomplexans

Parasite: *Eimeria falciformis*, *Eimeria ferrisi*, and *Eimeria hansonorum*

Host: Mice

Location: *E. falciformis* and *E. hansonorum* (small intestines); *E. ferrisi* (cecum)

Distribution: Worldwide

Derivation of Genus: Named after German biologist Gustav Eimer

Transmission Route: Ingestion of oocysts

Common Name: Coccidia of mice

Zoonotic: No

Several species of *Eimeria* infect mice, including *Eimeria falciformis*, *Eimeria ferrisi*, and *Eimeria hansonorum*. *E. falciformis* and *E. hansonorum* infect the small intestine, whereas *E. ferrisi* is found in the cecum. Although mixed infections can occur, little is known concerning the pathogenicity of *E. ferrisi* and *E. hansonorum*.

E. falciformis is common in wild mouse populations. Oocysts are 14 to $26 \mu\text{m} \times 11$ to $24 \mu\text{m}$, round to oval, smooth, and colorless. There is no micropyle or residuum. Sporocysts are oval and have a residuum and a small body. There are two sporozoites per sporocyst and four sporocysts per sporulated oocyst. Oocysts of *E. ferrisi* and *E. hansonorum* appear similar to those of *E. falciformis*, except they are small, 16 to $18 \mu\text{m}$, and more spherical. *E. ferrisi* has a small body on the sporocysts, whereas *E. hansonorum* has a broad body.

The oocysts of *Eimeria* species can be detected by fecal flotation. As in coccidial infections in other species, finding oocysts on fecal flotation does not necessarily mean that *Eimeria* species is a primary cause of the disease. Diagnosis is made by considering clinical signs usually caused by inflammation, the presence of enteric lesions, and identification of the coccidia in histopathologic section. Again, tissues suspected of harboring developmental stages of murine coccidiosis should be submitted to a

histopathology laboratory for confirmation by a veterinary pathologist or parasitologist.

Technician's Note



Finding *Eimeria* species oocysts does not mean that this organism is the primary cause of a disease.

Clinical signs, if seen, are usually in younger animals that have developed little to no immunity and may include diarrhea, catarrhal enteritis, anorexia, hemorrhage, and epithelial sloughing.

As with other species of *Eimeria*, transmission is by ingestion of sporulated oocysts that have been passed in the feces. Oocysts passed in the feces sporulate in about 3 days. *Eimeria* species are host specific and thus are not considered zoonotic parasites.

Urogenital System

The protozoans that infect the urogenital system of mice are apicomplexans.

Apicomplexans

Parasite: *Klossiella muris*

Host: Mice

Location: Kidneys

Distribution: Worldwide

Derivation of Genus: Little organism found by a researcher named Kloss

Transmission Route: Ingestion of oocysts

Common Name: *Klossiella*

Zoonotic: No

Klossiella muris is a relatively nonpathogenic coccidian that occurs mainly in the kidneys of both wild and laboratory mice. This parasite has also been found in different stages of its life cycle in the adrenal and thyroid glands and in the brain, lung, and spleen. The oocyst of *K. muris* matures in the endothelial cells that line the arterioles and capillaries associated with the glomeruli of the kidney. At maturity, the oocyst is 40 μm in diameter. The oocyst grows and divides to form sporoblasts, which eventually rupture the host's endothelial cells and pass through the urine as sporocysts. Other mice are then infected by ingestion of sporulated oocysts.

K. muris cannot be detected antemortem. On post-mortem examination, the kidneys may appear enlarged and have small gray necrotic areas on the surface. Histopathologic examination reveals that most of the necrotic areas are at the corticomedullary junction.

Infection with *K. muris* is usually diagnosed from gross and microscopic lesions, including finding the organism in renal tissue. Tissues suspected of harboring developmental stages of renal coccidiosis should be submitted to a histopathology laboratory for confirmation by a veterinary pathologist or parasitologist.

Transmission of *K. muris* is by ingestion of the sporulated sporocysts passed in the urine. Because wild mice can carry this parasite, strict sanitation and prevention of wild mouse access to the pet population are necessary to control this parasite. *K. muris* is species specific and is not a zoonotic parasite.

Technician's Note



Klossiella muris cannot be detected antemortem.

Rats

Gastrointestinal Tract

The protozoans that infect the gastrointestinal tract of rats are flagellates and apicomplexans.

Flagellates

Although somewhat less susceptible than mice, rats may be infected with the flagellates discussed previously in the mouse section: *Giardia* assemblage G, *S. muris*, *T. microti*, and *T. muris*. Identification, detection, clinical signs, and transmission in rats are similar to those discussed for the mouse.

Apicomplexans

Parasite: *Eimeria nieschultzi*

Host: Rats

Location: Intestines

Distribution: Worldwide

Derivation of Genus: Named after zoologist Gustav Eimer

Transmission Route: Ingestion of oocysts

Common Name: Coccidia of rats

Zoonotic: No

Eimeria nieschultzi is an intestinal coccidian uncommon in laboratory rats but common in wild rats. The sporulated oocyst of *E. nieschultzi* is oval, 16 to 26 μm $\times$ 13 to 21 μm , with no residuum. It has a smooth or colorless wall with no micropyle. The sporulated oocyst contains four oval sporocysts, each with a small Stieda body and a residuum.

Antemortem, *E. nieschultzi* may be detected by finding the oocysts in fecal flotations or direct fecal smears. However, diagnosis is usually based on identification of the organism histopathologically in sections of the intestinal epithelium. Clinical signs of *E. nieschultzi* infections are usually seen in young rats less than several months of age. Signs include diarrhea, weakness, emaciation, and possibly death as a result of inflammation of the intestines. Rats become infected with *E. nieschultzi* by ingestion of sporulated oocysts in the feces. *E. nieschultzi* is species specific and therefore is not considered a potential cross contaminant or zoonotic problem.

Technician's Note



E. nieschultzi is uncommon in pet rats but is common in wild rats.

Hamsters

Gastrointestinal Tract

The protozoans that infect the gastrointestinal tract of hamsters are flagellates.

Flagellates

Hamsters typically carry numerous intestinal flagellates without showing clinical signs. These parasites can be observed in fecal flotations or direct smear preparations. These flagellates include *Giardia* species, *S. muris*, *Tetranucleus microti*, and *T. muris (criceti)*. Infected hamsters may serve as a source of infection for more susceptible rodents, such as in the transmission of *S. muris* to mice.

The identification, detection, clinical signs, transmission, and public health significance of this parasite in hamsters are similar to those discussed for the mouse.

Technician's Note



Hamsters carry numerous intestinal flagellates but do not tend to show clinical signs of these protozoans.

Guinea Pigs

Gastrointestinal Tract

The protozoans that infect the gastrointestinal tract of guinea pigs are flagellates, amoebae, and apicomplexans.

Flagellates

Parasite: *Giardia* assemblage G

Host: Rodents

Location of Adult: Proximal small intestine

Distribution: Worldwide

Derivation of Genus: Named after the famous zoologist Alfred Giard

Common Name: *Giardia*

Zoonotic: No (only assemblage A is zoonotic)

Trophozoites of *Giardia* assemblage G are similar to those previously described. The body is pyriform, or pear shaped. Two nuclei lie at the anterior end, and four pairs of flagella emerge at various points of the body. Trophozoites are 8 to 15 $\mu\text{m} \times 6.5 \mu\text{m}$. Cysts are about the same size as the trophozoites and contain two to four nuclei.

Cysts or trophozoites of *Giardia* may be detected in a direct fecal smear or possibly in a fecal flotation preparation. If fecal flotation is used, zinc sulfate solution is preferred because sugar and salt solutions may distort the cysts. Diarrheic animals should be examined by direct smear for the presence of motile trophozoites; cyst forms will not be present.

There are no specific clinical signs in infected guinea pigs; however, mucoid diarrhea has been reported in other infected rodents. *Giardia* assemblage G is not considered a public health problem.

Technician's Note



Giardia assemblage G is not considered a public health hazard.

Parasite: *Tritrichomonas caviae*

Host: Guinea pig

Location: Cecum

Distribution: Worldwide

Derivation of Genus: Three-hair unit

Transmission Route: Ingestion of oocysts

Common Name: Flagellate of guinea pigs

Zoonotic: No

Tritrichomonas caviae is of little or no pathologic significance in the guinea pig. As with *T. muris*, *T. caviae* has three anterior flagella and a trailing posterior flagellum. *T. caviae* measures 10 to 22 $\mu\text{m} \times 6$ to 11 μm and is larger than *Giardia caviae*. It has an undulating membrane that extends the length of its body. These trichomonads are usually found in the cecum of the guinea pig. The veterinary

technician should be aware that in cases of protracted diarrhea produced by another pathogen, *T. caviae* protozoans proliferate secondarily because of the fluid medium produced by the diarrhea. *T. caviae* therefore may be observed on direct fecal smear, particularly in animals exhibiting clinical signs of diarrhea.

T. caviae is transmitted between guinea pigs by ingestion of the trophozoites passed in the feces of carrier animals. *T. caviae* is not seen in other species of animals and is not considered a public health hazard.

Technician's Note



Trichomonas caviae typically proliferate (as a secondary infection) in the presence of another pathogen causing diarrhea as a result of the fluid medium produced by the diarrhea.

Amoebae

Parasite: *Entamoeba caviae*

Host: Guinea pigs

Location: Cecum

Distribution: Worldwide

Derivation of Genus: Internal amoeba

Transmission Route: Ingestion of oocysts

Common Name: Amoeba of guinea pigs

Zoonotic: No

Entamoeba caviae is a relatively common nonpathogenic cecal organism in guinea pigs; it is mentioned in this chapter to make the veterinary technician aware that it should be disregarded as a pathogenic organism. The most frequently observed form of this protozoan is the motile trophozoite. Cysts are infrequently observed on concentration with zinc sulfate flotation medium. Mature cysts are 11 to 27 μm and have eight nuclei. The trophozoites are most often found in a direct fecal smear and measure 10.5 to 20 μm in diameter. The appearance of these trophozoite stages can be enhanced by staining the direct fecal smear with Lugol iodine.

Entamoeba caviae is transmitted by ingestion of infective cyst forms that have been passed in the feces of chronic carrier guinea pigs. *Entamoeba caviae* is species specific and is not considered to be of zoonotic significance.

Technician's Note



Entamoeba caviae is nonpathogenic and can be found on fecal flotation and direct fecal smears.

Apicomplexans

Parasite: *Eimeria caviae*

Host: Guinea pigs

Location: Large intestine

Distribution: Worldwide

Derivation of Genus: Named after zoologist Gustav Eimer

Transmission Route: Ingestion of oocysts

Common Name: Coccidia of guinea pigs

Zoonotic: No

Eimeria caviae is a typical coccidian, with an oval to slightly subspherical oocyst that is 13 to 26 μm $\times$ 12 to 23 μm . Oocyst walls are brown and have no micropyle or polar granule. However, oocysts contain a residuum, as do sporocysts. *Eimeria caviae* is commonly found in the guinea pig's large intestine, particularly the ascending or proximal colon.

Eimeria caviae can be detected by fecal flotation. Repeated flotation should be done 4 to 5 days apart for 2 to 3 weeks. Diagnosis is made more consistently postmortem, at which time intestinal scrapings placed in saline may be examined microscopically for both intracellular intestinal stages and oocysts of *Eimeria caviae*.

Eimeria caviae is generally nonpathogenic, but young animals stressed by poor nutrition and husbandry may show clinical signs. Clinical signs are limited to diarrhea seen 11 to 13 days after exposure related to inflammation of the intestine. The diarrhea ceases after a few days if the animal is not reinfected. Diarrhea may continue if reinfection occurs. As with the other protozoans of guinea pigs, *Eimeria caviae* is species specific and is not considered of zoonotic significance.

Technician's Note



Eimeria caviae is essentially nonpathogenic but can cause symptoms in stressed young animals with poor nutrition and husbandry.

Parasite: ♦ *Cryptosporidium wairi*

Host: Guinea pigs

Location of Adult: Tips of the intestinal villi of the ileum

Distribution: Worldwide

Derivation of Genus: Hidden small seeds

Transmission Route: Ingestion of oocysts

Common Name: *Cryptosporidium* or "Crypto"

Zoonotic: Yes

Cryptosporidium wairi of guinea pigs is similar to *C. parvum* and *C. muris* of mice. However, *C. wairi* is considered a distinct species. *C. wairi* is most often seen lining the tips

of the intestinal villi in the ileum of young guinea pigs. Examination of fresh mucosal scrapings by phase-contrast microscopy may provide the best results in the detection and identification of *C. wrairi*. Examination of paraffin-embedded materials is least satisfactory, especially when formalin is used as a fixative. The organisms appear to be extracellular but actually are within the microvilli of the intestinal epithelial cells. The only clinical sign of *C. wrairi* infection is weight loss. Younger guinea pigs at 250 to 300 g are most likely to carry the parasite. Older animals seem to be resistant or to have developed immunity to *C. wrairi*. *C. wrairi* is not found in other species of animals and is not considered a public health problem.

Technician's Note



Examination of fresh mucosal scrapings of the intestinal villi is the preferred diagnostic test for *Cryptosporidium wrairi*.

Fish

Skin

Protozoans that infect the skin of fish are ciliates.

Ciliates

Parasite: *Ichthyophthirius multifiliis*

Host: Freshwater and ornamental fish

Location: Skin, gills, fins, and eyes

Distribution: Worldwide

Derivation of Genus: Fish louse with many children

Transmission Route: Contact with infective stage of life cycle

Common Name: Ciliate of fish

Zoonotic: No

Ichthyophthirius multifiliis is a ciliate that infects the skin, gills, fins, and eyes of many freshwater tropical and ornamental fish in home aquaria and in hatcheries. This ciliated protozoan causes a skin disease called **ichthyophthiriasis**, or more commonly, *ich*. *Ich* is characterized by the formation of tiny white spots (the thin-walled trophozoite stage just beneath the epidermis) over many of the exposed surfaces of the fish. These parasites may be from 100 to 1000 μm in diameter, so they are grossly visible to the observer. Diagnosis is by observation of typical lesions; however, it is possible to perform skin scrapings on infected fish to reveal characteristic ciliates. *Cryptocaryon irritans*, a similar parasite, affects warm-water marine (saltwater) fish. Other ciliates infecting fish include *Chilodonella*, *Tetrahymena*, and *Piscinoodinium*. As with *I. multifiliis*, there are marine counterparts for these genera. For details of these and other protozoan parasites of both freshwater and marine fish, a fish disease textbook should be consulted.

Technician's Note



Ichthyophthirius multifiliis is diagnosed by observation of typical white spot lesions and skin scrapings.

Chapter Eleven Test

MATCHING—Match the scientific name in the left hand column of each parasite with the correct name, phrase, or term in the right hand column.

A. <i>Giardia</i> species	1. Very large ciliated protozoan found in the large intestine of swine
B. <i>Entamoeba histolytica</i>	2. Feline piroplasm—bejeweled ring within stained red blood cells of cats
C. <i>Balantidium coli</i>	3. Onionskin tissue cysts found in skeletal muscle of dogs transmitted by ingestion of the tick <i>Amblyomma maculatum</i>
D. <i>Cystoisospora</i> species in dogs and cats	4. Intestinal protozoan of cats (only definite host); zoonotic parasite
E. <i>Toxoplasma gondii</i>	5. Most commonly diagnosed clinical condition in puppies and kittens (coccidiosis)
F. <i>Trypanosoma cruzi</i>	6. Mutuals of cattle
G. <i>Babesia canis</i>	7. Hemoprotozoan of Central and South America with two forms: trypomastigote and amastigote (zoonotic parasite)
H. <i>Cytauxzoon felis</i>	8. Canine piroplasm; basophilic, pear shaped organism within canine red blood cells
I. <i>Hepatozoon americanum</i>	9. Amebic dysentery in humans
J. Rumen ciliates	10. Oval cysts with a refractile wall and two to four nuclei; may be distorted to semilunar appearance on standard fecal flotation

MATCHING—Match the scientific name of each parasite with the correct name, phrase, or term.

AA. <i>Eimeria bovis</i> , <i>Eimeria zuernii</i>	1. Protozoan parasite residing in the reproductive tract of cattle
BB. <i>Cryptosporidium</i> species	2. Equine piroplasms; pear shaped organisms that may join, giving the effect of a Maltese cross
CC. <i>Babesia bigemina</i>	3. Equine protozoal myeloencephalitis
DD. <i>Tritrichomonas foetus</i>	4. Piroplasm of cattle transmitted by the tick <i>Boophilus annulatus</i>
EE. Cecal ciliates of horses	5. Coccidiosis in cattle
FF. <i>Eimeria leuckarti</i>	6. Oocysts found on histopathologic examination of the horse kidney and in urine sediment
GG. <i>Theileria equi</i>	7. Nonpathogenic coccidian found in the kidneys of wild and laboratory rats
HH. <i>Klossiella equi</i>	8. Colorless sporulated oocyst; 3 to 5 μ m in diameter on fecal flotation (zoonotic parasite)
II. <i>Sarcocystis neurona</i>	9. Mutuals of horses
JJ. <i>Klossiella muris</i>	10. Unique oocysts that are the largest of the coccidians

MATCHING—Match the scientific name of each parasite with the correct name, phrase, or term.

AAA. <i>Cystoisospora suis</i>	1. Intracellular flagellate (amastigote) found within reticuloendothelial cells of capillaries, spleen, etc.; transmitted by phlebotomine sand flies; zoonotic parasite
BBB. <i>Histomonas meleagridis</i>	2. Ciliate affecting the skin, gills, fins, and eyes of freshwater, tropical, and ornamental fish in home aquaria
CCC. <i>Trichomonas gallinae</i>	3. Avian malaria
DDD. <i>Haemoproteus species</i>	4. Cecal ciliate of guinea pigs; usually nonpathogenic but may be observed in diarrheic conditions
EEE. <i>Plasmodium species of birds</i>	5. Bluish sausage shaped body within the cytoplasm of the avian red blood cell
FFF. <i>Leukocytozoon species</i>	6. Infectious enterohepatitis; blackhead in turkeys; intermediate host <i>Heterakis gallinarum</i>
GGG. <i>Eimeria stiedae</i>	7. Greatly distorts the shape of the avian white blood cell
HHH. <i>Trichomonas caviae</i>	8. Coccidian that parasitizes the small intestine of swine, especially young piglets
III. <i>Ichthyophthirius multifiliis</i>	9. Found within crop washes and crop swabs of pigeons, doves, and poultry
JJJ. <i>Leishmania species</i>	10. Coccidiosis within the bile ducts of the liver of rabbits

Questions for Thought and Discussion

1. Which protozoan parasites have life cycles that involve arthropods that serve as intermediate hosts? What is the significance of these relationships?
2. What are the four kinds of protozoans that affect domesticated animals? Give three examples of parasites for each of these groups.

Introduction to the Arthropods

OUTLINE

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LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Describe the key morphologic features of all arthropods.
- Identify four reasons arthropods are important.
- Detail the importance of crustaceans in veterinary parasitology.
- Detail the importance of insects in veterinary parasitology.
- Describe the key morphologic features of insects.
- Compare complex metamorphosis versus simple metamorphosis of insects.
- Identify the members of different orders of insects.
- Describe the key morphologic features of mites and ticks.

KEY TERMS

Abdomen	Chitin
Acariasis	Coleoptera
Acarines	Complex metamorphosis
Anoplura	Crustaceans
Arthropod	Dictyoptera
Capitulum	Dioecious
Chelicerata	Diptera

Head
Hemiptera
Hemocoel
Hemolymph
Hymenoptera
Idiosoma
Insects
Lepidoptera

Mallophaga
Mandibulata
Metamorphosis
Simple metamorphosis
Siphonaptera
Terminal anus
Thorax
Ventral mouth

Arthropoda

The phylum Arthropoda is one of the largest phyla. There are more than a million species of arthropods, including the extinct trilobites, spiders, mites, ticks, crabs, crayfish, lobsters, water fleas, copepods, millipedes, centipedes, and other insects. The **insects** include the cockroaches, beetles, bedbugs, fleas, bees, ants, wasps, mosquitoes, butterflies, moths, grasshoppers, lice, silverfish, and dragonflies. With more than 900,000 species, insects are by far the largest class within the phylum Arthropoda.

Technician's Note



The insects are the largest class in the phylum Arthropoda, with more than 900,000 species.

Key Morphologic Features

The name **arthropod** means “jointed foot” (*arthro* means “joint,” and *pod* means “foot”). All adult arthropods have jointed appendages. All arthropods are covered with a chitinous exoskeleton that is composed of segments. **Chitin** is a hard (yet elastic) body covering that envelops the entire body of all arthropods. Whenever you step

on a cockroach, the chitin makes the “crunch” sound. Arthropods have a **hemocoel**, a body cavity filled with hemolymph. **Hemolymph** is a blood-like fluid that bathes the internal organs of an arthropod. When a flying insect hits the windshield of a speeding car and “splats,” hemolymph is the fluid that creates the splat. Arthropods have a very simple circulatory system composed of a heart-like dorsal tube. This dorsal tube is actually a primitive heart that pumps the hemolymph to the arthropod’s head. The digestive system of arthropods begins with a **ventral mouth** and ends with a **terminal anus**. Arthropods possess a variety of respiratory systems; they may use gills, book lungs, or tracheal tubes as respiratory organs. Arthropods have complex nervous and excretory systems. However, the most important organ system of the arthropods is the reproductive system. Arthropods have separate sexes; they are **dioecious**. Reproduction is by means of eggs. Arthropods have a tremendous reproductive capacity.

Technician’s Note



Arthropods are dioecious and use eggs for reproduction. They have a tremendous capacity for reproduction.

Divisions of the Phylum Arthropoda

The phylum Arthropoda is made up of the following subphyla: Trilobitomorpha (the extinct trilobites), Onychophora (onychophorans, or “living fossils”), Tardigrada (water bears), Pycnogonida (sea spiders), Chelicerata (mites, ticks, spiders, scorpions, and others), and Mandibulata (crustaceans, centipedes and millipedes, and insects). Most of the arthropods important to veterinary parasitology are members of **Chelicerata** and **Mandibulata**.

Members of the phylum Arthropoda are important because (1) they may serve as causal agents themselves; (2) they may produce venoms or toxic substances; (3) they may serve as intermediate hosts for protozoan and helminth parasites; and (4) they may serve as vectors for bacteria, viruses, spirochetes, rickettsiae, chlamydial agents, and other pathogens.

Technician’s Note



Arthropods are extremely important ectoparasites because they can act as parasites themselves; can serve as intermediate hosts for other parasites; can produce toxins or venoms; or can serve as vectors for bacteria, viruses, spirochetes, rickettsiae, and other pathogens.

Crustacea (Aquatic Arthropods)

Phylum: Arthropoda

Subphylum: Mandibulata

Class: Crustacea (aquatic arthropods)

Members of the class Crustacea are usually aquatic. **Crustaceans** are important because they serve as intermediate hosts for many helminth parasites, including flukes (e.g., *Paragonimus kellicotti*), tapeworms (e.g., *Spirometra mansonioides*), and roundworms (e.g., *Dracunculus insignis*). Crustaceans also serve as causal agents because they are ectoparasites of many fish, amphibians, and exotic reptiles.

Myriapoda (Centipedes and Millipedes)

Phylum: Arthropoda

Subphylum: Mandibulata

Class: Myriapoda (centipedes and millipedes)

Members of the class Myriapoda are represented by centipedes and millipedes. Myriapodans are important because they produce venoms and toxic substances. Centipedes and millipedes are usually slow-moving arthropods. For defense mechanisms, they are capable of producing venoms and toxic substances that can sting, blind, paralyze, burn, or even kill. Centipedes and millipedes are not of veterinary significance in North America.

Insecta (Insects)

Phylum: Arthropoda

Subphylum: Mandibulata

Class: Insecta (insects)

As mentioned earlier, the class Insecta has the largest number of members (more than 900,000 species) in the phylum Arthropoda. This is also the most diverse group. Members of the class Insecta are important because (1) they may serve as causal agents themselves; (2) they may produce venoms or toxic substances; (3) they may serve as intermediate hosts for protozoan and helminth parasites; and (4) they may serve as vectors for bacteria, viruses, spirochetes, rickettsiae, chlamydial agents, and other pathogens. Examples of all of these important pathogenic mechanisms are covered in [Chapter 13](#).

Key Morphologic Features

As members of the phylum Arthropoda, insects share the following morphologic characteristics: a segmented body with three pairs of segmented legs, bilateral symmetry, a chitinous exoskeleton, a dorsal heart, a ventral nerve cord, a digestive system from mouth to anus, an excretory system, and a reproductive system. As with all other arthropods, insects are dioecious (they, too, have separate sexes) and demonstrate a tremendous reproductive capacity.

Technician's Note



All insects have the same morphologic characteristics: segmented body with three pairs of segmented legs, bilateral symmetry, chitinous exoskeleton, dorsal heart, ventral nerve cord, digestive system from mouth to anus, excretory system, and reproductive system.

The body of all adult insects is divided into three basic body sections: the head, thorax, and abdomen. The **head** is on the anterior, or front end, of the insect; the head contains the insect's brain, its antennae, the ventrally directed mouthparts, and the eyes (if eyes are present; some insects are eyeless). The **thorax** is the middle body section. The thorax of the adult insect always has three pairs of legs and may have either one or two pairs of wings; however, many insects, such as lice and fleas, are wingless. The **abdomen** is the posterior, or the hind section, of the insect. It often contains the reproductive organs but has no ventral segmented appendages (e.g., mouthparts of the head, legs of the thorax).

Technician's Note



The insect body is divided into the head, thorax, and abdomen.

To achieve the size and development of the adult insect, the young insect must undergo changes in size, form, and structure. This series of changes is called **metamorphosis**. For purposes of this text, there are two types of metamorphosis: simple metamorphosis and complex metamorphosis. **Simple metamorphosis** consists of three developmental stages: the egg stage, the nymphal stage, and the adult stage.

In this form of metamorphosis, the nymphal stage resembles the adult stage in form except that it is smaller and is not sexually mature (and therefore cannot reproduce). In winged insects, the wings may be absent in the nymphal stage. An example of an insect that undergoes simple metamorphosis is the cockroach.

Complex metamorphosis consists of four developmental stages: the egg stage, the larval stage, the pupal stage, and the adult stage. None of these developmental stages bears a resemblance to any of the others. The egg stage does not resemble the larval stage, which in turn does not resemble the pupal stage, which in turn does not resemble the adult stage. The larval stage is described as *worm-like*. To reach the adult stage, the insect must develop through the pupal stage, which is a resting stage. The adult stage emerges from the pupal stage and eventually becomes sexually mature and reproduces, producing large numbers of offspring.

Technician's Note



The insect goes through a simple or complex metamorphosis as it progresses through its life cycle. The metamorphosis depends on the species of the insect.

Orders of Insecta

With regard to veterinary parasitology, the class Insecta is further divided into nine orders. The orders of greatest significance in parasitology are **Dictyoptera** (cockroaches and grasshoppers), **Coleoptera** (beetles), **Lepidoptera** (moths and butterflies), **Hemiptera** (true bugs), **Hymenoptera** (ants, bees, wasps, yellowjackets, and other stinging insects), **Anoplura** (sucking lice), **Mallophaga** (chewing lice), **Diptera** (two-winged flies), and **Siphonaptera** (fleas). Each of the orders within the class Insecta and its relative importance in veterinary medicine is discussed in detail in [Chapter 13](#).

Acarina (Mites and Ticks)

Phylum: Arthropoda

Subphylum: Chelicerata

Order: Acarina (mites and ticks)

The subphylum Mandibulata comprises crustaceans, centipedes and millipedes, and insects. The members of the subphylum Chelicerata include mites, ticks, spiders, and scorpions. Within this subphylum are members of the class

Arachnida, order Acarina, the mites and the ticks. Mites and ticks are often referred to as **acarines**, and infestation with mites or ticks is referred to as **acariasis**.

Technician's Note



Ectoparasites cause infestations rather than infections. Infestation with mites and ticks is called *acariasis*.

Mites and ticks are *not* insects; they are acarines. They are morphologically different from insects. First, the body segmentation of mites and ticks is different from that of insects. Insects are divided into head, thorax, and abdomen; mites and ticks, however, have lost all the external signs of body segmentation and are divided into two body components, the **capitulum** (the mouthparts, or a fusion of the head and thorax) and the **idiosoma** (the abdomen). Discussions in this text refer to the two basic body parts of mites and ticks as the *mouthparts* and the *abdomen*. Although insects may have antennae, wings, and compound eyes, acarines lack these structures. The mouthparts of the mites and ticks have two basic functions: sucking blood or tissue fluids and attaching or holding on to the host. The following

organ systems are represented in mites and ticks: digestive, excretory, respiratory, nervous, and reproductive systems. As with insects, mites and ticks are dioecious (have separate sexes) and possess a tremendous reproductive capacity.

In contrast to insects, mites and ticks do not undergo metamorphosis. There are four developmental stages in the life cycle of acarines: the egg stage, the larval stage, the nymphal stage, and the adult stage. The major difference among these life stages is that the larval acarine has three pairs of legs (or six legs), whereas both nymphal and adult acarines have four pairs of legs (or eight legs). Only the adult stage is capable of sexual reproduction.

Technician's Note



Mites and ticks do not go through a metamorphosis as insects do. Instead, their four life stages resemble each other, with the exception of the number of pairs of legs possessed at each stage of development. Only the adult is capable of sexual reproduction.

Mites and ticks are significant in veterinary medicine and are discussed in detail in [Chapter 13](#).

Chapter Twelve Test

MATCHING—Match the scientific term on the left hand column with the correct phrase or term in the right hand column.

A. Arthropods	1. Beetles
B. Chitin	2. Ants, bees, wasps, yellowjackets, and other stinging insects
C. Dioecious	3. Centipedes and millipedes
D. Mandibulata	4. Jointed appendages
E. Chelicerata	5. Two-winged flies
F. Myriapoda	6. Egg, larva, pupa, and adult
G. Body sections of insects	7. Fleas
H. Simple metamorphosis	8. Having separate sexes; both male and female
I. Complex metamorphosis	9. Crustaceans, centipedes, millipedes, and insects
J. Dictyopterans	10. True bugs
K. Coleopterans	11. Causal agents, venom producers, intermediate hosts, vectors
L. Lepidopterans	12. The blood of most arthropods
M. Hemipterans	13. Mites and ticks collectively
N. Hymenopterans	14. Sucking lice
O. Anoplurans	15. Hard, elastic covering that envelops the bodies of all arthropods
P. Mallophagans	16. Mites, ticks, spiders, scorpions, etc.
Q. Dipterans	17. Head, thorax, and abdomen
R. Siphonapterans	18. Tremendous!
S. Capitulum	19. Developmental stages in the life cycle of a mite or tick
T. Idiosoma	20. Mouthparts of a mite or tick
U. Acarines	21. Infestation with either mites or ticks
V. Acariasis	22. Moths and butterflies
W. Egg, larva, nymph, adult	23. Cockroaches and grasshoppers
X. Importance of arthropods	24. Egg, nymph, and adult
Y. Reproductive potential for arthropods	25. Chewing lice
Z. Hemolymph	26. Abdomen of a mite or tick

Questions for Thought and Discussion

1. Compare and contrast insects and acarines. How are they similar? How are they different?
2. There are many diverse orders within the class Insecta. How does each of these orders integrate into the

ways in which arthropods are important? These facts will become evident after studying the following chapter.

Arthropods That Infect and Infest Domestic Animals

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LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Describe the subclass Mandibulata and the subclass Chelicerata.
- Identify the three types of arthropodan parasites that are reportable to the U.S. Department of Agriculture (USDA).
- Identify and give examples of arthropods that serve as causal agents themselves.
- Identify and give examples of arthropods that serve as producers of venoms or toxic substances.
- Identify and give examples of arthropods that serve as intermediate hosts for tapeworms, flukes, and especially nematodes.
- Identify and give examples of arthropods that serve as vectors of diseases.
- Compare and contrast the following disease entities in domestic animals: pediculosis, myiasis, siphonapterosis, and acariasis.
- Compare and contrast facultative myiasis and obligatory myiasis.
- Compare and contrast localized and generalized demodicosis.
- Compare and contrast insects and acarines.
- Identify the major arthropodan parasites of domestic animals (when given the host and the location within that host).

KEY TERMS

Acariasis	Common eastern rabbit
Adult stage	flea
Adulticide	Continental rabbit tick
American dog tick or wood tick	Crustaceans
Anoplura	Demodicosis
Argasid or soft tick	Dictyopterans
Arthropodology	Diptera
Bedbug	Drs. Smith and Kilbourne
Black fly	Egg stage
Blister beetle	Face fly
Borreliosis	Facultative myiasis
Brown dog tick	Festoon
Buffalo gnat	Flea dirt or flea frass
Cantharidin	Fly strike or strike
Chagas disease	Fomite
Centipede	Foot and tail mites
Cheliceræ	Fowl tick
Chelicerata	Free-living
Cheyletiellosis	Gadding
Chigger	Generalized demodicosis
Coleopterans	Giant eastern rabbit flea
	Gulf Coast tick

Heel fly	Psoroptidae family
Hippoboscid fly	Queensland itch, sweat
Hirsute	itch, sweet itch,
Horn fly	summer
Horse bots or stomach	dermatitis
bots	Red fowl mite
Hymenopterans	Reduviid bugs
Hypostome	Reportable parasite
Inornate	Reportable parasites
Insect growth regulator	Sarcoptiform mites
Insects	Sarcoptidae family
Ixodid or hard ticks	Scabies or sarcoptic
Lepidopterans	acariasis
Localized form of	Scaly leg
demodicosis	Screwworm fly
Lone star tick	Scutum
Mallophaga	Seed ticks
Mandibulata	Setae
Millipede	Sheep ked
Mucocutaneous	Siphon
Myiasis	Siphonapterans
Myriopoda	Siphonapterosis
Nasal bots or nasal bot	South American
flies	trypanosomiasis
New World sand flies	Spinose ear tick
Nit	Spiracular plate
North American chigger	Stable fly or biting
Northern mite of	housefly
poultry	Sticktight flea of
No-see-ums, punkies,	poultry
sand flies	Sylostome
Nymph	Synanthropic
Nymphal stage	Tasselfoot
Obligatory myiasis	Texas cattle
Ornate	fever tick or
Ox warbles, cattle grubs	North American tick
Palpi	Tick paralysis
Palps	Trombiculosis
Pedicels or stalks	Tropical rat mite
Pediculosis	Venations
Pedipalps	Walking dandruff
Periodic parasite	Wolves or warbles

The study of arthropods is referred to as **arthropodology**. Arthropods, members of the phylum Arthropoda, are important in veterinary parasitology for several reasons. Arthropods (1) serve as causal agents themselves by producing pathology or disease in domesticated or wild animals (or in humans); (2) serve as intermediate hosts for **helminths** (flukes, tapeworms, and roundworms) and **protozoans** (single-celled organisms) that infect domesticated or wild animals (or humans); (3) serve as vectors for bacteria, viruses, spirochetes,

chlamydial agents, and other pathogens that produce disease in domesticated or wild animals (or humans); and (4) produce venoms and other substances that may be toxic to domesticated or wild animals (or humans). From one to four of these important criteria are true for each group of arthropods.

Technician's Note



Arthropods can serve as agents of disease; intermediate hosts for other parasites; and vectors for bacterial, viral, spirochete, chlamydial, and other pathogenic diseases and can produce venoms or other substances that may be toxic to animals and humans.

The phylum Arthropoda is broken down into several subphyla, two of which are important in veterinary parasitology. These two subphyla are the **Mandibulata** (crustaceans, myriopodans, and insects) and the **Chelicerata** (mites, ticks, spiders, and scorpions).

Crustaceans

Kingdom: Animalia

Phylum: Arthropoda (arthropods)

Subphylum: Mandibulata (possess mandibulate mouthparts)

Class: Crustacea (aquatic crustaceans)

Crustaceans are important in veterinary medicine for several reasons. First, crustaceans may be causal agents themselves when they serve as ectoparasites of fishes and amphibians. Tiny, microscopic crustaceans, such as the *Argulus* species (Fig. 13.1), parasitize the skin and gills of aquatic animals and can produce significant pathology. Crustaceans such as crabs can also be important as causal agents when they are swallowed by dogs that frequent beaches; in this scenario, crustaceans act as foreign bodies within the stomach or other portions of the gastrointestinal tract. Crustaceans may also serve as intermediate hosts for certain helminth parasites of domesticated animals. For example, the crayfish serves as the intermediate host for *Paragonimus kellicotti*, the lung fluke of dogs and cats. Certain aquatic copepods serve as first intermediate hosts for *Diphylllobothrium latum* and *Spirometra mansonioides*, pseudotapeworms of dogs and cats. Finally, certain freshwater crustaceans serve as the intermediate host for *Dracunculus insignis*, the guinea worm, a subcutaneous parasite of dogs.

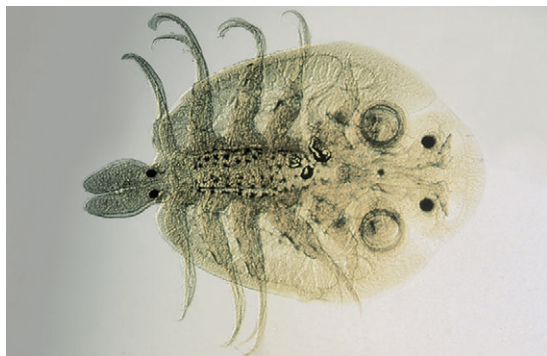


Fig. 13.1 Tiny, microscopic *Argulus* species parasitizes the skin and gills of fish.

Technician's Note

Argulus species of crustaceans parasitize the gills and skin of aquatic animals, whereas other crustacean species act as intermediate hosts to several types of parasites.

Technician's Note

Centipedes have one pair of legs for every body segment, whereas millipedes have two pairs of legs for every body segment.

Millipedes are also small terrestrial arthropods. Whereas centipedes are predatory on smaller creatures, millipedes are vegetarians. Millipedes have two pairs of legs for every body segment; remember that centipedes have only one pair. Beneath each pair of legs are repugnatorial glands that contain caustic substances capable of burning the skin. Millipedes are able to “squirt” these caustic, irritating substances onto the skin of any creature that might threaten them. As with the centipedes, most of the truly poisonous millipedes are restricted to the jungles and areas of dense vegetation throughout the world and *not* to the continent of North America. Some tribal people in these jungle areas grind up caustic millipedes and dip their arrow tips into the “juice” to make poisonous arrows. Although centipedes are sold as exotic pets in some pet stores, millipedes do not make good family pets.

Myriopodans

Kingdom: Animalia

Phylum: Arthropoda (arthropods)

Subphylum: Mandibulata (possess mandibulate mouthparts)

Class: Myriopoda (centipedes and millipedes)

The class **Myriopoda** comprises the centipedes and the millipedes (myriopodans). This strange class of arthropods is important because its members produce venoms or toxic substances.

Centipedes are usually small terrestrial arthropods, predatory on creatures smaller than themselves. Centipedes have one pair of legs for every body segment. On the anterior end, they possess poison claws that connect to large poison glands. Centipedes often subdue their prey with these poison claws. It is important to note, however, that most of the truly poisonous centipedes are restricted to the jungles and areas of dense vegetation throughout the world and *not* to the continent of North America. Some pet stores sell exotic varieties of centipedes, and veterinarians are infrequently asked to “treat” these exotic arthropods; however, a medical arthropodologist (or entomologist) might be consulted. Great care should be taken when handling all centipedes because they can bite. The bite of some of the larger centipede varieties has been likened to the sting of a hornet.

Insects

Kingdom: Animalia

Phylum: Arthropoda (arthropods)

Subphylum: Mandibulata (possess mandibulate mouthparts)

Class: Insecta (insects)

A major portion of this chapter discusses the orders of the class Insecta and their place in veterinary parasitology. The following orders are discussed:

Class: Insecta

Order: Dictyoptera (cockroaches)

Order: Coleoptera (beetles)

Order: Lepidoptera (butterflies and moths)

Order: Hymenoptera (ants, bees, and wasps)

Order: Hemiptera (true bugs)

Order: Mallophaga (chewing or biting lice)

Order: Anoplura (sucking lice)

Order: Diptera (two-winged flies)

Order: Siphonaptera (fleas)

Dictyoptera (Cockroaches)

Cockroaches or **dictyopterans** are members of the order Dictyoptera. These disgusting creatures are perhaps the

most commonly occurring insects that may actively “infest” a veterinary clinic. Because of their voracious feeding habits and their close association with stored food products (e.g., dried dog and cat food), cockroaches are often associated with the nocturnal environment of the veterinary clinic. Cockroaches habitually disgorge portions of their partly digested food and also defecate wherever they roam and feed. Under the proper circumstances, cockroaches may be incriminated in the natural transmission of pathogenic organisms such as *Salmonella* species to both humans and domesticated animals.

Coleoptera (Beetles)

Members of the order Coleoptera, **coleopterans** or beetles, are important because they may serve as intermediate hosts for certain parasites of domesticated animals. Dung beetles serve as intermediate host for *Spirocerca lupi*, the roundworm that produces esophageal nodules in dogs, and for *Gongylonema* species, a roundworm found in the tissues of the oral cavity and esophagus of goats and swine. Beetles can also serve as the intermediate host for the swine acanthocephalan *Macracanthorhynchus hirudinaceus*.

Technician's Note

Dung beetles are intermediate hosts to several parasites, including *Spirocerca lupi* in dogs and *Gongylonema* species in goats and swine.

Parasite: Blister beetles

Host: None

Location: Free in the environment

Distribution: Continental United States and Canada

Derivation of Genus: Based on individual type of beetle

Transmission Route: Usually ingested

Common Name: Blister beetles

Certain types of beetles, commonly called **blister beetles**, produce within their tissues a toxic substance called **cantharidin** (Fig. 13.2). If these beetles are ingested by a mammalian host, they can produce a blistering of the skin, the oral mucosa, and the epithelium lining the alimentary tract. These beetles often infest the earth immediately beneath alfalfa hay, and when the hay is harvested, the beetles may be collected and subsequently fed to horses. When horses ingest these beetles, a fatal colic often results. Blister beetles have been referred to as *Spanish fly*, a type of aphrodisiac or “love potion”; however, blister beetles are caustic and will burn living tissues and should not be used as an aphrodisiac.



Fig. 13.2 Blister beetles often infest alfalfa hay. They contain cantharidin, a toxic substance that produces colic in horses.

Technician's Note

Blister beetles produce a cantharidin, toxic substance that is caustic and will burn living tissues. These beetles are often found beneath alfalfa hay.

Lepidoptera (Butterflies and Moths)

Members of the order Lepidoptera, or **lepidopterans**, have two life-cycle stages—the adult stage and the larval, or caterpillar, stage—that may be pathogenic to domestic animals. Some moths and butterflies in certain parts of Southeast Asia feed on the lachrymal (lacrimal) secretions (tears) of domestic and wild animals. These are exotic creatures not native to North America. Some moths and butterflies from these exotic regions also have been known to suck blood.

Several species of larval moths and butterflies found in North America are covered with tiny urticating, or stinging, hairs. Because caterpillars are often slow moving, these hairs serve as defense mechanisms against their predators. These stinging hairs cause significant stings in humans and domestic animals.

Hymenoptera (Ants, Bees, and Wasps)

The veterinarian should remember three basic facts about ants, bees, wasps, and hornets (members of the order Hymenoptera, or **hymenopterans**). First, “fire ants” are indigenous to the southeastern United States and can bite and sting almost any domesticated animal. “Downer cows” and newborn animals (weak, young lambs and calves and hatchling chicks) are particularly at risk to the perils of fire ants. Fire ants can attack any animal with which they

come in contact. Ants can also serve as the second intermediate host for *Dicrocoelium dendriticum*, the lancet fluke of small ruminants. Second, bees, wasps, and hornets can sting domestic animals, particularly curious dogs and cats. These are minor envenomizations, seldom resulting in the death of an animal. Third, after being released in Brazil, Africanized honeybees, or “killer bees,” have spread throughout South America and have crossed the border separating Texas and Mexico. Each year, these bees invade farther into the United States. Almost any domestic animal (and humans) can be at risk of inadvertently disturbing a ground hive containing these bees and arousing its inhabitants. Death often results from thousands of stings from these killer bees. Bees and wasps can cause anaphylactic reactions in allergic animals and humans. If not treated, these reactions can be severe enough to cause death.

If the veterinary diagnostician suspects that ants, bees, wasps, or hornets are causing problems, the intact hymenopteran should be collected in a sealed container containing 10% formalin or ethyl alcohol and submitted to an entomologist for identification.

Technician's Note

The hymenopterans can bite and/or sting domesticated animals, causing mild envenomization to death, depending on the species and number of bites or stings and the reaction by the animal's or human's body.

Hemiptera (True Bugs)

Parasite: Reduviid bugs

Host: Dogs and humans

Location: On host's lips and skin of the mouth when feeding

Distribution: Species can be found worldwide

Derivation of Genus: None found

Transmission Route: Periodic parasite

Common Name: Kissing bugs

The veterinary diagnostician should remember the following basic facts about true bugs (members of the order Hemiptera). There are two groups of hemipterans that are of veterinary importance: reduviid bugs (kissing bugs) and bedbugs. Reduviid bugs are **periodic parasites**; that is, they make frequent visits to the host to obtain a blood meal. Kissing bugs serve as intermediate hosts for *Trypanosoma cruzi*, a protozoan parasite that can produce a rare disease called **Chagas disease** in humans and dogs. This disease is also called **South American trypanosomiasis** and is rarely diagnosed in the United States. *T. cruzi* infects a variety of internal organs; its infective stages swim in the blood of an

infected host. Kissing bugs take blood meals from infected hosts and incubate the parasite in their intestinal tracts. The parasites are then transmitted to uninfected mammals as the bugs defecate. After taking a blood meal from a host, a kissing bug turns around and defecates on the feeding site. This inoculates the infective trypanosomes into the uninfected host. Kissing bugs play a key role in the transmission of Chagas disease.

Technician's Note

Reduviid bugs are an intermediate host to *Trypanosoma cruzi*.

Parasite: *Cimex lectularius*

Host: Humans, rabbits, poultry, and pigeons

Location: On the host when feeding

Distribution: North America, Europe, and Central Asia

Derivation of Genus: Latin for “bug”

Transmission Route: Periodic parasite

Common Name: Bedbug

Bedbugs, *Cimex lectularius*, are the second type of hemipteran important in veterinary parasitology. Bedbugs are dorsoventrally flattened, wingless hemipterans with a three-segmented proboscis tucked under the thorax and ventral “stink glands” producing a characteristic “bedbug odor” that often infests human dwellings. They have operculated ova that are deposited on mattresses, in wall cracks and crevices, and under peeling wallpaper. They are periodic parasites, making frequent visits to the host to obtain a blood meal. Bedbugs are nocturnal feeders. They are diagnosed by the identification of wingless adult hemipterans, characteristic bedbug odor, and identification of operculated ova in the host environment. Although bedbugs are most often incriminated as human parasites, they may also be found in rabbit colonies, poultry houses, and pigeon colonies, preying on domesticated animals (Fig. 13.3). Unlike kissing bugs, bedbugs do not serve as intermediate hosts for pathogenic agents that infect humans or domestic animals.

Technician's Note

After feeding, the bedbug turns around and defecates onto the former feeding site. This act should set up a scenario for transmission of human pathogens, but the bedbug does not serve as a vector or intermediate host.

If the veterinary diagnostician suspects that reduviid bugs or bedbugs may be causing problems, the intact hemipteran



Fig. 13.3 Bedbugs are periodic parasites of rabbit colonies, poultry houses, and pigeon colonies. (From Bowman DD: *Georgis' parasitology for veterinarians*, ed 10, 2013, Elsevier.)

should be collected and stored in 10% formalin or ethyl alcohol and submitted to an entomologist for identification.

Technician's Note



The bedbug is making a comeback as a significant periodic parasite of humans. It has been found in many high-priced hotels, condominiums, and apartments in New York City.

Parasite: *Rhodnius* species, *Panstrongylus* species, and *Triatoma* species

Host: Dogs, humans, opossums, cats, guinea pigs, armadillos, rats, raccoons, and monkeys

Location of Adult: Lips and skin of the mouth when feeding (periodic parasites)

Distribution: South America, Central America, and parts of southwestern and western United States (i.e., Texas, Arizona, California, New Mexico)

Derivation of Genus: *Rhodnius*, rose; *Panstrongylus*, all round; *Triatoma*, cut into three

Transmission Route: Fly or move from host to host

Common Name: Kissing bugs

Rhodnius, *Panstrongylus*, and *Triatoma* species are known as the kissing bugs because they like to feed on **mucocutaneous** junctions, such as those between the lips and the skin of the mouth. They appear to be “kissing” the host. The adults have three body portions: head, thorax, and abdomen. These species are winged hemipterans capable of flying. They have a three-segment proboscis reflexed back (tucked) under the thorax. The ova can be found in the environment of the host but are not usually observed. Kissing bugs are periodic parasites and voracious blood-feeders. They do not reside upon the host but frequent the host to obtain a blood meal. The kissing bugs serve as intermediate hosts for *T. cruzi*, a protozoan parasite. These parasites reside in the host's environment and travel to the host to obtain their blood meal. They transmit *T. cruzi* to dogs and humans but may feed on other mammalian hosts. These other hosts may serve as reservoirs for *T. cruzi*. Humans infected with *T. cruzi* develop a disease called *Chagas disease*. Diagnosis is made by identifying the kissing bug within the host's environment, such as within the thatched roof of a hut and in cracks and crevices of mud walls.

Technician's Note



After feeding on the host's blood, the kissing bug turns around and defecates onto its former feeding site. This act sets up transmission of the infective forms of *Trypanosoma cruzi* to uninfected hosts.

Mallophaga (Chewing or Biting Lice) and Anoplura (Sucking Lice)

Lice are some of the most prolific ectoparasites of domesticated and wild animals. There are two orders of lice: **Mallophaga**, the chewing or biting lice, and **Anoplura**, the sucking lice. Lice are dorsoventrally flattened, wingless insects. As insects, lice have bodies with three divisions: (1) the head, with mouthparts and antennae; (2) the thorax, with three pairs of legs and a noticeable lack of wings; and (3) the abdomen, the portion that bears the reproductive organs. These body divisions and their relationship to each other are important in diagnostic veterinary parasitology.

Technician's Note



Lice are dorsoventrally flattened and wingless insects with three distinctive body parts: head, thorax, and abdomen.

Parasite: Mallophagan species
Host: Mammals and birds
Location of Parasite: In and among the hairs and feathers of the respective hosts
Distribution: Worldwide
Derivation of Genus: Wool eaters
Transmission Route: Animal-to-animal contact
Common Name: Chewing lice
Zoonotic: No

Members of the order Mallophaga (chewing or biting lice) are usually smaller than members of the order Anoplura (sucking lice). Mallophagans are usually yellow and have a large, rounded head. The mouthparts are mandibulate and are adapted for chewing or biting. Characteristically, the head of every chewing louse is wider than the widest portion of the thorax. On the thorax are the three pairs of legs, which may be adapted for clasping or for moving rapidly among feathers or hairs. Chewing (biting) lice may parasitize birds, dogs, cats, cattle, sheep, goats, and horses. Chewing lice of cattle and fowl include *Damalinia bovis* (Fig. 13.4), *Goniocotes gallinae* (Fig. 13.5), and *Menacanthus stramineus* (Fig. 13.6).

Technician's Note

Chewing lice are found on both birds and mammals; however, they are species specific, and there is no crossover between species of animals.

Parasite: Anopluran species
Host: Domestic animals except cats and birds
Location of Parasite: Clinging to the host's hair
Distribution: Worldwide
Derivation of Genus: Unarmed tail
Transmission Route: Animal-to-animal contact
Common Name: Sucking lice
Zoonotic: No

Members of the order Anoplura (sucking lice) are larger than chewing lice. These lice range from red to gray; the color usually depends on the amount of blood that has been ingested from the host. Anoplurans have three body portions: the head, thorax, and abdomen. The adult anoplurans are wingless. In contrast to the large-headed mallophagans, anoplurans have a head that is narrower than the widest part of the thorax. Their mouthparts are of the piercing type and are adapted for sucking. Their pincer-like claws are adapted for clinging to the host's hairs. Interestingly, although they are found on many species of domestic animals, sucking lice do not parasitize birds or cats. Sucking lice of sheep, swine, monkeys, and dogs are



Fig. 13.4 *Damalinia bovis*, the bovine-biting chewing louse.



Fig. 13.5 *Goniocotes gallinae*, the fluff louse of poultry.

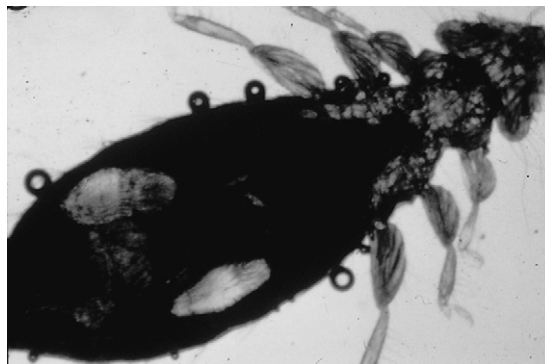


Fig. 13.6 *Menacanthus stramineus*, the avian body louse.

species specific and include, respectively, *Solenopotes capillatus* (Fig. 13.7), *Haematopinus suis* (Fig. 13.8), *Pedicinus obtusus* (Fig. 13.9), and *Linognathus setosus* (Fig. 13.10).



Fig. 13.7 Sucking louse *Solenopotes capillatus* of sheep. (From Bowman DD: *Georgis' parasitology for veterinarians*, ed 10, 2013, Elsevier.)



Fig. 13.8 Sucking louse *Haematopinus suis* of swine.

Technician's Note



Sucking lice are species specific and do not parasitize birds or cats. However, they can attach to other species to carry them from one host to another.

Anoplurans and mallophagans have a life cycle consisting of three developmental stages. The **egg stage**, which is also called a **nit**, is tiny, approximately 0.5 to 1 mm in length. Nits are oval and white and are usually found cemented to the hair or feather shaft. **Fig. 13.11** shows *L. setosus*, a gravid

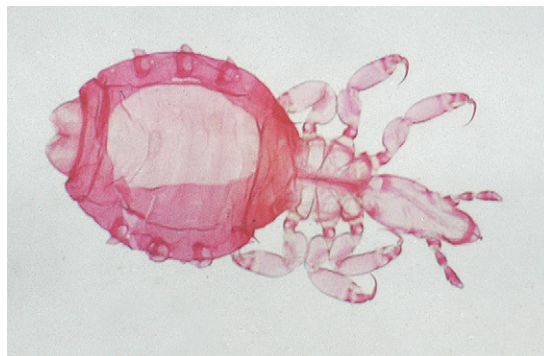


Fig. 13.9 Sucking louse *Pedicinus obtusus* of monkeys.



Fig. 13.10 Sucking louse *Linognathus setosus* of dogs.

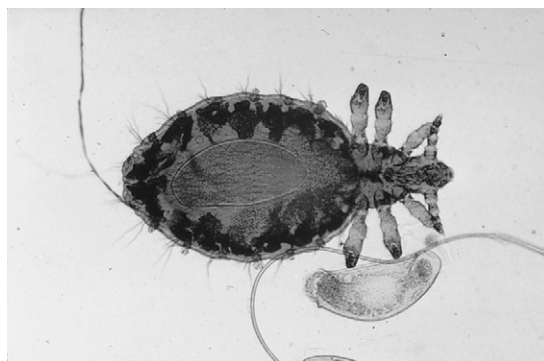


Fig. 13.11 *Linognathus setosus*. Gravid female sucking louse and associated nit on hair shaft collected from a dog. Nits are oval, white, and usually found cemented to the hair or feather shaft of the definitive host.

female sucking louse, and an associated nit collected from a dog. Nits hatch about 5 to 14 days after being laid by the adult female louse. Thousands of nits can be cemented by female lice to the hair coat of domesticated animals (**Fig. 13.12**). The **nymphal stage** is similar in appearance to the

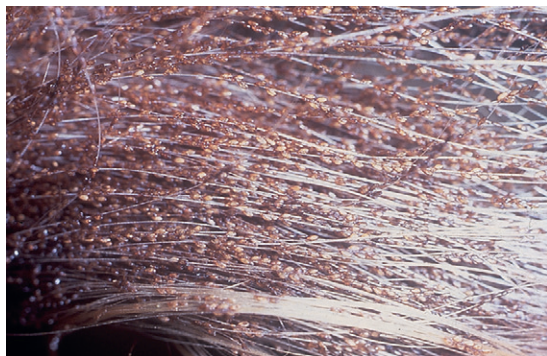


Fig. 13.12 Thousands of nits can be cemented by female lice to the hair coat of domestic animals. This calf's tail contains thousands of nits.

adult louse. However, the **nymph** is smaller and lacks functioning reproductive organs and genital openings. There are three nymphal stages, each progressively larger than its predecessor. The nymphal stage lasts from 2 to 3 weeks. The **adult stage** is similar in appearance to the nymphal stage except that it is larger and has functional reproductive organs (Fig. 13.13). The male and female lice copulate, the female louse lays eggs, and the life cycle begins again, taking 3 to 4 weeks to complete. Nymphal and adult stages may live no longer than 7 days if removed from the host. Eggs hatch within 2 to 3 weeks during warm weather but seldom hatch off the host.

Lice usually are transmitted by direct contact, but all life stages may be transmitted by **fomites**, inanimate objects such as blankets, brushes, and other grooming equipment. Lice are easily transmitted among young, old, and

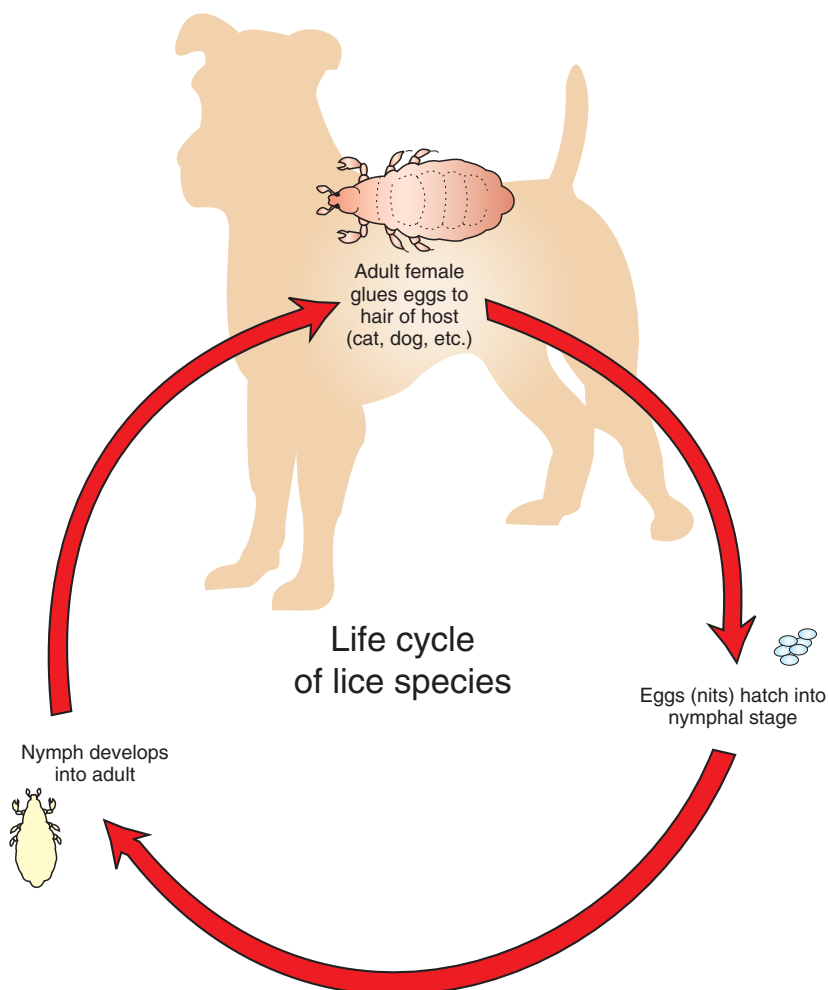


Fig. 13.13 Life cycle of the lice species.

malnourished animals. Veterinarians often cannot determine why certain animals in a flock or herd are heavily infested, whereas others have only a few lice.

Technician's Note



Sucking and chewing lice have three body portions: head, thorax, and abdomen. Chewing lice have a head that is wider than the thorax, whereas sucking lice have a head that is narrower than the thorax.

Infestation by lice (either mallophagan or anopluran) is referred to as **pediculosis** (Fig. 13.14). Sucking lice can ingest blood to such a degree that they produce severe anemia in the parasitized host; fatalities can occur, especially in young animals. The packed cell volume can decrease as much as 10% to 20%. As many as a million lice may be found on a severely infested animal. Infested animals become more susceptible to other diseases and parasites and may succumb to stresses not ordinarily pathologic to uninfested animals. When animals are poorly fed and kept in overcrowded conditions, they often become severely infested with lice and quickly become anemic and unthrifty.

Careful examination of the hair coat or feathers of infested animals easily reveals the presence of adult lice and their accompanying nits. Hair clippings also serve as a good source for collecting lice. For those animals with a thick hair coat, pediculosis may be overlooked. A handheld magnifying lens or a binocular headband magnifier (e.g., OptiVISOR) may assist in the isolation of adult or nymphal lice crawling through or clinging to hair or feathers or tiny nits cemented to individual hairs.

When lice or nits are isolated, they may be collected with tiny thumb forceps and placed within a drop of mineral oil

on a glass microscope slide. A coverslip should be placed over the specimen, and the slide should be examined using the 4× or 10× objective of the microscope (Fig. 13.15).

Identification of a louse to the genus and specific epithet is quite difficult. It is better to identify the specimen as being anopluran (sucking) versus mallophagan (chewing or biting). The veterinary diagnostician should remember that the head of every chewing louse is wider than the widest portion of its thorax. The typical sucking louse has a head that is narrower than the widest part of the thorax.

Technician's Note



Identification of lice to specific species is very difficult and should therefore be limited to identifying the louse as an anopluran or a mallophagan.

Lice of Mice, Rats, Gerbils, and Hamsters

Parasite: *Polyplax serrata*

Host: Mouse

Location of Parasite: Within hair coat

Distribution: Worldwide

Derivation of Genus: Many plates

Transmission Route: Direct contact between mice

Common Name: Mouse louse

Zoonotic: No

Polyplax serrata is the house mouse louse. This louse is an anopluran (sucking louse), with mouthparts morphologically adapted for sucking blood from its host. Anoplurans are generally more debilitating than mallophagans (chewing lice). *P. serrata* is 0.6 to 1.5 mm long. It is a slender louse, yellowish brown to white in color, with a head that is narrower than the widest part of the thorax. As with most lice,



Fig. 13.14 Pediculosis can be defined as infestation by either chewing or sucking lice; in this case, it is *Haematopinus suis* infestation in a pig.



Fig. 13.15 Appearance of operculated nits viewed with compound microscope.

P. serrata is large enough to be detected by careful visual inspection of the hair coat or by microscopic examination of pulled hairs. The adult stage of *P. serrata* is most likely found on the forebody of the mouse. Oval nits may be seen attached near the base of the hair shafts.

Clinical signs associated with infestation by *P. serrata* include restlessness, pruritus, anemia, unthrifty appearance, and death. The diagnostician should not attribute dermal signs to pediculosis unless a louse or a nit is detected. The dermal signs may be the result of other causes, such as concurrent infestation with mites. Therefore it is wise to examine an animal or hair sample thoroughly rather than ceasing when a single parasite has been identified.

Technician's Note

Clinical signs of *Polyplax serrata* include restlessness, pruritus, anemia, unthrifty appearance, and even death; however, dermal signs should not be attributed to pediculosis unless lice or nits are found.

P. serrata is transmitted by direct contact between mice. Because lice are species specific, cross-contamination of other species housed in the same area and transmission to humans are not considerations. However, *P. serrata* may serve as a vector for several rickettsial organisms and should therefore be handled with caution.

Parasite: *Polyplax spinulosa*

Host: Rat

Location of Adult: Within the hair coat

Distribution: Worldwide

Derivation of Genus: Many plates

Transmission Route: Direct animal-to-animal contact

Common Name: Rat louse

Zoonotic: No

As with *P. serrata* in the mouse, *Polyplax spinulosa* in the rat is an anopluran louse (sucking louse). *P. spinulosa* is similar to *P. serrata*, also having a narrow head compared with the thorax. Similarly, its mouthparts are adapted for sucking blood from the rat.

P. spinulosa may be detected by gross visual examination of the midbody and shoulders of the rat. Hair may be pulled from these areas and examined for nits, nymphs, and adults. Nits are often found attached to the base of the hair shafts. Nymphs resemble small, pale adult lice. Clinical signs include restlessness, pruritus, anemia, debilitation, and potentially death. Transmission of the rat louse is by direct contact. Ivermectin has been used successfully to treat lice in rodents. Because lice are species specific, transmission to other animals or humans is not a

concern. *P. spinulosa* is a vector responsible for the spread of *Haemobartonella muris* and *Rickettsia typhi* between rats. *R. typhi* also can be transmitted from infected rats to humans by rat fleas.

Technician's Note

Polyplax spinulosa is the vector of transmission for *Haemobartonella muris* and *Rickettsia typhi* in rats.

Parasite: *Hoplopleura meridionidis*

Host: Gerbil

Location of Adult: Within the hair coat

Distribution: Not found

Derivation of Genus: Unknown

Transmission Route: Direct animal-to-animal contact

Common Name: Gerbil louse

Zoonotic: No

The louse found on the common pet store gerbil is *Hoplopleura meridionidis*. It is interesting that there are no records of lice reported from either the common pet store hamster, *Cricetus*, or the common laboratory hamster, *Mesocricetus auratus*.

Technician's Note

Hoplopleura meridionidis of gerbils is similar to the lice of rats and mice.

Lice of Guinea Pigs

Parasite: *Gliricola porcelli* and *Gyropus ovalis*

Host: Guinea pig

Location of Adult: Within the hair coat

Distribution: Predominantly South and North America

Derivation of Genus: Unknown

Transmission Route: Direct animal-to-animal contact

Common Name: Guinea pig lice

Zoonotic: No

Gliricola porcelli and *Gyropus ovalis* are the lice of guinea pigs. Both species belong to the order Mallophaga (chewing lice). These lice differ from those of the order Anoplura (sucking lice) by their wide, triangular heads. Chewing lice have a strong pair of mandibles, which are used to abrade skin and obtain cutaneous fluids. *G. porcelli* and *G. ovalis* belong to the family Gyropidae, distinguished by having one or no claws on the second and third pairs of legs.

G. porcelli, the slender guinea pig louse, is 1 to 1.5 mm × 0.3 to 0.44 mm (Fig. 13.16). *G. ovalis*, as its name implies, is more oval than *G. porcelli* and measures 1 to 1.2 mm × 0.5 mm (Fig. 13.17). The head of *G. ovalis* is much broader than that of *G. porcelli*. Of these two lice, *G. porcelli* is the more common.

Guinea pig lice can be detected antemortem by careful inspection of the hair coat, either grossly or with a handheld magnifying lens. Postmortem, a method similar to that used to detect lice in other species of animals may be useful; that is, a piece of the pelt from the dead animal may be placed in a covered Petri dish and placed under a mild heat source, such as a small reading lamp. In a short time, as the pelt cools, the lice migrate toward the warmth of the lamp and to the tips of the hairs. The lice can be easily observed grossly or with a handheld magnifying lens.

Light infestations of *G. porcelli* and *G. ovalis* usually cause no clinical signs. In heavy infestations, however, alopecia

and scab-like areas may develop, especially in the areas caudal to the ears of the guinea pig. Excessive scratching may be noticed. Ivermectin can be used to treat *G. porcelli* and *G. ovalis* in guinea pigs.

Technician's Note



Diagnosis of guinea pig lice is made by finding the living parasites on the animal by using a magnifying glass.

Transmission of *G. porcelli* and *G. ovalis* is by direct contact with another host guinea pig or with bedding or other fomites from infested guinea pigs. As with other lice, lice of guinea pigs are species specific and do not cross-infest other species, including humans.

Lice of Rabbits

Parasite: *Hemodipsus ventricosus*

Host: Rabbit

Location of Adult: Within the hair coat

Distribution: Not found

Derivation of Genus: Unknown

Transmission Route: Direct animal-to-animal contact

Common Name: Rabbit louse

Zoonotic: No

Hemodipsus ventricosus is not typically found on domestic rabbits; however, when infestation does occur, it is especially debilitating. *H. ventricosus* is an anopluran louse, with a head narrower than the widest part of the thorax. Its mouthparts are specially designed for sucking blood from the host. It has a small thorax and a large rounded abdomen covered with numerous long hairs. Adult *H. ventricosus* are 1.2 to 2.5 mm long and can be observed antemortem by careful visual examination of the hair coat, especially on the dorsal and lateral aspects of the rabbit. On postmortem examination, hairs may be pulled and placed in a Petri dish under a warm lamp and examined with a dissecting microscope or magnifying glass. Adult lice are drawn by the warmth of the lamp to the tips of the hairs. The oval nits of *H. ventricosus* are 0.5 to 0.7 mm in length and may be found attached to the base of the hair shafts by pulling the fur and examining it microscopically.

Technician's Note



Hemodipsus ventricosus is not commonly found on pet rabbits but can be debilitating if it is found to infest the pet rabbit.



Fig. 13.16 *Gliricola porcelli*, the slender, commonly found guinea pig louse.

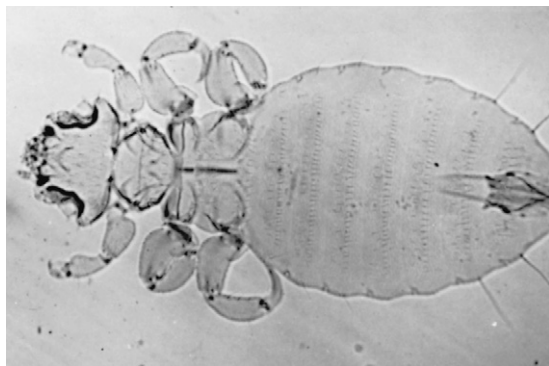


Fig. 13.17 *Gyropus ovalis* is more oval than *Gliricola porcelli*, and its head is much broader.

Clinical signs of *H. ventricosus* include alopecia and ruffled fur. Rabbit lice are avid bloodsuckers, so anemia may occur in severe infestations.

H. ventricosus is transmitted from rabbit to rabbit by prolonged direct contact. This mostly occurs between a doe and her litter. Although *H. ventricosus* is not considered zoonotic, it is a vector of *Francisella tularensis*, the etiologic agent that causes tularemia.

Diptera (Two-Winged Flies)

The order Diptera is a very large, complex order of insects. Adults, all members, have one pair of wings (two wings), thus the ordinal name **Diptera**; *di* means “two,” and *ptera* means “wing.” The members vary greatly in size, food source preference, and developmental stage or stages that parasitize animals or produce pathology. With regard to their role as ectoparasites, dipterans produce two contrasting pathologic scenarios. As adults, they may feed intermittently on vertebrate blood, saliva, tears, and mucus; as larvae, they may develop in the subcutaneous tissues or internal organs of the host. When adult dipterans make frequent visits to the vertebrate host and intermittently feed on that vertebrate host’s blood, they are referred to as *periodic parasites*. When dipteran larvae develop in the tissue or organs of vertebrate hosts, they produce a condition known as **myiasis**.

Technician’s Note

Dipteran larvae can cause a condition known as *myiasis* (maggot infestation) if they develop in the tissues or organs of vertebrate hosts.

As periodic parasites, blood-feeding dipterans can be classified in several ways according to the manner in which the adult male and female dipterans feed on vertebrate blood and their food preference. There are certain dipteran groups in which only the females feed on vertebrate blood; these female flies require vertebrate blood for laying their eggs. Included in this group are biting gnats (*Simulium*, *Lutzomyia*, and *Culicoides* spp.), the mosquitoes (*Anopheles*, *Aedes*, and *Culex* spp.), the horseflies (*Tabanus* spp.), and the deerflies (*Chrysops* spp.).

In the second group of blood-feeding dipterans, both male and female adult flies require a vertebrate blood meal. These species include *Stomoxys calcitrans*, the stable fly; *Haematobia irritans*, the horn fly; and *Melophagus ovinus*, the sheep ked.

Another dipteran fly, *Musca autumnalis*, feeds on the mucus, tears, and saliva of large animals, particularly cattle.

Technician’s Note

In some types of dipterans, the female is the only periodic parasite that feeds on vertebrate blood, whereas in other species of dipterans, both males and females feed on vertebrate blood.

Periodic Parasites of Which Only Adult Females Feed on Vertebrate Blood

In the first dipteran group of periodic parasites, only the female dipterans feed on vertebrate blood. The tiniest members of this group are the biting gnats of *Simulium*, *Lutzomyia*, and *Culicoides* species.

Parasite: *Simulium* species

Host: Domesticated animals, poultry, and humans

Location of Adults: Surface of the skin when feeding; otherwise, in the vicinity of swiftly flowing streams

Distribution: Worldwide, but not in Hawaii or New Zealand

Derivation of Genus: At the same time

Transmission Route: Fly from host to host

Common Name: Black flies or buffalo gnats

Simulium Species (Black Flies)

Members of the genus *Simulium* are commonly called **black flies**, although they may vary from gray to yellow, or **buffalo gnats** because their thorax humps over their heads, giving the appearance of a buffalo’s hump (Fig. 13.18). These are tiny flies, ranging from 1 to 6 mm in length. The adults have broad, unspotted wings that have prominent

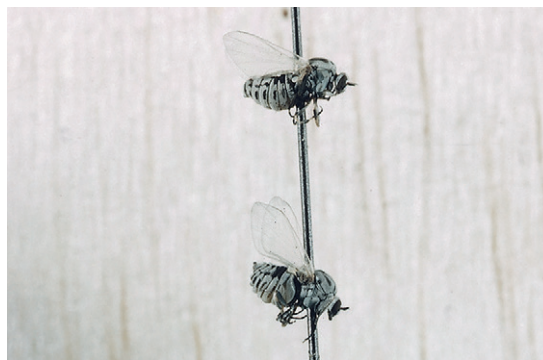


Fig. 13.18 Members of the genus *Simulium* are commonly called *black flies* (but may be gray to yellow) or *buffalo gnats* (thorax humped over the head gives the appearance of a buffalo’s hump). Note the small size compared with the straight pin that is sticking them.

veins along the anterior margins. They have serrated, scissor-like mouthparts, and thus their bites are very painful. Because the females lay eggs in well-aerated water, these flies are often found in the vicinity of swiftly flowing streams. They move in great swarms, inflicting painful bites and sucking the host's blood. These flies are voracious feeders (periodic parasites), but only the female flies feed on vertebrate blood. The males feed on nectar and pollen. The females fly great distances to find vertebrate blood. The female needs a vertebrate blood meal to lay her eggs. These flies may keep cattle from grazing or cause them to stampede. The ears, neck, head, and abdomen are favorite feeding sites. Black flies also feed on poultry and can serve as an intermediate host for a protozoan parasite known as *Leucocytozoon* species.

Technician's Note



The common name *black fly* is a misnomer; not all black flies are black. They can come in a variety of colors, from yellow to gray to black.

Black flies prefer the daylight hours and tend to be active in open air. Repellents may offer some relief from these flies. The best method of preventing infestation with black flies is by keeping the equine or bovine hosts in the barn during daylight hours.

Black flies are most often collected in the field (usually in the vicinity of their breeding sites, swiftly flowing streams) and are not found on animals presenting to a veterinary clinic. They are diagnosed by their small size, humped backs, and strong venation in the anterior region of the wings. Identification of black flies to the level of genus is probably best left to an entomologist.

Technician's Note



Black flies are usually found in the field rather than on animals presenting to a veterinary clinic.

Parasite: *Lutzomyia* species and *Phlebotomus* species

Host: Mammals of many species, reptiles, avians, and humans (*Lutzomyia* species); mammals, reptiles, avians, and humans (*Phlebotomus* species)

Location of Adult: On the skin surface when feeding; otherwise in dark, moist, and organic environments

Distribution: Worldwide (*Lutzomyia* species); tropics, subtropics, and Mediterranean regions (*Phlebotomus* species)

Derivation of Genus: *Phlebotomus*, vein cutting; *Lutzomyia*, Frank Eugene Lutz was a renowned entomologist, and *myia* means "fly"

Transmission Route: Fly from host to host

Common Name: New World sand flies (*Lutzomyia* species); sand flies (*Phlebotomus* species)

Lutzomyia Species (New World Sand Flies) and *Phlebotomus* Species

Members of the genus *Lutzomyia* are commonly referred to as **New World sand flies**. *Phlebotomus* species are commonly referred to as **sand flies**. These two genera represent the group of flies called the *phlebotomine sand flies*. They are tiny moth-like flies, rarely more than 5 mm in length. A key feature for identification is that the body (head, thorax, and abdomen) is **hirsute** (covered with fine hairs). *Lutzomyia* and *Phlebotomus* species tend to be active only at night and are weak fliers. These tiny flies transmit a zoonotic protozoan parasite known as *Leishmania* species, and the rodents that reside in the burrows in which the flies live serve as reservoirs for *Leishmania* species.

Technician's Note



Sand flies and New World sand flies are active only at night and do not fly far to get to a host.

As with black flies, sand flies most often can be collected in the field and are not found on animals presenting to a veterinary clinic. The adult flies are weak fliers and are often collected in rodent burrows, where they breed in moist organic debris. Phlebotomine sand flies can be diagnosed by their small size and hairy wings and bodies. Identification of sand flies is probably best left to an entomologist.

Technician's Note



Sand flies are diagnosed by their small size and the hairy wings on their bodies.

Parasite: *Culicoides* species

Host: Domestic animals and humans

Location of Adult: On the skin surface when feeding; otherwise in their aquatic or semiaquatic breeding grounds

Distribution: Worldwide

Derivation of Genus: Mosquito-like

Transmission Route: Fly from host to host

Common Name: No-see-ums, punkies, or sand flies (not to be confused with the phlebotomine sand flies: *Lutzomyia* and *Phlebotomus* species)

Culicoides species (No-See-Ums)

Culicoides gnats are also commonly known as **no-see-ums**, **punkies**, or **sand flies**. They are tiny gnats (1 to 3 mm in length) and similar to black flies in that they inflict painful bites and suck the blood of their hosts. The adults have a short proboscis and mottled or spotted wings with hairs on the wing margins. They are active at dusk and at dawn, especially during the summer months. The adults tend to be found around their aquatic or semiaquatic breeding grounds when not feeding. The developmental stages are primarily aquatic and are seldom observed in a veterinary clinic setting. These female gnats tend to feed on the dorsal or ventral areas of the host during dusk and evening hours; the feeding site preference depends on the species of biting gnat. Horses often become allergic to the bites of *Culicoides* species and start scratching and rubbing these areas, causing alopecia, excoriations, and thickening of the skin. This condition has several names, including **Queensland itch**, **sweat itch**, and **sweet itch**. Because this condition is often seen during the warmer months of the year, it is also referred to as **summer dermatitis**. The best prevention for these flies is stabling animals during the hours between dusk and dawn. Repellents may offer some protection against *Culicoides* species. These flies also serve as the intermediate host for *Onchocerca cervicalis*, a nematode whose microfilariae are found in the skin of horses. These flies also transmit the bluetongue virus of sheep.

Technician's Note

Several of the *Culicoides* species are intermediate hosts for protozoan and helminth parasites and can also transmit viral diseases. They are associated with the transmission of the bluetongue virus.

In contrast to the clear, heavily veined wings of black flies, the wings of *Culicoides* species are mottled. Identification of *Culicoides* species is probably best left to an entomologist.

Parasite: *Anopheles quadrimaculatus*, *Aedes aegypti*, and *Culex* species

Host: Mammals, reptiles, avians, and humans

Location of Adult: Skin surface when feeding

Distribution: Worldwide

Derivation of Genus: *Anopheles*, hurtful; *Aedes*, unpleasant; *Culex*, gnat

Transmission Route: Fly from host to host

Common Name: Malaria mosquito (*A. quadrimaculatus*), yellow fever mosquito (*A. aegypti*), and mosquito (*Culex* species)

Anopheles quadrimaculatus, Aedes aegypti, and Culex species (Mosquitoes)

Although they are tiny, fragile dipterans, mosquitoes are some of the most voracious blood-feeders (Fig. 13.19) and are strong fliers. Mosquitoes plague livestock, and as with black flies, swarms of mosquitoes have been known to keep cattle from grazing or cause them to stampede. The feeding of large swarms of mosquitoes can cause significant anemias in domestic animals. Because of their aquatic breeding environments, large numbers of mosquitoes can be produced from eggs laid in relatively small bodies of water.

Anopheles quadrimaculatus females lay their eggs on the surface of still water. Each egg possesses two lateral corrugated areas called **floats**. These floats allow the eggs of *A. quadrimaculatus* to float on the water's still surface. At the tip of the *Anopheles* larval abdomen is a breathing pore that lacks a **siphon**. The larva floats parallel to the surface of the water and wriggles in the water if disturbed. The pupa floats right at the surface of the water, and if disturbed, it will tumble down to a lower level within the water and slowly float back to the surface.

Technician's Note

The female mosquito requires a vertebrate blood meal in order to lay her eggs.

Aedes aegypti females lay their eggs on dry surfaces where water will accumulate. These eggs lack the floats of *A. quadrimaculatus*. The larval *A. aegypti* has three portions: head, thorax, and abdomen. On the tip of the abdomen is a breathing pore at the tip of the siphon. This mosquito larva floats parallel to the surface of the water and wriggles



Fig. 13.19 Female *Culex* species, one genus among several pathogenic genera of mosquitoes. Although mosquitoes are tiny, fragile dipterans, they are some of the most voracious blood-feeders known.

in the water if disturbed. As with *A. quadrimaculatus*, the *A. aegypti* pupa floats right at the surface of the water, and if disturbed, it will tumble down to a lower level within the water and slowly float back to the surface.

Technician's Note



Mosquito eggs, larvae, and pupae are associated with still water because this is where the life stages of the mosquito can be found.

Culex species females lay their eggs perpendicular to the surface of water to form a floating “egg raft.” The larval mosquito has three portions: head, thorax, and abdomen. In the tip of the abdomen is a breathing pore at the tip of the siphon. This mosquito larva floats parallel to the surface of the water and wriggles in the water if disturbed. The pupa floats right at the surface of the water, and if disturbed, it will tumble down to a lower level within the water and slowly float back to the surface.

Although they are known for spreading malaria (*Plasmodium* spp.), yellow fever, and elephantiasis in humans, mosquitoes are probably best known in veterinary medicine as intermediate hosts for the canine heartworm, *Dirofilaria immitis*.

Many of the repellents on the market are effective against mosquitoes. The repellents must be applied to the entire body at labeled frequencies to provide protection to the animal. In addition, preventing the buildup of small bodies of water on the premises (e.g., water in old tires, small puddles after rain) and cleaning water troughs frequently will help reduce the breeding grounds available to mosquitoes.

The adult and larval body of the mosquito has three portions: head, thorax, and abdomen. Adult mosquitoes have wings and body parts (head, thorax, and abdomen) covered by tiny leaf shaped scales. The adult female of the *Anopheles* species has a proboscis with long palps. The adult females of the *Aedes* species and *Culex* species have a proboscis with short palps. **Palps** are appendages found near the mouth in invertebrate organisms used for sensation, locomotion, and feeding. All females have a pilose (covered with fine hairs) antenna. Identification of both adult and larval *Anopheles*, *Aedes*, and *Culex* species is probably best left to an entomologist.

Technician's Note



Mosquitoes are capable of transmitting bacteria, viruses, spirochetes, *Chlamydia*, protozoans (e.g., *Plasmodium* species [malaria]), and helminths (e.g., *D. immitis* [heartworm]). Some of these may be zoonotic agents.

Parasite: *Chrysops* species and *Tabanus* species

Host: Large mammals and humans, but small animals and avians can be attacked

Location of Adult: Skin surface when feeding; otherwise around lakes and ponds

Distribution: Worldwide

Derivation of Genus: *Chrysops*, golden eye; *Tabanus*, gadfly

Transmission Route: Fly from host to host

Common Name: Deerflies (*Chrysops* species) and horseflies (*Tabanus* species)

Chrysops Species (Deerflies) and *Tabanus* Species (Horseflies)

Tabanus species (horseflies) are very large flies (up to 3.5 cm in length), whereas *Chrysops* species are smaller with banded wings. They both are heavy-bodied, robust, swift dipterans with powerful wings. These flies also have very large eyes. Horseflies and deerflies are the largest flies in this dipteran group in which only the females feed on vertebrate blood (Fig. 13.20). Horseflies are much larger than deerflies. Deerflies have a dark band passing from the anterior to the posterior margin of the wings.

Technician's Note



Deerflies and horseflies are the largest flies in the dipteran group and are voracious blood feeders that can consume large amounts of blood.

Adult flies lay eggs in the vicinity of open water, such as lakes and ponds. Larval stages of horseflies and deerflies are found in aquatic to semiaquatic environments, often buried



Fig. 13.20 *Tabanus* species (horseflies) are large (up to 3.5 cm in length), heavy-bodied, robust dipterans with powerful wings. Horseflies are swift, speedy dipterans. These flies have very large eyes. Horseflies are much larger than deerflies.

deep in mud at the bottom of lakes and ponds. Adults are seen in summer and prefer sunlight. The female flies feed in the vicinity of open water and have reciprocating scissor-like mouthparts, which they use to lacerate the tissues of vertebrates and lap up the oozing blood. These flies feed primarily on large animals such as cattle and horses. Site preferences include the underside of the abdomen around the navel, the legs, and the neck and withers. Horseflies and deerflies feed several times in multiple sites before becoming filled with blood. When disturbed by the animal's swatting tail or by the panniculus reflex, the flies leave the host, although blood often continues to ooze from the open wound. The bites of these flies are very painful. Cattle and horses become restless in their presence. Stabling cattle and horses during the day will help reduce the annoyance of these parasites. The newer varieties of insect repellents offer a degree of relief to those animals turned out during the day. These flies may act as mechanical transmitters of anthrax, anaplasmosis, and the virus of equine infectious anemia.

The veterinary diagnostician can probably best identify these flies by their large, scissor-like mouthparts. Species identification of intact adult horseflies and deerflies is probably best left to an entomologist.

Technician's Note

Identification is best made by observation of the large scissor-like mouthparts, whereas species identification is best left to an entomologist.

Periodic Parasites of Which Both Adult Males and Females Feed on Vertebrate Blood

In the second group of blood-feeding dipterans, both male and female adult flies require a vertebrate blood meal. These species include *Glossina* species (tsetse fly); *S. calcitrans*, the stable fly; *H. irritans*, the horn fly; and *M. ovinus*, the wingless sheep ked.

Parasite: *Glossina* species

Host: Mammals, reptiles, avians, and humans

Location of Adult: Skin surface when feeding

Distribution: Continent of Africa

Derivation of Genus: Little tongue

Transmission Route: Fly from host to host

Common Name: Tsetse fly (*tsetse* means "fly destructive to cattle" in Setswana, the language of Botswana and South Africa)

Glossina species (Tsetse Fly)

The tsetse fly, *Glossina* species, is a dipteran biting fly. The adult tsetse fly resembles a wasp or a large honeybee. This

biting fly has a bayonet-like proboscis that is designed for piercing the skin and sucking blood. Both male and female flies are avid blood feeders. There is an onion shaped bulb at the base of the proboscis. Adult dipterans are identified by their unique wing pattern (**venations**). The tsetse fly has a cleaver or hatchet cell in the middle of each wing.

These flies are unique in that they breed only once during their life cycle. The female retains the larva within her abdomen until she is ready to deposit a single larva at a time. She will produce only four to six eggs during her lifetime. The female deposits individual larvae in loose, sandy soil. The larva develops into a pupa in a short period of time. After pupation, the adults emerge from the pupal case and begin to fly. They copulate only once, and the life cycle begins again.

Technician's Note

Tsetse flies breed only once in their lifetime, and the female produces only one larva at a time.

These flies are found in fly belts (tropical) throughout the continent of Africa. They are periodic parasites; however, they serve as the intermediate host for *Trypanosoma* species, a protozoan parasite that produces both human and animal trypanosomiasis. These flies are not zoonotic because they only transmit animal trypanosomiasis between animals and human trypanosomiasis (African sleeping sickness) between humans. Animal trypanosomiasis is not transmitted to humans. Diagnosis is made by identifying the adult fly.

Technician's Note

Because tsetse flies breed only once during their lifetime, the flies can be controlled by using the sterile male release technique. Sterile males are released into the wild to compete with the intact males. The sterile males will mate with females without producing offspring.

Parasite: *Stomoxys calcitrans*

Host: A variety of animals and humans

Location of Adult: Around large animals, especially areas with large amounts of decaying vegetation

Distribution: Worldwide

Derivation of Genus: Mouth sharp

Transmission Route: Fly from host to host

Common Name: Stable fly, biting housefly, or legsticker

Stomoxys calcitrans (Stable Fly)

The **stable fly**, *Stomoxys calcitrans*, is often called the **biting housefly**. It is approximately the size and coloration of the housefly *Musca domestica*, but instead of having a sponging type of mouthpart, the stable fly has a bayonet-like proboscis that protrudes forward from its head (Fig. 13.21). These flies are found worldwide. In the United States, they are found in the central and southeastern states, areas known for raising cattle. As mentioned previously, both male and female flies are avid blood feeders, preying on most domestic animals. They usually attack the legs and ventral abdomen but also may bite the ears. These flies tend to feed on the tips of the ears of dogs with pointed or raised ears (commonly called *fly strike*), such as German Shepherd dogs. This problem can be resolved by applying topical repellents to the ear tips.

Technician's Note

Stomoxys calcitrans prefer to feed on the ear tips of dogs with erect ears, such as German Shepherd dogs.

Technician's Note

Control of the stable fly can be accomplished by removing piles of leaves, grass clippings, soiled bedding, and other decaying material from the premises to reduce the breeding areas.

S. calcitrans also feeds on horses and cattle, with horses being the preferred host. The fly usually lands on the host with its head pointed upward. It is a sedentary fly, not moving on the host. The flies inflict painful bites that puncture the skin and bleed freely. Stable flies stay on the host for short periods, during which they obtain their blood meals. This is an outdoor fly; however, in late fall and during rainy weather, it may enter barns or other enclosed areas. Topical insect repellents made for large animals work well against *S. calcitrans*. The repellents should be applied as recommended on the label for adequate protection.

Stable flies are mechanical vectors of anthrax in cattle and equine infectious anemia. This fly is the intermediate

host for *Habronema muscae*, a nematode found in the stomach of horses, and *Stephanofilaria stilesi*, a nematode found in the skin of cattle, goats, and buffalo. When large numbers of stable flies attack dairy cattle, a decrease in milk production can result. Beef cattle may refuse to graze in the daytime when attacked by large numbers of flies; as a result, these cattle do not gain the usual amount of weight.

Stable flies use decaying organic material for laying eggs. Removing piles of leaves, grass clippings, soiled bedding, and other decaying matter from the premises will reduce the stable fly breeding areas and reduce the *S. calcitrans* population. Eggs hatch and produce larvae. Each larva develops into a pupa in a short period of time. After pupation, the adult emerges from the pupal case and can fly immediately.

The veterinary diagnostician can easily identify the stable fly by its size (approximately the same size as a housefly) and the bayonet-like proboscis that protrudes forward from the head.

Parasite: *Haematobia irritans*

Host: Cattle and buffalo

Location of Adult: Clustered around the horns but can be around the shoulders, back, sides, and ventral abdomen

Distribution: North America, Europe, and Australia

Derivation of Genus: Bloody life

Transmission Route: Fly from host

Common Name: Horn fly

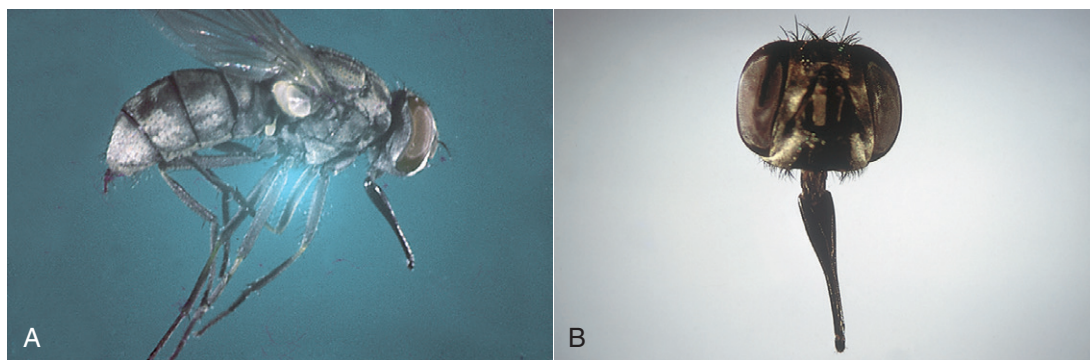


Fig. 13.21 *Stomoxys calcitrans*, the stable fly or biting housefly, is approximately the size of the housefly, *Musca domestica*. It has a bayonet-like proboscis that protrudes forward from its head.

Haematobia irritans (Horn Fly)

Hematobia irritans is often called the **horn fly**. It is a dark-colored fly, approximately 3 to 6 mm in length, half the size of *S. calcitrans*, the biting housefly. As with the stable fly, the horn fly has a bayonet-like proboscis that protrudes forward from the head (Fig. 13.22). These flies are found almost exclusively on cattle throughout North America.

When the air temperature is below 70°F, horn flies cluster around the base of the horns, thus the common name *horn fly*. In warmer climates, horn flies often cluster in large numbers on the host's shoulders, back, and sides; these are the areas least disturbed by tail swishing. On hot sunny days, horn flies often accumulate on the host's ventral abdomen. The use of insecticides effective against *H. irritans* will help reduce the horn fly population on the individual cow. This may be accomplished with a fly spray or pour-on solution. A walk-through horn fly trap will cut the individual population in half by mechanically removing the flies from the animal.

Adult horn flies spend most of their life on cattle; females leave the host to deposit their eggs in fresh cow manure. Within the "cow pie," the eggs hatch into larvae. Each larva develops into a pupa in a short period of time. At the end of the larval development, the larvae will crawl from the cow feces and pupate in loose soil. After pupation, the adult flies emerge from the pupal case and can fly immediately. The egg, larval, and pupal morphology are significant in a veterinary clinic setting for ease-of-control purposes. Disruption of the life cycle can be accomplished by spreading the cow feces so that it can dry out.

Technician's Note

Although these horn flies can be loosely classified as periodic parasites, they spend most of their adult lives on the animal until they are disrupted. Once disrupted, they fly off the host and either fly back to the same host or fly to a new host.

Using their tiny bayonet-like mouthparts, horn flies feed frequently, sucking blood and other fluids, and cause considerable irritation. Female flies are more aggressive than males. The energy lost in disturbing the feeding flies coupled with the loss of blood often results in reduced weight gain and milk production. Horn flies probably cause greater losses of cattle in the United States than any other blood-feeding fly. Adult horn flies also cause focal midline dermatitis on the ventral abdomen of horses. These flies serve as the intermediate hosts for *S. stilesi*, a filarial parasite that produces ventral plaque-like lesions on the underside of the abdomen of cattle.



Fig. 13.22 *Haematobia irritans* is approximately half the size of the stable fly, *Stomoxys calcitrans*. It also possesses a bayonet-like proboscis that protrudes forward from its head.

The veterinary diagnostician can easily identify *H. irritans* by its dark color and size (approximately half the size of a stable fly). As with the stable fly, the horn fly's bayonet-like proboscis protrudes forward from the head.

Technician's Note

Although horn flies are loosely classified as periodic parasites, they are typically found on the backs of cattle in the pasture in numbers as large as 20,000.

Parasite: *Melophagus ovinus*

Host: Sheep and goats

Location of Adult: Deep within the sheep's wool or the goat's fleece

Distribution: Worldwide

Derivation of Genus: Sheep eater

Transmission Route: Direct contact with infested animals

Common Name: Sheep ked

Melophagus ovinus (Sheep Ked)

M. ovinus is often referred to as the **sheep ked**. As mentioned earlier, members of the order Diptera usually possess one pair of wings; sheep keds are exceptions to that rule: They are wingless dipterans. Sheep keds have an unusual appearance; they are hairy and appear leathery and measure approximately 4 to 7 mm in length (Fig. 13.23). The head of this dipteran is short and broad and contains piercing (bloodsucking) mouthparts. The thorax is brown, and the abdomen is broad and grayish brown. The legs are strong and armed with stout claws (Fig. 13.24). Keds are often described as having a louse-like appearance, but they definitely are not lice.

Technician's Note

Although placed in the order Diptera, the sheep ked is a wingless dipteran that has an unusual hairy and leathery appearance.

The female sheep ked does not lay eggs but retains one larva within her abdomen until she is ready to deposit that one larva in the sheep's wool or the goat's fleece. The larvae develop into pupae quickly; the pupae are dark brown and are also found in the wool or fleece. After pupation, the adults emerge from the pupal case and can be found within the wool. The life cycle then begins again with the male and female sheep ked breeding. The entire life cycle of this dipteran takes place on the host.

Keds are permanent ectoparasites of sheep and goats. Their pupal stages are often found attached to the wool or

fleece of the host. Keds are avid blood feeders. Heavy infestations can reduce the condition of the host considerably and even cause significant anemia. The bites of *M. ovinus* cause pruritus over much of the host's body; the infested sheep often bites, scratches, and rubs itself, thus damaging the wool. Ked feces are dark brown, stain the wool, and do not wash out readily. Keds are most numerous in cold temperatures during fall and winter. Their numbers decline as temperatures rise in spring and summer. Close inspection of the wool and underlying skin reveals infestation by these wingless dipterans. Infested wool often has a dark-brown appearance because of discoloration by ked feces. Control of *M. ovinus* may be accomplished by applying an effective insecticide to the sheep after shearing.

Technician's Note

Lipoptena cervi is the ked found on deer.



Fig. 13.23 *Melophagus ovinus*, the sheep ked, is a wingless dipteran that is hairy, leathery, and approximately 4 to 7 mm in length.

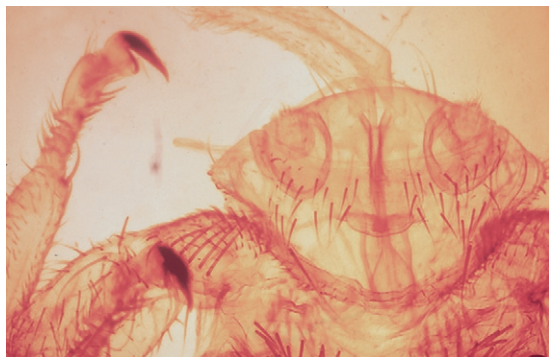


Fig. 13.24 The head of *Melophagus ovinus* is short and broad. The legs are strong and armed with stout claws. Some say keds have a louse-like appearance.

Sheep keds are closely related to the **hippoboscid flies**, winged dipterans that parasitize wild birds. These flattened, swiftly flying, blood-feeding dipterans are often found among the feathers of wild birds. Two important hippoboscid flies are *Lynchia* and *Pseudolynchia* species (Fig. 13.25). They can serve as intermediate hosts for *Haemoproteus* species, a malaria-like parasite of wild birds.

Parasite: *Lynchia* species and *Pseudolynchia* species

Host: Wild birds

Location of Adult: Deep within the feathers

Distribution: Tropical and subtropical regions

Derivation of Genus: Unknown

Transmission Route: Direct contact with infested bird

Common Name: Bird keds



Fig. 13.25 Louse flies, *Lynchia* or *Pseudolynchia* species, often parasitize wild birds.

Lynchia species and Pseudolynchia species (Bird Keds)

The bird keds are winged dipterans in that they possess one pair of wings and are strong and swift fliers. The adults have piercing (bloodsucking) mouthparts. Both males and females are avid blood feeders. The adults can be found deep within the feathers of the bird. At the end of each of the adult fly's legs is a fierce-looking claw designed to grip the feathers.

The female bird ked does not lay eggs but retains a single larva within her abdomen until she is ready to deposit it. The larvae develop into pupae very quickly. The pupae are dark brown. After pupation, adults emerge from the pupal case and can be found among the feathers. The life cycle begins again with the male and female breeding. The entire life cycle usually takes place on the host. Although transmission is usually from infested bird to uninfested bird by direct contact, the adults are strong fliers, so they can fly from host to host; thus they should be considered periodic parasites.

Technician's Note

If one is handling birds infested with bird keds, the flies may fly off the avian host and try to get in the hair of the veterinarian, technician, or presenting client.

Periodic Parasites That Feed on Mucus, Tears, and Saliva

The final periodic parasites among the dipteran flies discussed here are ones that are not blood feeders but instead feed on the mucus, tears, saliva, or feces of animals. These flies are known as *M. domestica* (housefly), *M. autumnalis* (face fly), *Calliphora* species, *Lucilia* species, *Phormia* species, *Phaenicia* species, *Sarcophaga* species, and *Hippelates* species.

Parasite: *Musca domestica*

Host: A variety of animals

Location of Adult: Within the house

Distribution: Worldwide

Derivation of Genus: Fly

Transmission Route: Fly from host to host

Common Name: Housefly

Musca domestica (Housefly)

Musca domestica, or the houseflies, are medium-sized, mouse-gray flies that have sponging mouthparts. These mouthparts cannot be used for lacerating flesh but are designed for lapping up liquid food, including secretions

from animals. These flies are "vomit-drop feeders." The adults disgorge their stomach contents, which contain digestive enzymes that liquefy their food. They have freely movable heads and are covered with tiny hair-like bristles called *setae*. Their legs have sticky footpads. These flies are "designed" for spreading pathogens.

Technician's Note

The larval stage of the housefly life cycle produces a facultative myiasis that is of great veterinary significance.

Egg and pupal morphologies of *M. domestica* are not of great veterinary significance, but larval morphology is very important in the clinic setting. The larval stage is called *facultative myiasis*. In facultative myiasis, the larval stages may be found in tissues or organs of domestic or wild animals and sometimes in humans. This is discussed more in the section Facultative Myiasis-Producing Flies.

M. domestica are **synanthropic** (living with humans), meaning they are house-invading flies. Houseflies fly freely from feces to food and can transmit a variety of pathogens to animals and humans. The identification of the adult flies is best left to a trained entomologist.

Technician's Note

Houseflies are efficiently designed for spreading pathogens.

Parasite: *Musca autumnalis*

Host: Cattle predominately

Location of Adult: Feeding around the medial canthus of the eye

Distribution: Worldwide

Derivation of Genus: Fly

Transmission Route: Fly from host to host

Common Name: Face fly

Musca autumnalis (Face Fly)

Face flies, *Musca autumnalis*, are so named because they gather around the eyes and muzzle of livestock, particularly cattle. They may also be found on the withers, neck, brisket, and sides. Face flies feed mostly on saliva, tears, and mucus. They usually are not considered blood feeders because their mouthparts are not piercing or bayonet-like. Instead, their mouthparts are adapted for sponging up saliva, tears, and mucus (Fig. 13.26). These flies often follow flies that feed on blood, disturb them during their feeding process, then lap up the blood and

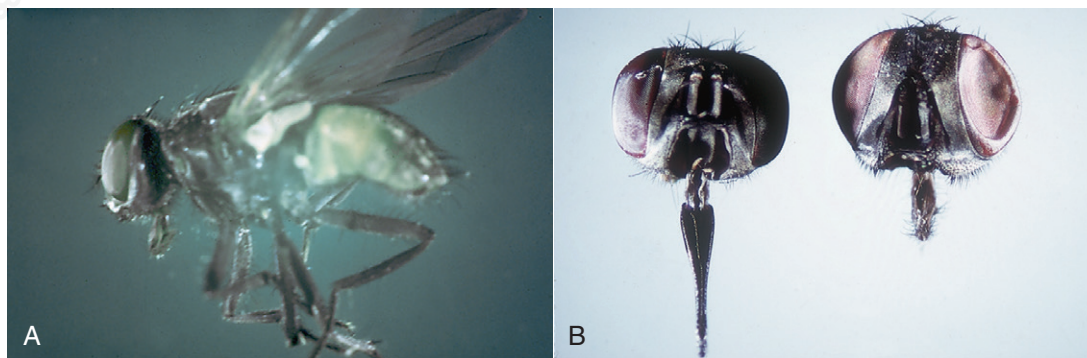


Fig. 13.26 **A**, *Musca autumnalis*, the face fly. These flies gather around the eyes and muzzle of livestock, particularly cattle. Their mouthparts are adapted for sponging up saliva, tears, and mucus. **B**, Left, *Stomoxys calcitrans*; right, *Musca autumnalis*.

body fluids that ooze and accumulate on the host's skin. Face flies are found on animals that are outdoors; they usually will not follow animals into barns or other enclosures.

Face flies produce considerable pathology because of their annoyance of the host. The irritation around the host's eyes stimulates the flow of tears, which attracts more flies. The flies' activity produces annoyance, which ultimately interferes with the host's productivity. Face flies may be vectors in the transmission of *Moraxella bovis*, a bacterium that causes infectious keratoconjunctivitis, or pinkeye, in cattle. Face flies may be controlled with the application of an insecticide to the animal's body to offer a degree of relief. Spraying potential breeding sites with insecticide will help reduce fly populations. The eggs are laid in fresh cow feces, whereas the larval and pupal stages can be found in the soil surrounding dried cow feces.

Technician's Note

The face fly is a great annoyance to the host and is a vector for transmitting *Moraxella bovis*, the etiologic agent for infectious bovine keratoconjunctivitis.

Grossly, the face fly is morphologically similar to the housefly, *M. domestica*. These two species in the genus *Musca* can be differentiated only through minor differences in eye position and color of the abdomen. The veterinary diagnostician should probably not attempt to speciate this fly; speciation requires the skills of a trained entomologist. Rather, the veterinary diagnostician should remember this rule of thumb: If a fly with sponging mouthparts is found around the face of a cow or horse, it is most probably a face fly.

Technician's Note

A symbiotic relationship between two organisms of different species in which a smaller organism (*Moraxella bovis*) is carried about by a larger organism (*Musca autumnalis*) is called *phoresis*. The relationship between *M. autumnalis* and *M. bovis* is an excellent example of phoresis.

Parasite: *Calliphora* species, *Lucilia* species, *Phormia* species, and *Phaenicia* species

Host: Domestic animals, wild animals, and humans

Location of Adult: Free-living with humans

Distribution: Australia, England, and North America (*Calliphora*); worldwide (*Lucilia*, *Phormia*, and *Phaenicia* species)

Derivation of Genus: *Calliphora*, beauty-bearing; *Lucilia*, light

Transmission Route: Fly from feces to food

Common Name: Bottle flies or blowflies

Calliphora species, Lucilia species, Phormia species, and Phaenicia species

These dipteran species are collectively known as the *bottle flies* or *blowflies*. These flies are medium sized, shiny, and iridescent (blue, black, and green resembling the color of glass bottles, hence the name *bottle flies*), with sponging mouthparts. The mouthparts cannot be used for lacerating flesh but are designed for lapping up liquid food. These flies are vomit-drop feeders. The adult flies disgorge their stomach contents, which contain digestive enzymes that liquefy their food. They have freely movable heads and are covered with tiny hair-like bristles called *setae*. Their legs have sticky footpads. These flies are designed for spreading pathogens.

The egg and pupal stages of the life cycle are not of great veterinary significance. However, the morphology of the larval stage is very important in the clinical scenario called *facultative myiasis*. In facultative myiasis, the larval stages of these flies may be found in the tissues or organs of domestic or wild animals and sometimes human beings. This is discussed further in the section *Calliphora*, *Lucilia*, *Phormia*, and *Phaenicia* Species—Larval Stages.

Technician's Note



Bottle flies or blowflies are important in veterinary parasitology as facultative myiasis-producing flies.

Like the houseflies, the bottle flies or blowflies are synanthropic (living with humans), meaning they are house-invading flies. The bottle flies or blowflies fly freely from feces to food, transmitting a variety of pathogens. These pathogens are spread by the host eating the infected food on which the flies have disgorged their stomach contents. Thus they can spread a variety of zoonotic pathogens.

Technician's Note



Some of the larvae of some species of bottle flies or blowflies are classified as surgical maggots because their larvae have been purposefully introduced into infected wounds of both animals and humans to facilitate the healing process.

Parasite: *Sarcophaga* species

Host: Domestic animals, wild animals, and humans

Location of Adult: Free-flying in the environment

Distribution: North America and Hawaii

Derivation: Flesh eater

Transmission Route: Fly from feces to food

Common Name: Flesh fly

Sarcophaga species (Flesh Fly)

Sarcophaga species are known as the flesh flies. They are medium- to large-sized flies possessing a striped thorax and a checkerboard abdomen. They possess sponging mouthparts that cannot be used for lacerating flesh but instead are designed for lapping up liquid food. These flies are vomit-drop feeders. The adult flies disgorge their stomach contents, which contain digestive enzymes that liquefy their food. They have freely movable heads and are covered with setae. Their legs have sticky footpads. These flies are designed for spreading pathogens.

The female fly retains her eggs within her abdomen. These flies do not lay eggs but instead deposit first-stage larvae in

feces, carrion, or contaminated wounds. The pupal stage is not of great veterinary significance; however, the larval stage is very important in the clinical scenario called *facultative myiasis*. In facultative myiasis, the larval stages of these flies may be found in tissues or organs of domestic and wild animals and sometimes in humans. This is discussed more in the section *Sarcophaga* Species—Larval Stage.

Adult flesh flies fly freely from feces to food and (like houseflies, bottle flies, and blowflies) are efficiently designed for transmitting a variety of pathogens, some of which are zoonotic.

Technician's Note



Speciation of flesh flies should be left to an entomologist.

Parasite: *Liohippелates* species (formerly *Hippelates*) species

Host: Bovines and canines

Location of Adult: On or about mucocutaneous junctions of the eyes, lips, and teats of cattle and the penis of the dog

Distribution: North and South America

Derivation of Genus: Unknown

Transmission Route: Fly from host to host

Common Name: Dog penis gnats

Liohippелates species

Liohippелates species of dipterans are known as dog penis gnats because of their proximity to the glans penis of the male dog. These are tiny, nonbiting gnats (not to be confused with the biting gnats *Simulium*, *Phlebotomus*, *Lutzomyia*, or *Culicoides* species). Instead of the lacerating mouthparts possessed by the biting gnats, these nonbiting gnats have sponging mouthparts very similar to those of the housefly, *M. domestica*. These flies are found in locations on or about the mucocutaneous junctions around the eyes, lips, and teats of cattle and around the penis of the male dog. These flies are irritating to the host. They feed on moisture associated with the mucocutaneous junctions.

Technician's Note



Dog penis gnats are often found in the proximity of the glans penis of the male dog, hence the common name, *dog penis gnats*.

Myiasis-Producing Flies

With regard to their roles as ectoparasites, larval dipterans may develop in the subcutaneous tissues of the skin

of many domestic animals. When dipteran larvae develop in the tissues or organs of vertebrate hosts, these larvae produce a condition known as *myiasis*. Depending on the degree of host dependence, there are two types of myiasis: (1) facultative myiasis, in which the fly larvae are usually **free-living**, and (2) obligatory myiasis. In **facultative myiasis**, the normally free-living larvae adapt themselves to a parasitic dependence on a host. In **obligatory myiasis**, the fly larvae are completely parasitic; that is, they are dependent on the host during development throughout the life cycle. In other words, without the host, the obligatory parasites will die.

Technician's Note



Free-living fly larvae can become adapted to being parasitic and being dependent on a host to survive to the next stage of their life cycle.

Dipteran Fly Larvae That Infest the Skin

Facultative Myiasis—Producing Flies. The dipteran larvae capable of producing facultative myiasis in the skin are *M. domestica*, the housefly; *Calliphora*, *Phaenicia*, *Lucilia*, and *Phormia* species, the blowflies or bottle flies; and *Sarcophaga* species, the flesh flies. The larval stages of these flies are usually associated with skin wounds contaminated with bacteria or with a matted hair coat contaminated with feces.

Under normal conditions, adult flies of these genera lay their eggs in decaying animal carcasses or in feces. In facultative myiasis, the adult flies are attracted to an animal's moist wound, skin lesion, or soiled hair coat. These sites provide the adult fly with moist media on which to feed. As adult female flies feed in these sites, they lay eggs. The eggs hatch, producing larvae (maggots), which move independently about the wound surface, ingesting dead cells, exudate, secretions, and debris but not live tissue. This condition is known as **fly strike** or **strike**. These larvae irritate, injure, and kill successive layers of skin and produce exudates. Maggots can tunnel through the thinned epidermis into the subcutis. This process produces tissue cavities in the skin that measure up to several centimeters in diameter (Fig. 13.27). Unless the process is halted by appropriate therapy, the infested animal may die of shock, intoxication, histolysis, or infection. A peculiar, distinct, pungent odor permeates the infested tissue and the affected animal. Advanced lesions may contain thousands of maggots. It is important to remember that as adults, these flies can be pestiferous in a veterinary clinical setting. These flies are vomit-drop feeders and fly from

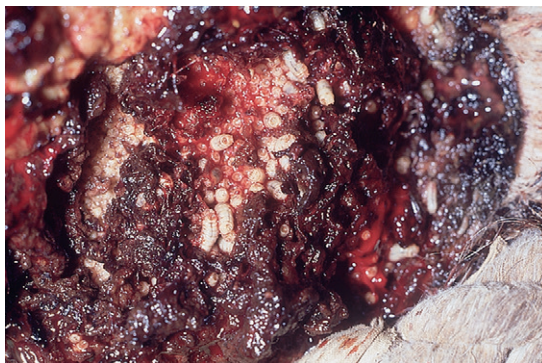


Fig. 13.27 Fly strike in a Hereford cow. The fly larvae (maggots) move independently about the wound surface, ingesting dead cells, exudate, secretions, and debris but not live tissue. This condition is known as *fly strike* or *strike*.

feces to food, spreading bacteria on their feet and within their disgorged stomach contents.

Technician's Note



A facultative myiasis fly can lay eggs in the moist wound, skin lesion, or soiled hair coat of an animal or human. These eggs then hatch and produce a maggot infestation in that area.

A tentative diagnosis of maggot infestation in any domestic animal can easily be made by a veterinary diagnostician because maggots can be observed in an existing wound or among the soiled, matted hair coat. A specific diagnosis can be made by examining the **spiracular plate** on the posterior end of the fly maggot. Each species of fly maggot has its own distinctive spiracular plate, much like a fingerprint (Fig. 13.28). Dichotomous keys are available for identifying the specific spiracular plate of each species. As soon as a diagnosis of facultative myiasis has been made, the veterinary diagnostician must rule out the possibility of obligatory myiasis caused by *Cochliomyia hominivorax*.

Technician's Note



Maggot infestation is easily diagnosed by a veterinarian because the maggots can be observed in an existing wound or around the soiled and matted hair coat.

The larval stages of *Calliphora*, *Lucilia*, *Phormia*, *Phaenicia*, and *Sarcophaga* species are very recognizable by the owner



Fig. 13.28 Diagnostic spiracular plates on the posterior end of a fly maggot. This plate can be used for positive identification of the fly maggot.

or the veterinarian. The typical larva is fusiform (bullet shaped). On its anterior end is a pair of hooks that are used to assist the larva in crawling about the contaminated wound surface. *Sarcophaga* species deposit larvae rather than eggs into contaminated wounds (particularly skin wounds) of warm-blooded animals so that the larvae can live a “parasitic existence”; thus, they are considered facultative parasites. Wounds are not absolutely necessary for the laying of eggs because flies can lay their eggs in the pelage (hair coat) that is contaminated with urine or feces. Bottle fly or blowfly larvae can be differentiated from that of *C. hominivorax* by the absence of the two deeply pigmented (black), parallel tracheal tubes on the dorsal posterior third of the third-stage larva of *C. hominivorax*.

Technician's Note

There are some species of bottle flies or blowflies that produce larvae that *only* ingest unhealthy tissues (tissues contaminated with pathogenic species of bacteria). These species are referred to as *surgical maggots*.

Obligatory Myiasis–Producing Flies. The dipteran larvae capable of producing obligatory myiasis in the skin are *C. hominivorax*, *Cuterebra* species, and *Hypoderma* species. In obligatory myiasis, the dipteran larvae lead a parasitic existence.

Parasite: *Cochliomyia hominivorax*

Host: Domestic animals

Location of Larva: Fresh, uncontaminated wounds of warm-blooded animals

Distribution: North America

Derivation of Genus: Screw fly

Transmission Route: Fly from host to host

Common Name: Screwworm, primary screwworm, or New World screwworm

***Cochliomyia hominivorax*.** Only one fly in North America, *C. hominivorax*, is a primary invader of fresh, uncontaminated skin wounds of domestic animals. These larvae must not be confused with the larvae of the facultative myiasis–producing flies just described. *C. hominivorax* is often referred to as the **screwworm fly**. In economic terms, it is the most important of the flies that attack livestock in the southwestern and southern United States. These are nonbiting muscoid flies. Adult female flies are attracted to fresh skin wounds (such as recent surgical sites or recent lacerations) on warm-blooded animals, where they lay batches of 15 to 500 eggs in a shingle-like pattern at the edge of the wounds. The female fly lays several thousand eggs during her lifetime. The cream-colored, elongated eggs hatch within 24 hours. Larvae enter the wound, where they feed for 4 to 7 days before they become third-stage (fully grown) larvae. The veterinarian *must* be able to identify the third-stage larvae of this obligatory myiasis–producing fly. The third-stage larvae are segmented, with each segment being emphasized by the presence of rows of tiny, backward-facing black spines along the segment, giving the larvae the appearance of a spiraling wood screw. These larvae can be as long as 1.5 cm; at this stage they resemble a wood screw, thus the name *screwworm*. The third larval stage is *unique* in its appearance. It possesses two deeply pigmented (black), parallel tracheal tubes on the dorsal posterior third of the third-stage larva (Fig. 13.29). When fully grown, the larvae drop to the ground, after which the adult flies emerge.



Fig. 13.29 Larvae of *Cochliomyia hominivorax* can be identified by the wood-screw shape and two deeply pigmented tracheal tubes on the dorsal aspect of the caudal ends of the third larval stage.

The adult male and female flies breed only once during their lifetime, a key fact that is used to control these flies biologically. Adult screwworm flies are shiny and greenish blue, with a reddish-orange head and eyes, and are 8 to 15 mm long.

Technician's Note



Identification of the distinct third-stage larva is used to diagnose this stage of *Cochliomyia hominivorax*. It has been eradicated from the United States. Unique features include the characteristic wood-screw shape and the presence of two deeply pigmented, parallel tracheal tubes at the dorsal posterior third stage of the larva.

Because of the obligatory nature of the screwworm with regard to breeding in the fresh wounds of warm-blooded animals, the veterinary diagnostician must report the parasite to both state and federal authorities. *C. hominivorax* had been eradicated from the United States. A resurgence occurred in Florida in the Key deer population in 2016 but was eradicated in 2017. Local areas of infestation can occur from animals imported into the United States. Although *C. hominivorax* is not a true zoonotic parasite, it can develop in any warm-blooded animal, including humans.

CASE PRESENTATION 13-1

Setting Up the Scenario

You have just earned a much-needed vacation after working all year at your small animal veterinary clinic. You have decided to make the most of your time off by vacationing in the Florida Keys for an entire week. Days are spent taking tours of Key West, Florida, with a couple of days set aside for scuba diving excursions. One evening about halfway through the week, you are resting in your motel room and are watching the 11:00PM local news out of Miami. A reporter has traveled all of the way down to the tip of the Keys to do a report on imported cases of the New World screwworm, *Cochliomyia hominivorax*, in the endangered Key deer population at the Key Deer Refuge on Florida's Big Pine Key. From your veterinary studies, you fully understand that screwworms can seriously affect the livestock industry. This industry is worth over \$2.5 billion in Florida alone and must be protected. To show his concern, the reporter uses a blown-up stock photograph of the anterior end of a third-stage larva of *C. hominivorax*. The reporter announces to his television audience that this tiny little maggot is "public enemy number one" to the Florida livestock industry. In addition to livestock, pets and even humans can become infected with this tiny maggot, he notes, "so everyone

should be very wary of the presence of maggots in skin lesions in our country." You are concerned that there may be other genera of nonpathogenic fly larvae found in the skin of livestock, pets, and humans. You are also concerned that the reporter did not show the viewing audience the exact morphologic features used to identify third-stage larvae of *C. hominivorax*.

What Information Must the Veterinary Technician Convey to the Television News Reporter?

There are other species of fly larvae that may be found infecting mammalian or avian tissues. There are two types of maggots that can be identified from these skin wounds. These include the very common house fly (*M. domestica*), the blowfly/bottle fly/flesh fly species (*Calliphora*, *Phaenicia*, *Lucilia*, *Formia*), and flesh fly (*Sarcophaga*) species. These flies are referred to as *secondary myiasis-producing flies*. These flies infect wounds that are contaminated, that is, older wounds that are infected with bacteria. Infestations with these flies can occur throughout the summer months and are observed quite often during the warmer months of the year. They are diagnosed by examining the unique fingerprint "pattern" of the spiracular plates (breathing pores) at the flat, posterior end of the infesting maggot. Morphologic dichotomous keys are used to identify these species exactly. Adult flies of *C. hominivorax* are much easier to diagnose. They are referred to as *primary myiasis-producing flies* and are reportable. These economically important flies infect wounds that are fresh and uncontaminated, that is, newer, uninfected wounds. Infestations with these flies can also occur throughout the summer months and are also observed quite often during the warmer months of the year. They are diagnosed by examining the unique morphologic characteristics of this screwworm fly's third-stage larvae. These highly infective third-stage fly larvae are identified by observing the deeply pigmented tracheal tubes on the posterior (rear) dorsal (top) of the third-stage larval maggot. If these fly larvae are identified from any warm-blooded animal, they must be immediately reported to the U.S. Department of Agriculture (USDA) and to state veterinary offices for the initiation of governmental control programs such as the sterile male release technique.

Technician's Note



Cochliomyia hominivorax was once present in most of the United States and Canada; however, it has been eradicated from these portions of North America. Because these flies breed only once in their lifetime, they can be controlled using the sterile male release technique.

Parasite: *Cuterebra* species

Host: Rabbits, squirrels, mice, rats, chipmunks, occasionally dogs and cats

Location of Larva: Areas around the head and neck

Distribution: North America

Derivation of Genus: Skin borer

Transmission Route: Direct contact with first-stage larvae

Common Name: Warbles or wolves

Cuterebra. Larvae of the genus *Cuterebra* (commonly called **wolves** or **warbles**) infest the skin of rabbits, squirrels, mice, rats, chipmunks, and occasionally dogs and cats. The adult flies look almost exactly like bumblebees. Ova are never observed on the animal. A large discrepancy exists concerning the morphologic descriptions of larval *Cuterebra*. Most of the specimens recovered in a clinical setting are of the second-stage or third-stage larvae. Second-stage larvae are grub-like, 5 to 10 mm long, and cream to grayish white; this stage is often sparsely covered with tiny, black, tooth-like spines. Third-stage larvae are large, robust, and coal black, with a heavily spined appearance; they are up to 3 cm in length. Larval stages are usually found in swollen, cyst-like subcutaneous sites, with a fistula (pore or hole) communicating to the outside environment (Fig. 13.30). It is through this pore that the larval *Cuterebra* breathes.

Adult flies lay eggs near the entrance to rodent burrows. Pets usually contract this parasite while investigating or seeking out rodent prey. As a result, the most frequently affected cutaneous sites in dogs and cats are the subcutaneous tissues of the neck and head. Most cases occur during the late summer and early fall. Among the myiasis-producing flies, this dipteran larva is known for its aberrant or erratic migrations, having been found in a variety of extracutaneous sites, such as the cranial vault, the anterior chamber of the eye, the nose, and the pharyngeal regions. Clinical signs vary with the site of infection or infestation. Larval *Cuterebra* species are often discovered in cutaneous sites during physical examination. They are usually removed surgically by enlarging the breathing pore and removing the larva with thumb forceps. Great care must be taken not to crush the larva during the extraction process because anaphylaxis may result.

Cuterebrosis is diagnosed by observing the characteristic swollen, cyst-like subcutaneous lesion with its fistula or central pore that communicates to the outside environment. Second-stage or third-stage larvae are usually removed from these cutaneous lesions. These larvae are usually covered with tiny black spines (Fig. 13.31).



Fig. 13.30 Larval *Cuterebra* species are usually found in swollen, cyst-like subcutaneous sites, with a fistula (pore or hole) communicating to the outside environment. The larva breathes through the pore.



Fig. 13.31 Different developmental stages of *Cuterebra* species. Larval *Cuterebra* are either sparsely or thickly covered with tiny black spines.

Technician's Note



Cuterebra species should be removed carefully; great care must be taken not to crush the larva during extraction to avoid a possible anaphylactic reaction in the host.

Parasite: *Hypoderma* species

Host: Cattle and, in rare instances, horses, sheep, and humans

Location of Larva: In large boil-like cysts in the back of the cow

Distribution: Northern and southern United States and Canada

Derivation of Genus: Under the skin

Transmission Route: Adult female flies from host to host
Common Name: Gadflies (adults) and cattle grubs (larvae)

Hypoderma species (Ox Warbles). Two larval species of *Hypoderma* flies (**ox warbles** or **cattle grubs**) infect cattle: *Hypoderma lineatum* and *Hypoderma bovis*. *H. lineatum* is found in the southern United States, and both species are found in the northern United States and Canada. The adult flies are heavy and resemble honeybees; they are often called **heel flies**. These adult flies have very primitive mouthparts, so they are not capable of biting the cow; however, they do produce much annoyance for the cow.

The entire life cycle is almost a year long. Adult flies are bothersome to cattle as they approach to lay eggs. Animals often become apprehensive and disturbed and attempt to escape this pesky fly by running away, an action called **gadding**. At the end of the adult female's abdomen, there is an ovipositor, which she uses to deposit her eggs on the hairs of the cow's leg. The eggs are about 1 mm long and white and are attached to hairs on the legs of cattle. *H. lineatum* deposits a row of six or more eggs on an individual hair shaft; *H. bovis* lays its eggs singly on the hair shaft. The larvae hatch in about 4 days and crawl down the hair shaft to the skin, which they penetrate. The larvae wander through the subcutaneous connective tissues in the leg, migrating through the esophagus (*H. lineatum*) or the region of the spinal canal and epidural fat (*H. bovis*) until they reach the subcutaneous tissues of the back. Here the larvae create breathing holes in the skin of the dorsum; it is through these pores that they later exit and fall to the ground to pupate. The adult flies emerge from the pupae.

Technician's Note



Hypoderma species produce pathology both as an adult (in the form of annoyance and gadding) and as a larval stage (within boil-like cysts in the skin of the back of the cow). If systemic insecticides are used while the larvae are migrating through the spinal cord or esophagus, limb paralysis or bloat may result.

Adult *Hypoderma* species are bee-like and are covered with yellow to orange hairs. Mature larvae are 25 to 30 mm long, cream to dark brown, and covered with small spines. Lesions consist of large, cyst-like swellings on the back, with a central breathing pore (Fig. 13.32). As with *Cuterebra* species, great care must be taken not to crush the *Hypoderma* larva during the extraction process because anaphylaxis may result.

Dipteran Fly Larvae That Infect the Gastrointestinal Tract

Parasite: *Gasterophilus* species
Host: Horses and donkeys

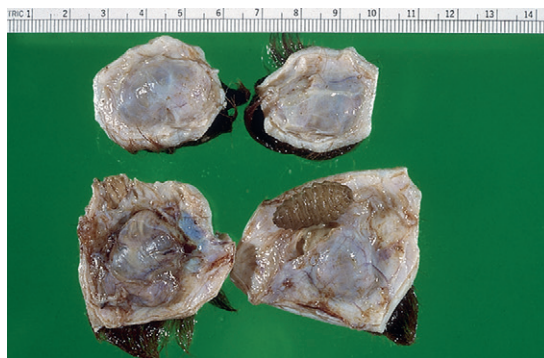


Fig. 13.32 Mature larvae of *Hypoderma* species are 25 to 30 mm long, cream to dark brown, and covered with small spines. Lesions consist of large cyst-like swellings on the back, with a central breathing pore.

Location of Larva: Attached to horse's gastric mucosa

Distribution: Worldwide

Derivation of Genus: Stomach loving

Transmission Route: The adult female lays eggs on the horse's leg, the horse grooms itself, and the larvae hatch and penetrate the mucosa

Common Name: Bot flies (adults), horse bots (larvae)

Gasterophilus species (**horse bots** or **stomach bots**) have three developmental stages that may be associated with pathology in the horse. Just as adult *Hypoderma* species are annoying to the host, adult *Gasterophilus* species are similarly annoying. These adult flies resemble honeybees. The adult flies have very primitive mouthparts; thus, they are not able to bite the horse. During late summer and early fall, adult females fly around the fetlocks of the forelegs and the chin and shoulders of the horse to oviposit eggs on the hairs in these regions (Fig. 13.33). This fly's activity and the accompanying oviposition cause extreme annoyance to the host. Some horses will panic because of the egg-laying activity of these flies. The bot fly eggs are small and white. The female fly "glues" each egg individually to single hairs on the leg of the horse (or appropriate location). Within each egg is a tiny fly larva (first-stage larva), which is ringed by several rows of backward-facing spines. Once the eggs have been laid on the hairs, the horses lick themselves. The abrasive tongue and accompanying saliva are a stimulus for the larvae to hatch from the eggs (Fig. 13.34). The larvae penetrate the mucosa of the lips, tongue, and buccal cavity and migrate through the oral mucosa. They eventually emerge and migrate to the cardiac portion of the stomach, where they remain attached for 10 to 12 months. The larvae measure up to 20 mm in length, are red to brown, and possess dense spines on the anterior border of each body



Fig. 13.33 Numerous eggs cemented to the forelimb of a horse.



Fig. 13.34 Individual eggs of *Gasterophilus* species cemented by an adult female fly to the hairs on a horse's leg.

segment. There is a pair of indistinct mouth hooks (organs of attachment) on the anterior end of the first body segment and a spiracular plate on the posterior end. These larvae usually pass out of the host in the spring (Fig. 13.35) and pupate on the ground for 3 to 5 weeks. The adult flies emerge from the pupal case and live during the latter half of the summer. The larval stage of the *Gasterophilus* species can be treated with dichlorvos, trichlorfon, or ivermectin dewormers in the fall and spring seasons. A bot knife may be used on the legs of the animal to remove the eggs before they are able to infect the animal.

Technician's Note

Gasterophilus species produces pathology as both an adult (annoyance) and as a larva (attachment to gastric mucosa).



Fig. 13.35 The final larval stage of *Gasterophilus* species is often found within the feces of the equine host. Note the presence of anterior hooks with the larva attached to the gastric mucosa.

The veterinary diagnostician should be able to identify the annoying adult female flies seen around the horse in the fall. The telltale egg stages contain tiny larvae, and the dark-brown bots pass out with the feces. It is through the feces that the third larval stage exits the gastrointestinal tract; therefore this parasitic stage may be recovered in horse feces.

Dipteran Fly Larvae That Infect the Respiratory Tract

Parasite: *Oestrus ovis*

Host: Sheep and goats

Location of Larva: Nasal passages

Distribution: Worldwide

Derivation of Genus: Gadfly

Transmission Route: Adult female flies from host to host and lays larvae in the nares

Common Name: Nasal bot fly (adult); grub (larvae)

Technician's Note

How does a bot fly get a name that sounds like a portion of a female's reproductive cycle? It was once believed that when women were undergoing the estrus phase of their menstrual cycle, they would "act irrationally" or become "hysterical." When sheep are plagued by the adult nasal bot fly, they run about madly, hence the name *Oestrus ovis*.

Oestrus ovis (Nasal Bots).

Oestrus ovis (nasal bots or nasal bot flies) produce a respiratory myiasis in sheep. The adults are bee-like flies and, like both *Hypoderma* and *Gasterophilus* species, are quite annoying to the sheep or goat. The adult female fly flies into the area of the nostrils, where she deposits a tiny first-stage larva. This causes a great deal of annoyance, resulting in the



Fig. 13.36 Several larval stages of *Oestrus ovis* extracted from the nasal passages of sheep.

sheep or goat keeping its nostrils very close to the ground as an avoidance mechanism. This tiny white to yellow larva crawls upward into the nostrils and sinuses of the sheep or goat, often producing a purulent rhinitis or sinusitis. The larvae grow rapidly into 3-cm, dark-brown larvae with large black oral hooks (Fig. 13.36). When fully developed, the larvae drop out of the nostrils and pupate in the ground; the adults then emerge from the pupae. Ivermectin has been shown to be very effective against *O. ovis*.

The veterinary diagnostician should be able to identify the large dark-brown bots as they pass out of the nostrils.

Technician's Note



Occasionally the larvae of *Oestrus ovis* wander aberrantly and get into the host's cranial vault, producing neurologic abnormalities. This neurologic condition is referred to as *false gid*.

Siphonaptera (Fleas)

Of all the orders of arthropods discussed thus far, members of the order Siphonaptera, or fleas, are perhaps the most important insect with respect to veterinary economics. Treating for fleas can be a veterinary practice builder. Because of the extreme popularity of dogs and cats and the prolific nature of the flea (and thus its ability to return after populations are exterminated on the animal and within the animal's environment), the veterinarian should pay special attention to diagnosing the various life-cycle stages of fleas both on the pet and in the pet's environment (Fig. 13.37).

Parasite: ♦ *Ctenocephalides felis*, *Ctenocephalides canis*, *Cediopsylla simplex*, *Odontopsylla multispinosus*, and *Echidnophaga gallinacea*



Fig. 13.37 Life stages of *Ctenocephalides felis*, the cat flea: adult males and females, eggs, larvae, and pupae.

Host: Cats and dogs (*C. felis*), dogs (*C. canis*), rabbits (*C. simplex*), rabbits (*O. multispinosus*), and poultry but will feed on dogs and cats (*E. gallinacea*)

Location of Adult: On the skin

Distribution: Worldwide

Derivation of Genus: Cockle or comb-like head (*Ctenocephalides*); monster eater (*Echidnophaga*)

Transmission Route: Host-to-host contact and contact with infested environment

Common Name: Cat flea, dog flea, common Eastern rabbit flea, giant Eastern rabbit flea, and poultry flea, respectively

Zoonotic: Yes, adults will bite humans for a blood meal but will not infest humans as they do animals

Fleas, or **siphonapterans**, are small (4 to 9 mm in length), laterally compressed, wingless insects with powerful hind legs that are used for jumping onto hosts. Their "flatness" allows them to run through the pelage (hair coat). Adult fleas have piercing and sucking (siphon-like) mouthparts that are used to suck the blood of their hosts (Fig. 13.38). Adult female fleas are usually larger than male fleas. The adult flea has three body components: the head, the thorax, and the abdomen. They also have three pairs of legs, with the posterior pair being larger than the first two pairs. It is this posterior pair of legs that allows fleas to jump great distances. More than 2000 species of fleas have been identified throughout the world. Adult fleas are always parasitic, feeding on both mammals and birds (Fig. 13.39). Dogs and cats are host to comparatively few species of fleas.

Technician's Note



Adult fleas are able to jump great distances with their very powerful rear legs.



Fig. 13.38 Mouthparts of *Echidnophaga gallinacea*, the sticktight flea of poultry. Adult fleas are placed in the order Siphonaptera because they possess piercing-sucking (siphon-like) mouthparts used to suck the host's blood.

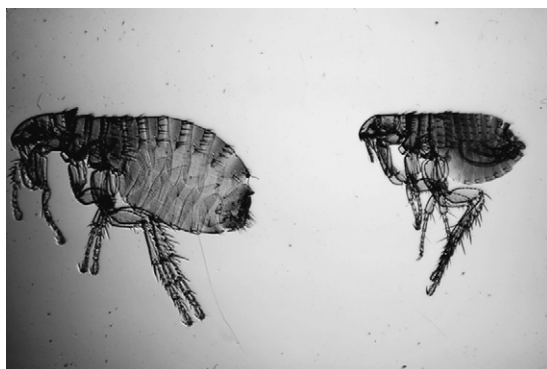


Fig. 13.39 Morphologic details of the adult male (right) and female *Ctenocephalides felis* (left), cat fleas. Note the penis rods of the male and the spermatheca of the female.

The flea life cycle consists of four stages: (1) adult stage, (2) egg stage, (3) larval stage, and (4) pupal stage. The female flea can lay up to several thousand eggs in her lifetime. The eggs may be laid on the infested animal or in the environment. Eggs laid on the animal will drop to the ground or bedding. The eggs are very small and resemble tiny pearls. Typical flea eggs are smooth, white, and oval. They are not sticky, so they will fall off the host and be found in the host's environment. The eggs hatch into larvae within 2 weeks. Flea larvae are maggot-like in appearance and sparsely covered in hairs. The larvae eat organic debris (e.g., dead skin, dead hair, flea feces) from the environment. The larva begins to form a cocoon as it passes into the pupal stage. The pupal stage is carried out entirely within the cocoon and can last for months. The cocoon keeps the pupa from desiccating over long periods (Fig. 13.40). The flea pupae are seldom observed by the client or

veterinarian. The flea pupa has a loosely spun cocoon that is very sticky—so sticky that environmental debris such as sand and dust adheres to the pupa. Flea eggs, larvae, and pupae are found in the host's environment, from the pet's bedding to the owner's bed—any site to which the infested pet has access. The flea emerges from the pupal stage only if environmental signs (air pressure, vibrations, warmth) indicate a host is present. The adult flea can survive only up to 1 week without a blood meal. Once emerged, the adult flea will find a host, take a blood meal, and begin the life cycle again.

Ctenocephalides felis, the cat flea, is the most common flea found on dogs and cats. The dog flea, *Ctenocephalides canis*, is uncommon and occurs much less frequently on dogs than does the cat flea.

When flea infestation is suspected in domestic rabbits, a complete physical examination of the rabbit hair coat should be performed because different species of fleas prefer different areas of the body surface. *Cediopsylla simplex*, the **common eastern rabbit flea**, is often found around the face and neck of domestic rabbits. *Odontopsylla multispinosus*, the **giant eastern rabbit flea**, is often found over the "tail-head" region at the base of the tail of domestic rabbits (when they curl up in sleep with the head close to the tail).

Echidnophaga gallinacea is also known as the **sticktight flea of poultry** (Fig. 13.41; see also Fig. 13.38). A common flea of chickens and guinea fowl, *E. gallinacea* also feeds on dogs and cats. This flea has unique feeding habits. The female flea inserts her mouthparts into the skin of the host and remains attached at that site. On first observation, these specimens resemble attached ticks; however, they are indeed fleas. *E. gallinacea* prefer to attach and feed around the eyes and ears of dogs and cats. Because these fleas are usually associated with farm environments, the egg, larval, and pupal stages are rarely observed. However, these stages would be exactly the same as those corresponding to the same stages of *C. felis*.

Fleas are not typically found on either horses or ruminants. In barns where "barn cats" abound and excessive straw is present, large numbers of fleas have been found on calves. Under these conditions, fleas can produce significant anemias in young calves. *Pulex irritans*, the flea of humans, has been recovered from dogs and cats, especially in the southeastern United States.

Technician's Note



Cat and dog fleas will get on human hosts and bite them. Certain species of fleas are also capable of transmitting zoonotic disease (e.g., *Yersinia pestis*, the bacterium that causes bubonic plague, is transmitted from rats to humans by fleas).

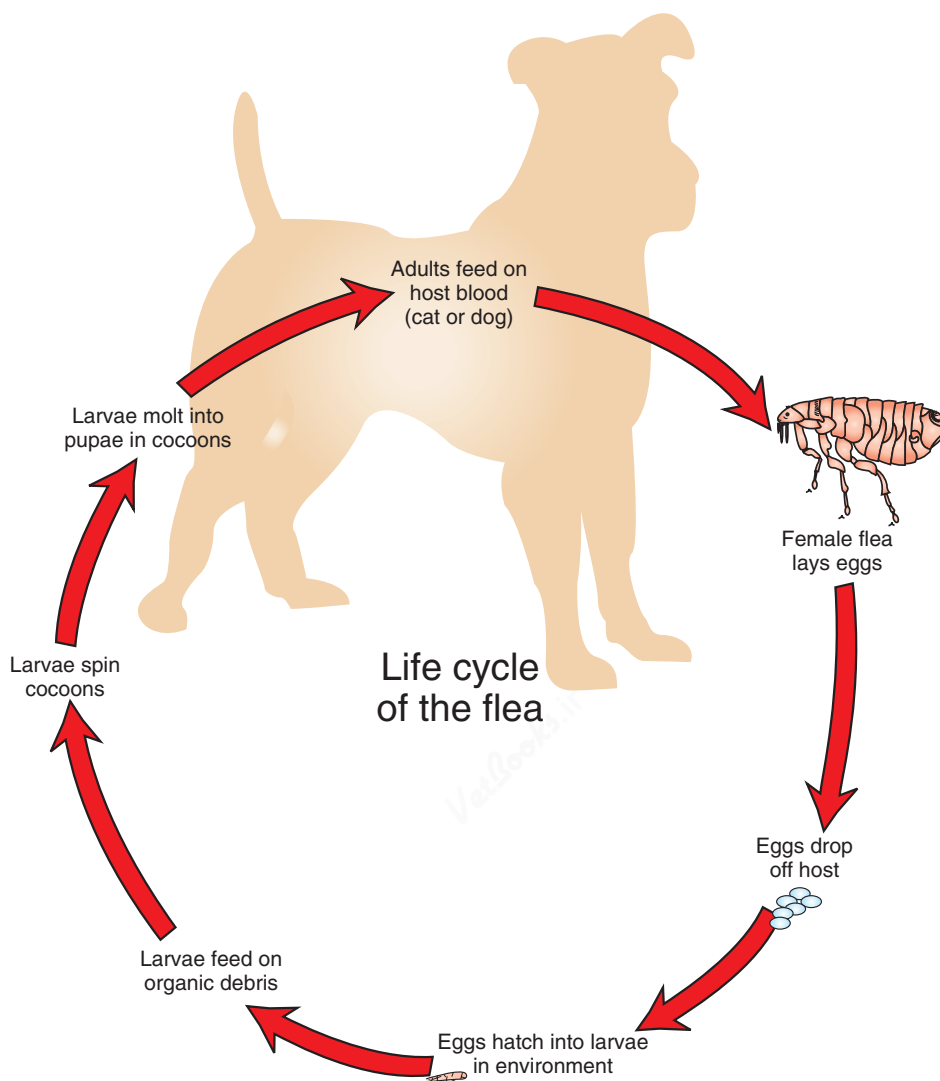


Fig. 13.40 Life cycle of the flea.

Although the adult flea is the life-cycle stage most often encountered, the veterinary diagnostician may also be presented with flea eggs or with larval fleas from the pet's environment. Flea eggs and larvae are frequently found in the owner's bedclothes, the pet's bedding, travel carriers, dog-houses, and clinic cages. Flea eggs resemble tiny pearls; they are nonsticky, 0.5 mm long, white, oval, and rounded at both ends (Fig. 13.42). Flea larvae resemble tiny fly maggots; they are 2 to 5 mm long, white (after feeding they become brown), and sparsely covered with hairs (Figs. 13.43 and 13.44).

Adult fleas are usually encountered on the animal but may also be collected in the pet's environment. Observed

on recovery from the pet, the larger fleas with an abdomen that is orange to light brown are females; the smaller, darker specimens are males.

Because adult fleas spend most of their time on the host, diagnosis of flea infestation or **siphonapterosis** is usually obvious. However, in animals with flea allergy dermatitis, fleas may be so few on the pet that the diagnosis of flea infestation is quite difficult.

Definitive diagnosis of a flea infestation requires demonstration of the adult fleas and/or their droppings (flea dirt, flea feces, or flea frass) (Fig. 13.45). Flea dirt can be used to diagnose current or recent infestations of fleas. Fleas can be

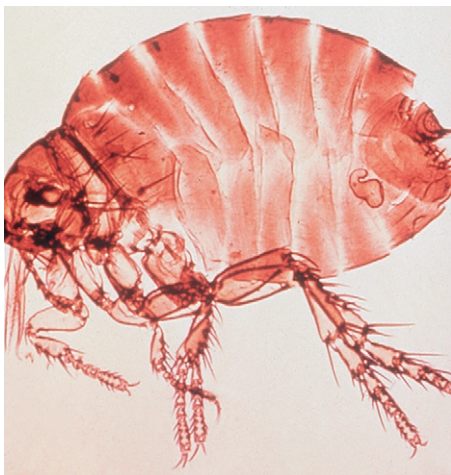


Fig. 13.41 Adult *Echidnophaga gallinacea*, the sticktight flea of poultry. Note the angular profile. A common flea of chickens and guinea fowl, it also feeds on dogs and cats.

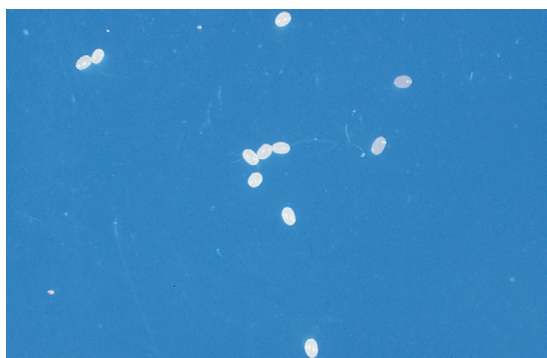


Fig. 13.42 Eggs of *Ctenocephalides felis*, the cat flea. Flea eggs resemble tiny pearls; they are nonsticky, 0.5 mm long, white, oval, and rounded at both ends.

easily collected by spraying the pet with an insecticide. After a few minutes, dead fleas drop off the animal. Alternatively, fleas may be collected using a fine-toothed flea comb, available from any veterinary supply company or pet store.

Technician's Note

Flea infestation on a dog with flea allergy dermatitis can be difficult to diagnose because there may be only a few fleas on this type of allergic dog.



Fig. 13.43 Larva of *Ctenocephalides felis*, the cat flea. Flea larvae resemble tiny fly maggots; they are 2 to 5 mm long, white (after feeding, they become brown), and sparsely covered with hairs.

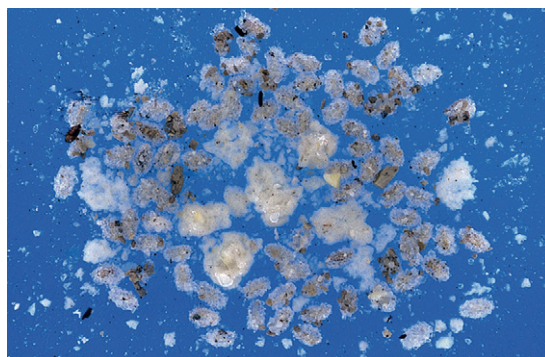


Fig. 13.44 Sand-covered pupae of *Ctenocephalides felis*, the cat flea.

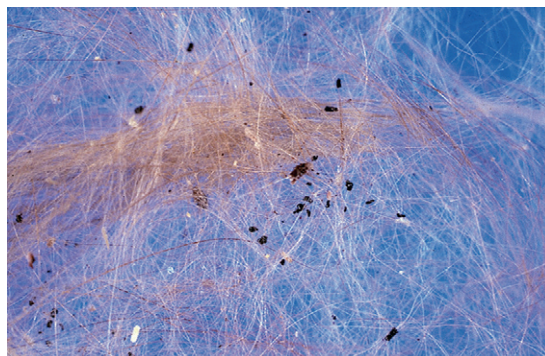


Fig. 13.45 Flea dirt (flea feces or flea frass) of *Ctenocephalides felis*, the cat flea. Flea dirt can be used to diagnose current or recent infestations by fleas. If water is slowly dropped onto flea dirt on a gauze sponge, the flea dirt will reconstitute to the host's blood.

Adult fleas defecate large quantities of partially digested blood, commonly called **flea dirt** or **flea frass**. These feces are reddish black and can appear as fine pepper-like specks, comma shaped columns, or long coils. To collect a sample of flea dirt, the diagnostician must comb the pet with a flea comb and place the collected debris on a white paper towel moistened with water. Rubbing the flea dirt with a fingertip causes the flea dirt to dissolve, producing a characteristic blood-red or rust-red color.

Flea control is important because fleas not only cause discomfort and irritation to the pet but also serve as intermediate hosts to certain helminth parasites. Fleas serve as intermediate hosts for *Dipylidium caninum*, the double-pored tapeworm of dogs and cats, and for *Acanthocheilonema reconditum*, the filarial parasite that resides in the subcutaneous tissues of dogs. Some types of fleas can also transmit diseases such as bubonic plague and endemic typhus to humans.

Technician's Note



The sale of flea-control products for dogs and cats can be a practice builder in a veterinary clinic; however, many of these products are sold over the counter in pet stores.

Flea control makes up a large part of pet care costs in the United States. There are many different types and styles of flea prevention products on the market. Flea prevention should encompass three different areas to ensure proper control: (1) the yard, (2) the house, and (3) the animal. The yard is the major source of initial flea infestation. A good-quality yard spray approved for fleas will reduce the flea population in the outside environment, thus reducing the chances of the pet bringing new adult fleas into the home. The house is a major source of animal reinfestation. Once the adult fleas breed and the female lays eggs, the eggs are present in the house. The pupae that result from the life cycle of the flea remain in the house and hatch as adults to reinfest the pet. Several types of products are available for use in the house, including foggers, sprays, and powders. Each of these products may incorporate an **adulticide** to kill the adult fleas and an **insect growth regulator** (IGR) to prevent the other life stages from developing to maturity. Although many products can be used to treat the yard and home, great improvements have been made in products for animal application. There are daily or weekly sprays and powders available. However, the greatest advancements include once-a-month applications. Topical products such as Frontline, Top Spot, Advantage, Advantix, and Advantage Multi can be applied once a month, are resistant to water, and contain an adulticide or an adulticide and IGR. Other products such as Program and Sentinel (which also contains heartworm prevention) contain IGR and are given

monthly in pill form to dogs. Program can also be given as a 6-month injection to cats. Capstar can be given to dogs and cats orally for the treatment of adult fleas over a 24-hour period; however, there is no residual activity after 36 hours. There are also products such as Bravecto that can be given once every 3 months and Seresto collars that are good for up to 8 months. Regardless of the product used, all three forms of flea prevention (yard, house, animal) should be used for proper control of the flea population.

CASE PRESENTATION 13-2 SETTING UP THE SCENARIO

Ms. Leonard brought in her 10-year-old spayed female Bichon Frise, Betsy, for hair loss and scratching. The technician got Betsy's weight, temperature, and flea comb analysis. The technician found live adult fleas on the flea comb and noted the finding in the patient record. After the examination, the technician was asked to discuss fleas with Ms. Leonard.

What Information Must the Veterinary Technician Convey to Ms. Leonard?

"Ms. Leonard, Betsy has fleas. Fleas will make Betsy itch, so she scratches, and the more she scratches, the more likely it is that she will scratch out her hair. Because Betsy has fleas, it means there are fleas in your house. Betsy most likely picked up the fleas outside, where the eggs were dropped by wild animals such as raccoons. The eggs developed through several stages (larva and pupa) to become adults that then jumped on Betsy. Once Betsy was infected, she brought the adult fleas into your house. The fleas mated and produced eggs that have fallen off Betsy and onto the carpets, bedding, and furniture in your house.

"Fleas can be difficult to control once they infest the house, so we need to get a handle on this problem. I see you have another dog and two cats. Part of flea control will be using a flea prevention product on all of your pets. We have several very good options that we recommend." The technician then discussed the products recommended by the clinic.

"In addition to treating all of your pets, you will also need to treat your house. The best way is to vacuum each room and then throw the used vacuum cleaner bag into the outdoor garbage after spraying with a flea spray to kill the adults in the bag. This will reduce the eggs, larvae, and pupae in the carpets. You will then need to treat each room (carpets and furniture) with a flea product."

The technician explained the products recommended by the clinic.

"Finally, because wild animals tend to spread the eggs as they pass through your yard, you should also treat it with a yard and kennel spray. The areas to concentrate on are the shaded areas of the yard. Do you have any questions?"

The technician noted the discussion in the patient record.

Technician's Note

Once-a-month flea preventatives have undergone great advances and make client compliance with flea preventative use much higher than it was in the past.

Mites and Ticks

Kingdom: Animalia

Phylum: Arthropoda (arthropods)

Subphylum: Chelicerata (possess chelicerate mouthparts)

Class: Acarina (mites and ticks)

Because mites and ticks belong to the class Acarina, any infestation of domestic animals by either mites or ticks is referred to as **acariasis**. The four developmental stages in the typical life cycle of the mite or tick are (1) the egg stage, (2) the six-legged larval stage, (3) the eight-legged nymphal stage, and (4) the eight-legged adult stage.

Mites of Veterinary Importance

The first group of parasitic mites can be classified as **sarcoptiform mites**. As sarcoptiform mites, they have the following key features in common:

1. These mites can produce severe dermatologic problems in a variety of domestic animals. This dermatitis is usually accompanied by a severe pruritus, or itching.
2. Typically, sarcoptiform mites are tiny mites barely visible to the naked eye, approximately the size of a grain of salt.
3. In silhouette, the bodies of sarcoptiform mites have a round to oval shape.
4. Sarcoptiform mites have legs that have **pedicels**, or **stalks**, at the tips. The pedicels may be long or short. If the pedicel is long, it may be straight (unjointed) or jointed. At the tip of each pedicel, there may be a tiny sucker. Veterinary diagnosticians should use the description of the pedicel (long or short, jointed or unjointed) to identify sarcoptiform mites.

Technician's Note

Sarcoptiform mites can cause severe dermatologic problems in a variety of domestic animals and even humans.

Sarcoptiform mites can be broken down into two basic families: the **Sarcoptidae** family, sarcoptiform mites that

burrow or tunnel within the epidermis, and the **Psoroptidae** family, sarcoptiform mites that reside on the surface of the skin or within the external ear canal. Sarcoptidae includes *Sarcoptes*, *Notoedres*, *Cnemidocoptes*, and *Trixacarus* species. Psoroptidae includes *Psoroptes*, *Chorioptes*, and *Otodectes* species.

Technician's Note

Sarcoptiform mites are broken down into two families: Sarcoptidae mites that burrow or tunnel within the epidermis and Psoroptidae mites that reside on the surface of the skin or within the external ear canal.

Family Sarcoptidae (Mites)

Members of the family Sarcoptidae burrow or tunnel within the epidermis of the infested definitive host. The entire four-stage life cycle is spent on the host. Male and female mites breed on the skin surface. The female mite penetrates the keratinized layers of the skin and burrows or tunnels through the epidermis. Over a 10- to 15-day period, she deposits 40 to 50 eggs within the tunnel. After egg deposition, the female dies. Six-legged larvae emerge from the eggs in 3 to 10 days and exit the tunnel to wander on the skin surface. These larvae molt to the eight-legged nymphal stage within tiny pockets in the epidermis. Nymphs become sexually active adults in 12 to 17 days, and the life cycle begins again.

Sarcoptes scabiei (Scabies Mite)

The disease caused by *Sarcoptes scabiei* is called **scabies**, or **sarcoptic acariasis**. Sarcoptic acariasis is extremely pruritic. *Sarcoptes* species exhibit host specificity. For example, *S. scabiei* variety *canis* affects only dogs, and *S. scabiei* variety *suis* affects only pigs. Almost every domestic animal has its own distinct variety of this mite, which does not infest other hosts.

Technician's Note

Sarcoptes scabiei species are species specific; however, *S. scabiei* variety *canis* can cause a self-limiting infestation in humans, so it is considered zoonotic. *S. scabiei* variety *hominis* is the human sarcoptic mite that causes scabies in humans.

Parasite: ♦ *Sarcoptes scabiei* variety *canis*

Host: Canines

Location of Adult: Tunneling in the superficial layers of the epidermis for the majority of their life cycle; for a short period of their life cycle, can be found on the skin surface

Distribution: Worldwide

Derivation of Genus: Flesh cutters

Transmission Route: Direct contact from host to host

Common Name: Scabies mite of the dog

Zoonotic: Yes

Canine scabies is caused by *S. scabiei* variety *canis*, which produces lesions consisting of an erythematous, papular rash. Scaling, crusting, and excoriations are common. The ears, lateral elbows, and ventral abdomen are sites that are likely to harbor mites. The animal's entire body, however, may be infested. The eight-legged adult mite has a unique silhouette—an oval shape. Each leg possesses a sucker (much like the “cup” of a plumber's plunger) on the ends of some of its legs. If present, the sucker is connected to the legs by a pedicel. The condition of the pedicel (long or short; jointed or unjointed) assists in speciating or identifying the Sarcoptiform mites. *S. scabiei* has long, unjointed pedicels. The anus of the adult *S. scabiei* is terminal, not dorsal. These mites are spread by direct contact or by combs and brushes containing mites and/or their eggs and can affect all dogs in the household. For only a short period of their life cycle, these mites are found on the skin surface. For most of their life cycle, however, they may be found tunneling in the superficial layers of the epidermis. *S. scabiei* variety *canis* is extremely contagious. The dog owner can become infested with this mite, but the disease is self-limiting. The mites burrow into the skin of humans, producing a papule-like lesion; however, the mites will not establish a full-blown infestation in humans. Therefore *S. scabiei* variety *canis* is considered to be zoonotic. Some dogs may be asymptomatic carriers of *S. scabiei* variety *canis*.

Technician's Note



Sarcoptes scabiei variety *canis* is extremely contagious, and dogs can be asymptomatic carriers of the mite.

Superficial skin scrapings (to the extent that a bit of capillary blood is drawn) are used to diagnose this mite. Impression smears on glass slides can also be used. The skin scrapings or impression smears are viewed microscopically for the developmental stages of mites (egg, larva, nymph, adult).

Parasite: ♦ *Sarcoptes scabiei* variety *felis*

Parasite: *S. scabiei* variety *suis*, *bovis*, *equi*, and *ovis*

Host: Feline (*felis*), pigs (*suis*), cattle (*bovis*), horses (*equi*), and sheep and goats (*ovis*)

Location of Adult: For most of its life cycle, it is found tunneling in the superficial layers of the epidermis. For a short period of its life cycle, it is found on the surface of the skin.

Distribution: Worldwide

Derivation of Genus: Flesh cutters

Transmission Route: Direct contact from host to host

Common Name: Scabies mite of cats, scabies mite of pigs, scabies mite of cattle, scabies mite of horses, and scabies mite of sheep and goats, respectively

Zoonotic: Yes for *S. scabiei* variety *felis*

Cats also are parasitized by a variety of this mite, *Sarcoptes scabiei* variety *felis*. Feline scabies caused by this variety is an extremely rare condition.

Among large animals, pigs are most often affected by scabies. Lesions caused by *S. scabiei* variety *suis* include small red papules, alopecia, and crusts, most frequently on the trunk and ears. Scabies in cattle (*S. scabiei* variety *bovis*) is rare. The main areas of infestation are the head, neck, and shoulders. Scabies in horses (*S. scabiei* variety *equi*) is an even rarer entity. The main area of infestation is the neck. *S. scabiei* variety *ovis* affects the face of sheep and goats rather than the fleece.

Areas with an erythematous, papular rash and crust should be scraped, especially the areas most associated with sarcoptic infestation in dogs, that is, the ears, lateral elbows, and ventral abdomen. Adult sarcoptic mites are oval and approximately 200 to 400 μm in diameter, with eight legs. The key morphologic feature used to identify this species is the long, unjointed pedicel with a sucker on the end of some of the legs. The anus is located on the caudal end of the body (Fig. 13.46). The eggs of *Sarcoptes* mites are oval (Fig. 13.47).

S. scabiei can be treated with selamectin and moxidectin/imidacloprid (labeled for treatment); currently, afoxolaners and surolaners are also used off-label.

Parasite: ♦ *Notoedres cati*

Host: Felines and occasionally rabbits

Location of Adult: For most of its life cycle, the adult is found tunneling in the superficial layers of the epidermis, but for a short period of its life cycle, it can be found on the surface of the skin around the ear pinna, face, neck, and feet of the cat

Distribution: Worldwide

Derivation of Genus: Back (referring to the dorsal anus)

Transmission Route: Direct contact from host to host

Common Name: Notoedric mange mite of cats or feline scabies mite

Zoonotic: Yes (per American Association of Veterinary Parasitologists)

Notoedres cati (Feline Scabies Mite) and Notoedres muris

Although cats may be parasitized by *S. scabiei* variety *felis*, the mite most often associated with feline scabies is *Notoedres cati*. This mite infests mainly cats but occasionally

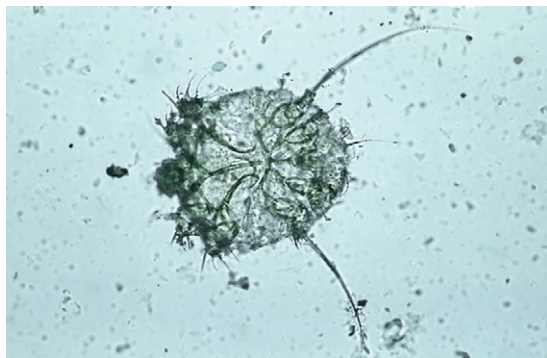


Fig. 13.46 Adult *Sarcoptes scabiei* mite. The anus is located on the caudal end of the body.

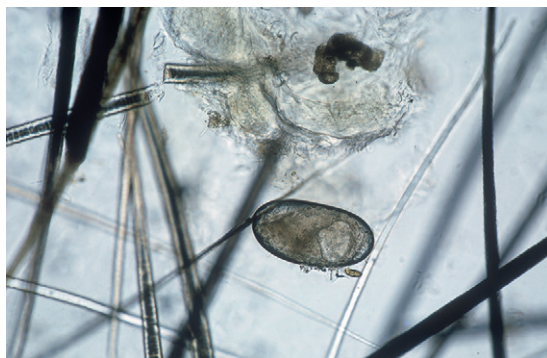


Fig. 13.47 Oval eggs of *Sarcoptes scabiei*. Note the emergence of the six-legged larval mite.

parasitizes rabbits. This sarcoptiform mite is found chiefly on the ears, back of the neck, face, and feet; in extreme cases, however, the entire body may be affected. This mite is almost identical to the mite *S. scabiei* except for the position of the anus. The anus in *S. scabiei* is terminal, whereas the anus in *N. cati* is dorsal. Like *S. scabiei*, *N. cati* has long, unjointed pedicels. The life cycle is similar to that of *S. scabiei*, with the mite burrowing or tunneling in the superficial layers of the epidermis and with only a short period of the life cycle being spent on the surface of the skin. The characteristic lesion of notoedric acariasis is a yellowing crust in the region of the ears, face, or neck.

Technician's Note

Notoedres cati parasitize the cat but can occasionally infest the rabbit. It is found mainly around the ear pinna, back of the neck, face, and feet but can affect the entire body in extreme cases.

Superficial skin scrapings (with a bit of capillary blood being drawn) and impression smears can be used to microscopically diagnose this mite of the cat. Diagnosis is made by identifying the developmental stages of the mite life cycle (egg, larva, nymph, and adult). Notoedric mites are easier to demonstrate in cats than are sarcoptic mites in dogs. Again, likely infestation sites should be scraped. As with *Sarcoptes* species, *Notoedres* mites have a long, unjointed pedicel with a sucker on the end of some of the legs. Adult notoedric mites are similar to sarcoptic mites but are smaller, with a dorsal subterminal anus. The eggs of notoedric mites are oval. *N. cati* can be transmitted to humans, where it causes pruritic papules. Therefore it is a zoonotic parasite.

Technician's Note

Notoedres cati is easier to demonstrate on cats with a skin scraping or impression smears than *Sarcoptes scabiei* is in the dog.

N. cati mites are treated with ivermectin. The best prevention is avoiding contact between infected cats and uninfected cats.

Parasite: *Notoedres muris*

Host: Rats

Location of Adult: Most of the life cycle is spent tunneling in the superficial epidermis, with only a short period being spent on the skin surface

Distribution: Worldwide

Derivation of Genus: Back (referring to the dorsal anus)

Transmission Route: Direct contact from host to host

Common Name: Scabies mite of rats

Zoonotic: No

A related species, *Notoedres muris*, produces otic acariasis in rats (Fig. 13.48). This mite resembles *S. scabiei*, with a rounded body and suckers on the first two pairs of legs of female mites and on the first, second, and fourth pairs of legs of male mites. Female *N. muris* can be distinguished from female *S. scabiei* by the dorsal subterminal anal opening of *N. muris*. The anal opening of *S. scabiei* is terminal (Fig. 13.49).

The burrowing mite *N. muris* usually can be detected and diagnosed before and after death by collecting deep skin scrapings from the edges of suspected lesions. Lesions are usually on the unfurred parts of the body, such as the ear pinnae, tail, nose, and extremities. Lesions appear as crusted areas with reddened vesicles. *N. muris* is quite common in wild rodents. Transmission is by direct contact, so owners should be cautioned to keep pet rats safely away from wild rodent contact. This mite is also known to infest guinea pigs, but it does not infest humans.

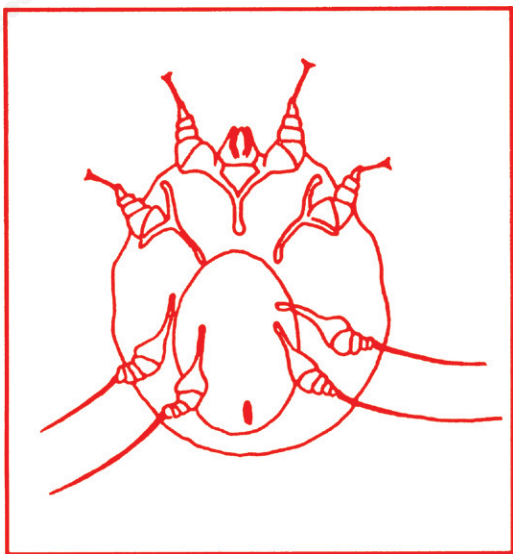


Fig. 13.48 Drawing of the female *Notoedres muris* showing the dorsal subterminal anal opening.

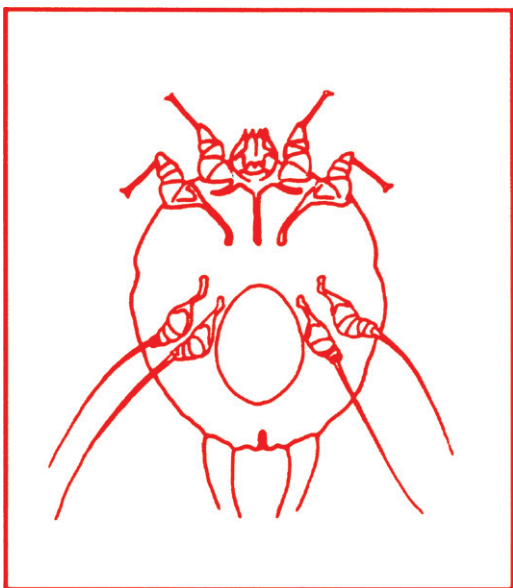


Fig. 13.49 Drawing of the female *Sarcoptes scabiei* showing the terminal anal opening.

Rabbits can be infested by notoedric and sarcoptic acarines. These mites cause similar lesions, usually on the head, neck, and legs. Lesions may also appear on the pinnae, making it necessary to distinguish *N. cati* and *S. scabiei* (see Fig. 13.49) from the guinea pig mite *Trixacarus caviae*



Fig. 13.50 *Trixacarus caviae*, typical sarcoptiform mite of guinea pigs.

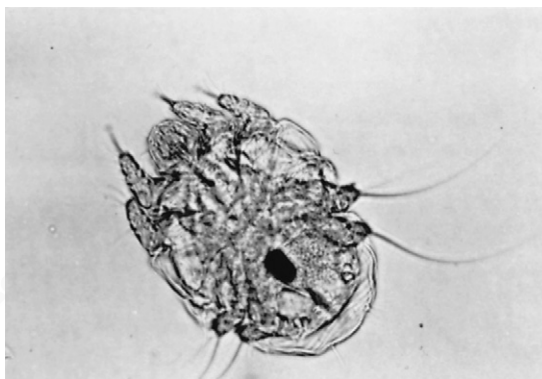


Fig. 13.51 Adults of *Psoroptes cuniculi*, occurring most often in the external ear canal of rabbits but also collected from horses, goats, and sheep. Mites exhibit characteristic long, jointed pedicels with suckers on the ends of some legs.

(Fig. 13.50) and the rabbit ear mite *Psoroptes cuniculi* (Fig. 13.51).

In general, notoedric mites are smaller than sarcoptic mites, and *P. cuniculi* is larger than both. Except for size, the major distinguishing characteristic of *N. cati* and *S. scabiei* is the location of the mite's anus. The anus is dorsal and subterminal in *N. cati* and terminal in *S. scabiei*. In both *N. cati* and *S. scabiei*, suckers are found at the end of long, unjointed stalks on the first two pairs of legs in adult females and on the first, second, and fourth pairs of legs in adult males. Psoroptic mites are distinguished by suckers at the end of long, jointed stalks on the first, second, and fourth pairs of legs in adult females and on the first, second, and third pairs of legs in adult males.

Diagnosis of infestation by *N. cati* and *S. scabiei* is by identification of larval, nymphal, or adult mites or the eggs from deep skin scrapings. Deep skin scrapings from the edges of lesions are necessary to detect the burrowing

mites. Lesions normally begin near the nose or lips; spread over the face; and may eventually involve the external or lateral pinnae, extremities, and genital region. Both *N. cati* and *S. scabiei* cause intense pruritus that may result in self-mutilation. A crust or scale may develop over infested areas, and the skin may become thick and wrinkled. Secondary bacterial infection may occur.

Technician's Note



Notoedres muris can be diagnosed with deep skin scrapings at the edges of suspected lesions, usually found at the ear pinnae, tail, nose, and extremities.

Transmission of notoedric and sarcoptic mites is by direct contact. *S. scabiei* is extremely contagious from rabbit to rabbit and from rabbit to human. The pet owner can become infested with this mite, but the disease is self-limiting. The mites burrow into the skin of humans, producing a papule-like lesion; however, the mites will not establish a full-blown infestation. Both *N. cati* and *S. scabiei* are considered to be zoonotic.

Technician's Note



Sarcoptes scabiei and *Notoedres cati* cause an intense pruritus that can result in self-mutilation of the host. Lesions are characterized by crusting and scaling, whereas the skin may become thick and wrinkled.

Parasite: *Cnemidocoptes pilae* and *Cnemidocoptes mutans*

Host: Budgerigars and parakeets (*C. pilae*) and poultry (*C. mutans*)

Location of Adult: *C. pilae* spends most of its life cycle tunneling under the superficial epidermis of the feet, cere, and beak, whereas *C. mutans* tunnels under the superficial epidermis of the feet. They both spend a short period on the surface of the skin.

Distribution: Worldwide

Derivation of Genus: Koptein means “to cut” in Greek

Transmission Route: Direct contact from host to host

Common Name: Scaly leg mite of parakeets and scaly leg mite of chickens, respectively

Zoonotic: No

Cnemidocoptes pilae (Scaly Leg Mite of Budgerigars)

Cnemidocoptes pilae is the sarcoptiform mite that causes scaly leg or scaly face in budgerigars and parakeets. This mite tunnels in the superficial layers of the epidermis, affecting the pads and shanks of the feet; in severe cases, it may also affect the beak and the cere, the junction of the feathers and the beak. The mite characteristically produces a yellow to

gray-white mass resembling a honeycomb. This condition can be quite disfiguring to the parakeet. The parasites pierce the skin underneath the scales, causing an inflammation with exudate that hardens on the surface and displaces the scales upward. This process causes the thickened, scaly nature of the skin. In canaries, *Cnemidocoptes* species produces a syndrome called **tasselfoot**, a proliferation of the toes and feet. A related species, *Cnemidocoptes mutans*, produces a condition called **scaly leg** in chickens, turkeys, and wild birds. These mites are extremely pruritic, producing a severe disfigurement of the beak, cere, and feet of parakeets and the legs of chickens.

Technician's Note



Cnemidocoptes pilae cause an extreme pruritus on the feet of parakeets but can also affect the beak and cere (the junction of the feathers and the beak).

Infestation sites should be scraped. Great care should be taken in handling the infested birds because parakeets and canaries are fragile creatures. The adult mites are eight-legged, round to oval in silhouette, and about 500 μm in diameter (Fig. 13.52). The adult female mites have very short legs and lack suckers. The adult male has longer legs and possesses the long, unjointed pedicel with a sucker on the end of some of the legs.

C. pilae is treated with ivermectin.

Technician's Note



Cnemidocoptes species have very short, stubby legs, very similar in appearance to the legs of a tortoise.

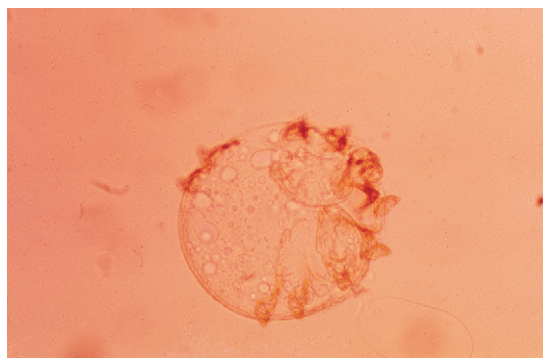


Fig. 13.52 Adult *Cnemidocoptes pilae*, a sarcoptiform mite that causes scaly leg or scaly face in budgerigars and parakeets. Adults are eight-legged, round to oval in silhouette, and about 500 μm in diameter. Adult females have very short legs and lack suckers. Adult males have longer legs and long, unjointed pedicels with a sucker on the end of some legs.

Parasite: *Trixacarus caviae*

Host: Guinea pigs

Location of Adult: For most of its life cycle, the adult can be found tunneling into the superficial epidermis, whereas a short period is spent on the surface of the skin

Distribution: Europe and North America

Derivation of Genus: Unknown

Transmission Route: Direct contact from host to host

Common Name: Burrowing mite of guinea pigs

Zoonotic: No

Trixacarus caviae

A burrowing or tunneling mite that infests guinea pigs is *Trixacarus caviae* (see Fig. 13.50). *T. caviae* is a typical sarcoptiform mite with a rounded body and suckers on long, unjointed stalks on the first two pairs of legs of females and on the first, second, and fourth pairs of legs of males.

Deep skin scrapings from the edges of suspected lesions around the back, neck, and shoulders are necessary to detect this mite both antemortem and postmortem. Lesions include dry, scaly skin with pruritus, alopecia, and dermatitis.

Technician's Note

Trixacarus caviae mites cause lesions with dry, scaly skin, pruritus, alopecia, and dermatitis.

Other burrowing mites that may infest guinea pigs are *S. scabiei* (see Fig. 13.49) and *N. muris* (see Fig. 13.48). *S. scabiei* can be transmitted from rabbits to guinea pigs, in which they produce scabby lesions on the nose and lips. Young guinea pigs are particularly susceptible and may become anorectic to the point of death if not treated. (See previous discussion on identification, detection, and transmission of *S. scabiei* in rabbits.) *N. muris* is generally associated with rats but has also been reported in guinea pigs. This mite produces red, crusty lesions on the face of guinea pigs. (See previous discussion on identification, detection, and transmission of *N. muris* in rats.)

Psoroptidae

Members of the family Psoroptidae reside on the surface of the skin or within the external ear canal. The entire five-stage life cycle (egg, larva, protonymph, deutonymph or pubescent female, and adult ovigerous female) is spent on the host. Adult male and female mites breed on the skin surface. The female produces 14 to 24 elliptic, opaque, shiny white eggs that hatch within 1 to 3 days. The six-legged mites are small, oval, soft, and grayish brown. Eight-legged nymphs are slightly larger than larvae. Larval and nymphal

stages may last 7 to 10 days. The life cycle is completed in about 10 to 18 days. Under favorable conditions, mites can live off the host for 2 to 3 weeks or longer. Under optimum conditions, mite eggs may remain viable for 2 to 4 weeks.

Parasite: *Psoroptes cuniculi*

Host: Rabbits (most common), horses, goats, and sheep

Location of Adult: External ear canal

Distribution: Worldwide

Derivation of Genus: Scabby

Transmission Route: Direct contact from host to host

Common Name: Rabbit ear mite or rabbit ear canker mite

Zoonotic: No

Technician's Note

Psoroptes cuniculi mites are commonly seen in the ears of rabbits but have also been reported in horses, goats, and sheep.

Psoroptes cuniculi (Ear Canker Mite of Rabbits)

Psoroptes cuniculi occurs most often in the external ear canal of rabbits but has also been collected from horses, goats, and sheep. These nonburrowing mites reside on the surface of the skin and feed on the rabbit host by puncturing the epidermis to obtain tissue fluids. Within the external ear canal of the infested host are the characteristic dried crusts of coagulated serum. (In chronic cases, the rabbit's ears appear to be packed with dried cornflakes cereal.) Affected animals shake their heads and scratch their ears. Although usually associated with otitis media produced by secondary infection with *Pasteurella multocida*, the ear mites themselves are not responsible for this condition. Lesions sometimes occur on the head and legs. *P. cuniculi* are extremely pruritic, and severely infested animals may become debilitated. Loss of equilibrium may occur with torticollis, or abnormal contraction of neck muscles.

Diagnosis can be made by superficial skin scrapings or the removal of the scab-like lesions. The samples are viewed microscopically for the developmental stages of the mite (egg, larva, nymph, and adult). The *P. cuniculi* mites within the cornflake-like crusty debris inside the ear can be easily isolated. The brownish-white female mite is large, 409 to 749 $\mu\text{m} \times 351$ to 499 μm ; males are 431 to 547 $\mu\text{m} \times 322$ to 462 μm (see Fig. 13.51). The mites exhibit characteristic long, jointed pedicels with suckers on the ends of some of the legs (Fig. 13.53). The anus is in a terminal slit. In addition, mites can be observed with the unaided eye or with a handheld magnifying glass.

Transmission of *P. cuniculi* is by direct contact. This parasite has no zoonotic potential. Treatment may be accomplished with the use of ivermectin otic (not approved for

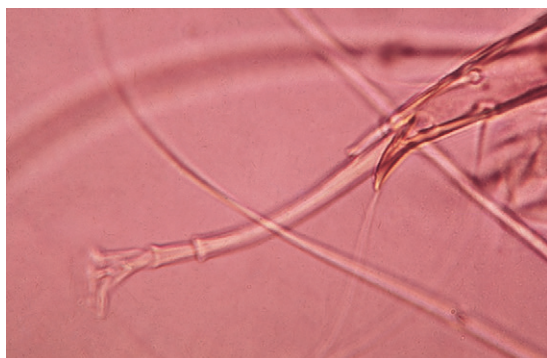


Fig. 13.53 Detail of long, jointed pedicel on the leg of *Psoroptes cuniculi*.

rabbits), milbemycin otic, or thiabendazole-dexamethasone-neomycin sulfate solution.

Technician's Note

Psoroptes cuniculi mites are easily diagnosed with an ear cytology specimen viewed under the microscope for the eggs, larval, nymphal, and adult stages of the parasite. Adult mites can also be seen with the aid of a magnifying glass or with an otoscope.

Parasite: *Psoroptes ovis*, *Psoroptes bovis*, and *Psoroptes equi*

Host: Sheep, cattle, and horses, respectively

Location of Adult: Skin surface on the body (*P. ovis*); withers, neck, and rump (*P. bovis*); and mane and tail (*P. equi*)

Distribution: Worldwide

Derivation of Genus: Scabby

Transmission Route: Direct contact from host to host

Common Name: Scabies mites of sheep, cattle, and horses, respectively

Zoonotic: No

Psoroptes of Large Animals

Psoroptes ovis, *Psoroptes bovis*, and *Psoroptes equi* are the scab mites of large animals residing on sheep, cattle, and horses, respectively. These mites are host specific and reside within the thick-haired or long-wooled areas of the animal. The adults are eight-legged, with an oval shape. Each mite possesses a sucker on the ends of some of its legs. If present, the sucker is connected to the legs by a pedicel. The mites are surface dwellers and feed by puncturing the host's epidermis to feed on lymphatic fluid. Serum exudes through the puncture site; after the serum coagulates and forms a crust, wool is lost. The feeding site is extremely pruritic, and the animal excoriates itself, producing further wool loss. Mites migrate to

undamaged skin. As *Psoroptes* mites proliferate, tags of wool are pulled out and the fleece becomes matted. Finally, patches of skin are exposed, and the skin becomes parchment-like, thickened, and cracked and may bleed easily. Infested sheep constantly rub against fences, posts, farm equipment, and any object that might serve as a scratching post. The disease is spread by direct contact or infested premises.

Technician's Note

Psoroptes species of large animals are extremely pruritic and cause the host to rub the affected area against fences, posts, equipment, or any object it can use as a scratching post. This can lead to areas of alopecia (hair loss) and excoriations.

P. bovis produces lesions on the withers, neck, and rump that consist of papules, crusts, and wrinkled, thickened skin. *P. equi* in horses is rare and affects the base of the mane and tail.

Because of the intense pruritus and the highly contagious nature of this infestation, the occurrence of *Psoroptes* species in large animals should be reported to both state and federal authorities. This disease is reportable to the USDA.

Mites of *Psoroptes* species that infest large animals are host specific. Adults are up to 600 μm in length. The mites exhibit characteristic long, jointed pedicels with suckers on the ends of some of the legs.

Large-animal *Psoroptes* species can be treated with lime sulfur dips or ivermectin.

Technician's Note

The species of *Psoroptes* that are found on large animals produce a highly pruritic, highly transmissible dermatologic condition known as *scabies*. These species of *Psoroptes* mites in large animals are **reportable parasites** to both state and federal authorities, whereas *Psoroptes cuniculi* is not a **reportable parasite**.

Parasite: *Chorioptes equi*, *Chorioptes bovis*, *Chorioptes caprae*, and *Chorioptes ovis*

Host: Horses, cattle, goats, and sheep, respectively

Location of Adult: Surface of skin, particularly lower hind legs, flanks and shoulders, and on dairy cattle in the region of the escutcheon

Distribution: Worldwide

Derivation of Genus: Membrane visible

Transmission Route: Direct contact from host to host

Common Name: Foot and tail mites or itchy leg mite

Zoonotic: No

Chorioptes Species (Foot and Tail Mite, Itchy Leg Mite)

Chorioptes equi, *Chorioptes bovis*, *Chorioptes caprae*, and *Chorioptes ovis* are the **foot and tail mites** of large animals, residing on horses, cattle, goats, and sheep, respectively. As with *Psoroptes*, these mites are found on the skin surface. Their predilection sites are on the lower part of the hind legs, but they may spread to the flank and shoulder areas. On cattle, they are frequently found in the tail region, especially in the area of the escutcheon. These mites do not spread rapidly or extensively. They puncture the skin, causing serum to exude. Thin crusts of coagulated serum form on the skin surface. The skin eventually wrinkles and thickens, although pruritus is not severe. The presence of these mites on the lower limbs may cause intense pruritus, although the pruritus is not normally severe, with much scratching and licking of the area.

Infested horses stamp, bite, and kick, especially at night. Mites typically infest the pasterns, especially those of the hind legs.

Characteristic mites of the genus *Chorioptes* can be identified from skin scrapings of infested areas. The mites have characteristic short, unjointed pedicels with suckers on the ends of some of the legs. The female mites are about 400 μm long (Fig. 13.54). Because these mites can be licked by the infected animal, developmental stages of these mites may be found on fecal flotation.

Ivermectin and lime sulfur dips are used to treat *C. equi*, *C. bovis*, *C. caprae*, and *C. ovis*.

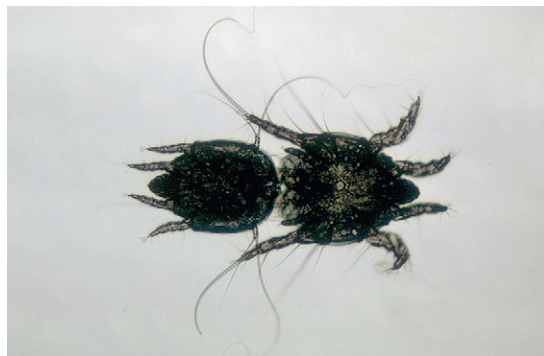


Fig. 13.54 Female and male *Chorioptes* species. Note the short, unjointed pedicels.

primarily in the external ear canal, ear mites may be found on any area of the body. A common infestation site is the tail-head region because as dogs and cats curl up to sleep, their head (and ears) are often close to the base of the tail. These mites are spread by direct contact and are highly transmissible both among and between dogs, cats, and ferrets.

Technician's Note



Otodectes cynotis mites are highly transmissible from host to host and can be found at the tail-head region because of the way dogs, cats, and ferrets tend to sleep curled up.

Technician's Note



On superficial inspection, *Chorioptes* species have been found to have the same configuration of pedicels as *Otodectes cynotis*. The "pedicel formula" (position of suckers and pedicels on the mite's limbs) may be similar, legs with short stalks and terminal suckers. *Chorioptes* species are found on the legs of large animals, whereas *Otodectes cynotis* is found in the ears of small animals.

Parasite: ♦ *Otodectes cynotis*

Host: Canines, felines, and ferrets

Location of Adult: External ear canal

Distribution: Worldwide

Derivation of Genus: Ear biter or ear receiver

Transmission Route: Direct contact from host to host

Common Name: Ear mites

Zoonotic: Yes, but extremely rare (per American Association of Veterinary Parasitologists and Companion Animal Parasite Council)

Otodectes cynotis (Ear Mites)

Ear mites, *Otodectes cynotis*, are a common cause of otitis externa in dogs, cats, and ferrets. Although they occur

Mites are found within the external ear canal, where they feed on epidermal debris and produce intense irritation. Infestation is usually in both ears. The host responds to the mite infestation by shaking its head and scratching its ears. In cases of infestation with these mites, the "massaging" or petting of the external ear canal elicits a scratching response by the animal called the *pedalpinnal response* (foot-ear response). In severe infestations, otitis media with head tilt, circling, and convulsions may occur. Auricular hematomas may develop.

Ear mites are usually identified with an otoscope, under which the mites appear as white motile objects. Exudate collected by swabbing the ear may be placed in mineral oil on a glass slide and the mites observed under a compound microscope using the 10 $\times$ objective. These mites are fairly large, approximately 400 μm (Fig. 13.55); they can also be easily seen with the unaided eye. The mites exhibit characteristic short, unjointed pedicels with suckers on the ends of some of the legs (Fig. 13.56). The anus of *O. cynotis* is terminal.

Ivermectin otic, milbemycin otic, and thiabendazole-dexamethasone-neomycin sulfate solution are used to treat *O. cynotis*. In addition to the use of medication, the ears should be cleaned to remove the debris and mites.



Fig. 13.55 Adult male ear mite *Otodectes cynotis*.



Fig. 13.56 Detail of the leg of *Otodectes cynotis* with a short, unjointed pedicel.

Technician's Note

If *Otodectes cynotis* is found in one pet of the household, all pets in the household should be treated.



Nonsarcoptiform Mites

The members of the following group of parasitic mites are discussed together because they are not sarcoptiform mites. They can, however, produce severe dermatologic problems in a variety of domestic animals. These mites lack the pedicels, or stalks, on their legs that are so important in diagnosing the sarcoptiform mites.

Parasite: *Demodex* species

Host: Domestic animals and humans (host specific)

Location of Adult: Hair follicles and sebaceous glands of the skin

Distribution: Worldwide

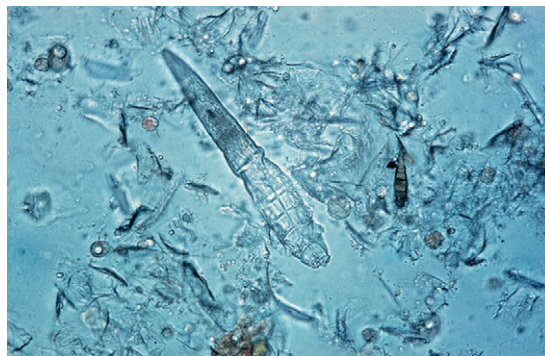


Fig. 13.57 Adult *Demodex canis*. *Demodex* mites resemble eight-legged alligators; they are elongated, with very short, stubby legs. Adult and nymphal stages have eight legs; larvae have six legs.

Derivation of Genus: Fat worm or tallow receiver

Transmission Route: Direct contact, especially intimate contact between dam and neonates

Common Name: Red mange mite, follicular mite, canine follicular mite, or demodectic mange mite

Zoonotic: No

Demodex Species

Mites of the genus *Demodex* reside in the hair follicles and sebaceous glands of humans and of most domesticated animals. In many species, mites of the genus *Demodex* are considered normal, nonpathogenic fauna of the skin. These mites are host specific and are not transmissible from one species of host to another. The clinical disease caused by many of these mites is called **demodicosis**.

Demodex mites resemble eight-legged alligators or cigars, and some even say they have a carrot shape—elongated, with very short, stubby legs. No other mite looks like this one. The adult and nymphal stages have eight legs, and larvae have six. Adult *Demodex* mites are approximately 250 μm long (Fig. 13.57). The eggs are spindle shaped or tapered at each end (Fig. 13.58).

Technician's Note

The *Demodex* mite has a characteristic carrot-, cigar-, or alligator shaped body, with very short and stubby legs. The nymphal and adult stages have eight legs, whereas the larval stage has six legs.



Of all the domestic animals infested with *Demodex* species, the dog is the most often and the most seriously infested. These mites are considered part of the normal skin flora of all dogs; in some dogs with immunodeficiencies,

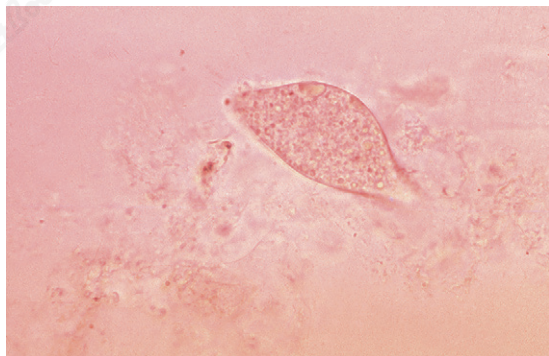


Fig. 13.58 The egg of *Demodex canis* is either spindle shaped or tapered at each end.

however, they proliferate to the point that they produce pathology. The clinical syndromes relative to the form of demodicosis present in dogs are localized demodicosis and generalized demodicosis.

The predominant clinical sign of the **localized form of demodicosis** is a patchy alopecia, especially of the muzzle, face, and forelimbs. It is thought that *Demodex* mites are acquired during the close, intimate contact that develops as the dam nurses the puppy. As a result of that contact, localized demodicosis often develops in the region of the face or forelimbs.

Generalized demodicosis is characterized by diffuse alopecia, erythema, and secondary bacterial contamination over the entire body surface of the dog. An inherited defect in the dog's immune system is thought to be an important factor in the development and the pathogenesis of generalized demodicosis. Generalized demodicosis can affect the entire skin surface, and on occasion, demodectic mites have been known to infect internal organs.

Technician's Note



Demodex mites can produce three syndromes in animals: the asymptomatic carrier, localized demodicosis, and generalized demodicosis.

Cats are infested by two species of demodectic mites, *Demodex cati* and *Demodex gato* of *Demodex*. *D. cati* is an elongated mite similar to *Demodex canis*. *D. gato* has a broad, blunted abdomen, unlike the elongated abdomen of *D. cati*. The presence of either species in the skin of cats is rare. In localized feline demodicosis, patchy areas of alopecia, erythema, and occasionally crusting occur on the head (especially around the eyes), ears, and neck. In generalized feline demodicosis, the alopecia, erythema, and crusting

usually involve the entire body. Demodicosis also has been associated with ceruminous otitis externa.

Demodectic mites reside in the hair follicles of other species of domestic animals but rarely produce clinical disease. Cattle and goats are most often infested, and then only rarely.

Technician's Note



Demodex mites live within the hair follicles and sebaceous glands of the skin, but dogs are the hosts most commonly seen with clinical signs of infestation.

In cattle, *Demodex bovis* causes large nodules or abscesses on the shoulders, trunk, and lateral aspects of the neck. In goats, *Demodex caprae* occurs in small, papular, or nodular lesions on the shoulders, trunk, and lateral aspects of the neck. *Demodex ovis* causes pustules and crusting around the coronet, nose, ear tips, and periorbital areas. They rarely occur in sheep. *Demodex phylloides* produces pustules and nodules on the face, abdomen, and ventral neck. They rarely occur in pigs. In horses, *Demodex equi* occurs around the face and eyes and rarely produces clinical disease.

Demodex aurati (Fig. 13.59) and *Demodex criceti* (Fig. 13.60) infest hamsters. As with other *Demodex* species, they live in hair follicles and adjacent sebaceous glands. Deep skin scrapings at the edges of the lesions are necessary to detect the mites. Lesions are most often seen on the dorsum of the hamster near the rump.

Clinical signs that may indicate demodicosis in the hamster include alopecia and dry, scaly skin or scabby dermatitis, particularly over the rump and on the back of the hamster. Demodicosis is most often observed in aged or otherwise stressed hamsters. The mite population in hamsters is usually greater in males than in females. As with *D. canis* in dogs, *D. aurati* and *D. criceti* may be present without producing clinical signs.

Gerbils have been reported to carry two species of *Demodex*, *D. aurati* and *D. criceti* (see Figs. 13.59 and 13.60). These mites are similar in size and shape to the demodectic mites of hamsters. Demodectic mites also have been recovered from gerbils with facial dermatitis. As in other species with demodectic acariasis, infested gerbils have other concomitant disease. Lesions are similar to those described in the hamster.

Demodicosis may be detected on postmortem examination by histopathologic examination of skin sections. Transmission is by direct contact, with the primary route thought to be from mother to suckling young. *Demodex* species of hamsters are considered to be species specific, with the possible exception of the gerbil, and thus are not likely to cross-contaminate other species or pose a zoonotic problem to humans.

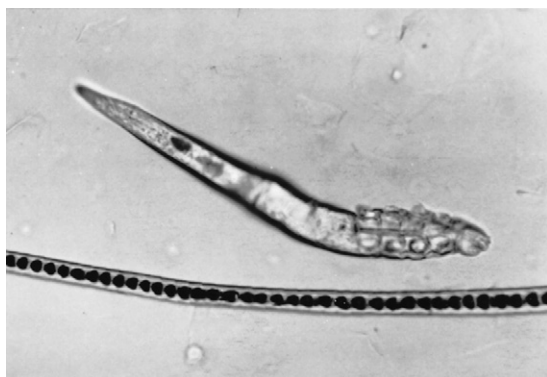


Fig. 13.59 *Demodex aurati*, a burrowing mite of hamsters.



Fig. 13.60 *Demodex criceti*, a hamster mite, is distinguishable from *Demodex aurati* by its blunt body shape.



Fig. 13.61 Results of a thorough, deep skin scraping revealing numerous mites of *Demodex canis*.

and a fold of skin gently squeezed to express any mites from the hair follicles. Scraping should be continued until capillary blood is observed oozing because these mites live deep in the hair follicles and sebaceous glands (Fig. 13.61).

Nodular lesions in large animals should be incised with a scalpel and the caseous material within smeared on a microscope slide with mineral oil, covered with a coverslip, and examined for mites.

The veterinary diagnostician should count the mites on the glass slide and determine the live:dead ratio. The presence of larval or nymphal stages or eggs should be noted. Treatment for demodicosis involves dipping the affected animal in an amitraz (not used on horses) or trichlorfon dip. During therapy for *Demodex* species, a decrease in the number of eggs and the number of live or moving mites is a good prognostic indicator.

Technician's Note



Demodex infestation in animals showing clinical symptoms is diagnosed by deep skin scrapings to find the developmental stages of the mite (egg, larva, nymph, and adult).

Skin with altered pigmentation, obstructed hair follicles, erythema, or alopecia should always be scraped with a deep skin scraping to the extent of drawing capillary blood. In localized demodicosis, the areas most often affected are the forelegs, the perioral region, and the periorbital regions. In generalized demodicosis of dogs, the entire body may be affected; however, the face and feet usually are the most severely involved. In dogs, normal skin should also be scraped to determine whether the disease is generalized. The areas should be clipped

Technician's Note



The veterinarian or technician should count the live versus dead mites for a live:dead ratio to determine the prognosis of treating the infection during therapy.

Parasite: *Trombicula* species

Host: Domestic animals, wild animals, and humans

Location of Larva: The larval stage is the only stage that parasitizes animals and humans. It is found attached to the skin of the host.

Distribution: Worldwide

Derivation of Genus: Unknown

Transmission Route: Direct contact of host and larval mites within forest environments with underbrush

Common Name: Chiggers or red bugs

Zoonotic: No

Trombicula Species (Chiggers)

The **chigger**, *Trombicula* species, is yellow to red, has six legs, and ranges in size from 200 to 400 μm in diameter (Fig. 13.62). The larval stage is the only developmental stage that parasitizes humans, domestic animals, and wild animals. The larvae are most common during the late summer and early fall and are transmitted by direct contact of the host with the ground or by brushing against foliage in fields or heavy underbrush. The nymphal and adult stages of chiggers are nonparasitic and are free-living in nature.

Larval chiggers do *not* burrow into the skin, as commonly believed, nor do they feed primarily on host blood. Their food consists of the serous components of tissues. Chiggers attach firmly to the host and inject a digestive fluid that produces liquefaction of host cells. The host's skin becomes hardened, and a tube called a **stylostome** forms at the chigger's attachment site. Chiggers suck up liquefied host tissues. When the mite has finished feeding, it loosens its grip and falls to the ground. The injected digestive fluid causes the attachment site to itch intensely. In animals, cutaneous lesions tend to be restricted to areas of the body that come in contact with the ground or underbrush, that is, the head, ears, limbs, interdigital areas, and ventrum.

The most common chigger mite affecting animals and humans is *Trombicula alfreddugesi*, the **North American chigger**. Lesions caused by *T. alfreddugesi* consist of an erythematous, often pruritic papular rash on the ventrum, face, feet, and legs.

The diagnosis of chiggers is based on the presence of an orange-crusting dermatosis, a history of exposure (roaming outdoors), and identification of the typical six-legged larval stage on skin scraping or on collection from the host. The larval chigger remains attached to the skin only for several hours. Consequently, **trombiculosis** may be difficult to diagnose because the pruritus persists after the larva has dropped off the host.

Technician's Note



Diagnosis of chiggers is made by observing the red, pruritic papular lesions on the skin surface. Diagnosis should be confirmed by a human dermatologist.

Parasite: *Pneumonyssus* (*Pneumonyssoides*) *caninum*

Host: Canines

Location of Adult: Nasal turbinates and nasal sinuses

Distribution: Worldwide

Derivation: Lung piercer

Transmission Route: Direct contact from host to host

Common Name: Nasal mites

Zoonotic: No

***Pneumonyssus* (Formerly, *Pneumonyssoides*) *caninum* (Nasal Mites of Dogs)**

Pneumonyssus (*Pneumonyssoides*) *caninum* is a rare species of mite that lives in the nasal turbinates and associated



Fig. 13.62 The chigger, *Trombicula* species, is yellow to red, has six legs, and ranges in size from 200 to 400 μm in diameter. (From Bowman DD: *Georgis' parasitology for veterinarians*, ed 10, 2013, Elsevier.)

paranasal sinuses of dogs. Generally, nasal mites are considered to be nonpathogenic; however, reddening of the nasal mucosa, sneezing, shaking of the head, and rubbing of the nose often accompany infestation. Fainting, labored breathing, asthma-like attacks, and orbital disease have been associated with this mite. Sinusitis caused by these mites may lead to disorders of the central nervous system. Owners will observe these mites exiting the nostrils.

The life cycle of *P. caninum* is unknown, but it apparently takes place entirely within the host. Adult males, females, and larvae have been identified, but no nymphal stages have been observed. Transmission probably occurs through direct contact with an infested animal.

Technician's Note

Diagnosis of *Pneumonyssus (Pneumonyssoides) caninum* infestation can be made from the owner's observation of mites exiting the dog's nostrils.

Nasal mites are oval and pale yellow. They are 1 to 1.5 mm × 0.6 to 0.9 mm and possess a smooth cuticle with very few hairs. The abdomen lacks setae (fine hairs). Larvae have six legs, and adults have eight legs. All legs are located on the anterior half of the body (Fig. 13.63). Diagnosis is usually made at necropsy on asymptomatic animals by finding the characteristic adult mites.

Technician's Note

When dogs infested with *Pneumonyssus (Pneumonyssoides) caninum* lie down in front of a fireplace with a roaring fire, the mites may be seen temporarily exiting the nares of the dog as they are attracted to the warmth of the fire.

Parasite: *Ornithonyssus sylviarum* and *Dermanyssus gallinae*

Host: Poultry

Location of Adult: On the skin of poultry (*O. sylviarum*); in the environment of poultry (*D. gallinae*)

Distribution: Worldwide in temperate zones (*O. sylviarum*); worldwide (*D. gallinae*)

Derivation of Genus: Bird piercer (*Ornithonyssus*); skin piercer (*Dermanyssus*)

Transmission Route: Direct contact from host to host (*O. sylviarum*); direct contact with infested environment (*D. gallinae*)

Common Name: Northern fowl mite (*O. sylviarum*); red fowl mite (*D. gallinae*)

Zoonotic: No



Fig. 13.63 *Pneumonyssus (Pneumonyssoides) caninum*, a rare mite that lives in the nasal passages and associated paranasal sinuses of dogs.

Ornithonyssus sylviarum (Northern Mite of Poultry) and Dermanyssus gallinae (Red Mite of Poultry)

Ornithonyssus sylviarum and *Dermanyssus gallinae* both parasitize poultry but differ in the sites where they are collected. *O. sylviarum* is a 1-mm, elongate to oval mite with eight legs that is usually found on birds; it also may be found on nests or within poultry houses. The adults are sparsely covered with setae. In specimens that have been cleared in lactophenol, there is an anal plate on the ventral surface of the mite. The anus of this mite is on the posterior half of that anal plate. This species, the **northern mite of poultry**, feeds intermittently on birds, producing irritation, weight loss, decreased egg production, anemia, and even death. These mites have been known to bite humans. The adult is the only life stage that feeds on the host. The larval and nymphal stages do not feed on the host.

D. gallinae is similar in appearance to *O. sylviarum* except the anus is on the anterior surface of the anal plate and is approximately 1 mm in length; elongate to oval; whitish, grayish, or black; and feeds on birds. This mite has a distinct red color when it has recently fed on its host's blood, thus its common name, the **red fowl mite**. *D. gallinae* lays its eggs in the cracks in the walls of poultry houses. Both the **nymphal stage** and the adults are periodic parasites, hiding in the cracks and crevices of poultry houses and making frequent visits to the host to feed. Because of their blood-feeding activity, these mites may produce significant anemia and much irritation to the host. Birds are listless, and egg production may decrease. Loss of blood may result in death. These mites also occur in bird nests in the eaves of houses or in air conditioners. They migrate into homes and attack humans. *D. gallinae* can be treated with pyrethrin sprays or ivermectin. If a flock is infected with *D. gallinae*, dichlorvos strips may be used to treat the flock.

Technician's Note

Because *Ornithonyssus sylviarum* and *Dermanyssus gallinae* are similar in appearance, it is important to determine the location of the anus on the anal plate for identification of these mites.

Because of their similar morphology, these mites are difficult to differentiate. *O. sylviarum* is usually found on the avian host, whereas *D. gallinae* is a periodic parasite usually found in the host's environment. If specimens are recovered, they should be cleared in lactophenol and the ventral anal plates examined under a compound microscope. The anus of *O. sylviarum* is on the anterior half of the ventral anal plate, whereas that of *D. gallinae* is on the posterior half of the ventral anal plate.

Parasite: *Ornithonyssus bacoti*

Host: Rats and mice; can infect hamsters and guinea pigs

Location of Adult: In host environment most of life cycle; on skin surface when feeding

Distribution: Tropical and subtropical climates

Derivation of Genus: Bird piercer

Transmission Route: Direct contact with contaminated environment

Common Name: Tropical rat mite

Zoonotic: No

Ornithonyssus (Liponyssus) bacoti

Ornithonyssus (Liponyssus) bacoti is commonly called the **tropical rat mite**. This bloodsucking mite can cause severe problems in rats and mice and can also infect hamsters and guinea pigs. It is especially common in tropical and subtropical climates. *O. bacoti* has a wide host range beyond rodents and can also infect hamsters and guinea pigs.

Oddly, even though *O. bacoti* is a bloodsucking mite, it is more closely related to ticks than mites. This mite is unusual in that it spends most of its life cycle off the host animal, in the host's environment. Both male and female mites are bloodsuckers. The females are larger than the males. These mites may be filled with blood, which produces a reddish-brown color, or if they have not fed, they may be white. The mites can measure up to 750 μm in length (Fig. 13.64).



Fig. 13.64 *Ornithonyssus (Liponyssus) bacoti*, the tropical rat mite.

O. bacoti mites intermittently feed on rodent blood, dropping into nests or surrounding cracks and crevices between feedings. These mites can gain access to other pet animals by dropping from wild or feral animals; days later, when the original host is no longer in the area, they may attack a pet animal for a blood meal.

Infestation with *O. bacoti* is usually diagnosed by observing the blood-filled mites in the bedding, nests, or cracks and crevices near the cages of pet animals. Animals in an environment infested with *O. bacoti* may be anemic and may exhibit a marked reproductive decline. The mite can transmit rickettsial organisms and cause allergic dermatitis in humans. In the absence of a suitable rodent host, *O. bacoti* readily attacks humans for a blood meal.

O. bacoti has a wide host range beyond rodents and is especially common in tropical and subtropical climates.

Technician's Note

Ornithonyssus bacoti can carry rickettsial organisms that can be transmitted to humans and also cause allergic dermatitis in humans.

Technician's Note

The tropical rat mites can cause anemia in rats and mice; however, they can also infest hamsters and guinea pigs. They are bloodsucking mites that are found on the host only when they feed.

Fur Mites

Parasite: ♦ *Cheyletiella parasitivorax*

Host: Dogs, cats, and rabbits

Location of Adult: Surface of the skin and hair coat

Distribution: Worldwide

Derivation of Genus: Small lip

Transmission Route: Direct contact from host to host

Common Name: Walking dandruff

Zoonotic: Yes (per the American Association of Veterinary Parasitologists)

***Cheyletiella* Species (Walking Dandruff)**

Mites of the genus *Cheyletiella* are surface-dwelling (non-burrowing) mites that reside in the keratin layer of the skin and in the hair coat of various definitive hosts, which may be dogs, cats, or rabbits. These mites ingest keratin debris and tissue fluids and are often referred to as **walking dandruff** because the motile mites resemble large, moving flakes of dandruff. Cheyletid mites have unique morphologic features. They are large mites ($386 \times 266 \mu\text{m}$), visible to the naked eye. The compound microscope allows easy visualization of this mite's most characteristic morphologic feature, enormous hook-like accessory mouthparts (**palpi**) on the anterior end. These palpi assist the mite in attaching to the host as it feeds on tissue fluids. The mite also has comb-like structures at the tip of each of its legs. Members of the genus are also known for their characteristic body shape, a silhouette that has been reported as resembling a shield, a bell pepper, the acorn of an oak tree, or a Western horse saddle when viewed from above (Fig. 13.65). Eggs are 235 to $245 \mu\text{m}$ long $\times$ 115 to $135 \mu\text{m}$ wide (smaller than louse nits) and supported by cocoon-like structures bound to the hair shaft by strands of fibers. Two or three eggs may be bound together on one hair shaft or found in the keratin debris of pet dander.

Technician's Note

Walking dandruff mites has been reported to resemble a bell pepper from the lateral view or an acorn from an oak tree.

The key feature of active infestation by *Cheyletiella parasitivorax* is often the moving white dandruff-like flakes along the dorsal midline and head of the host. A handheld magnifying lens or a binocular headband magnifier (e.g., OptiVISOR) may be used to view questionable dandruff flakes or hairs; these are perhaps the quickest methods of diagnosing **cheyletiellosis**. A fine-toothed flea comb may be used to collect mites; combing dandruff-like debris onto black paper often facilitates visualization of these highly motile mites. Using clear cellophane tape to entrap mites collected from the hair coat often simplifies localization and viewing under the compound microscope.

C. parasitivorax can be treated with ivermectin (not approved for rabbits) and malathion dips.

Technician's Note

Superficial combing with a flea comb onto black paper, examination of the dorsal midline and head of the host, and the cellophane tape technique are used to diagnose *Cheyletiella parasitivorax*.



Fig. 13.65 Adult mite, *Cheyletiella parasitivorax*. *Cheyletiella* species have hook-like accessory mouthparts (palpi) on the anterior end and comb-like structures at the tip of the legs. These mites have a characteristic body shape variously described as a shield, bell pepper, acorn, or Western horse saddle when viewed from above.

Parasite: *Lynxacarus radovskyi*

Host: Cats

Location of Adult: Hair shafts on the back, neck, thorax, and hind limbs

Distribution: Tropical or warm regions of the United States and Puerto Rico, Australia, and Fiji

Derivation of Genus: Lynx mite

Transmission Route: Direct contact from host to host

Common Name: Feline fur mite

Zoonotic: No

***Lynxacarus radovskyi* (Feline Fur Mite)**

Lynxacarus radovskyi, the feline fur mite, is found attached to the shafts of individual hairs on the back, neck, thorax, and hind limbs of cats residing in tropical or warm areas of the United States, such as Florida, Puerto Rico, and Hawaii. These fur mites are laterally compressed. The adults are approximately $500 \mu\text{m}$ long (Fig. 13.66). Pruritus is not always associated with infestations of *L. radovskyi* in cats. These mites are diagnosed by observing the mites attached to hair shafts and examining the dander and other debris after combing. This mite may also affect humans who handle infested cats, producing a papular dermatitis.

Technician's Note

The feline fur mite can be diagnosed by seeing the adult mites attached to the hair shafts and examining the dander and debris after combing.

Parasite: *Myobia musculi*, *Myocoptes musculus*, and *Radfordia affinis*

Host: Mice

Location of Adult: Hair shafts

Distribution: Worldwide

Derivation of Genus: Unknown

Transmission Route: Direct contact from host to host

Common Name: Mouse fur mites

Zoonotic: No

***Myobia musculi*, *Myocoptes musculinus*, and *Radfordia affinis* (Mouse Fur Mites)**

The three most common fur mites of the mouse are *Myobia musculi*, *Myocoptes musculinus*, and *Radfordia affinis*. Mice housed in close association with rats may become infested with *Radfordia ensifera*, a fur mite of rats (see next discussion). Rodent mites have life cycles similar to those of mites

of other animal species, with larval and nymphal stages. Larval mites have only six legs, whereas nymphal stages (Fig. 13.67, A) and adult specimens have eight legs (see Fig. 13.67, B).

The first pair of legs of *M. musculi*, *R. affinis*, and *M. musculinus* is distinctly short and adapted for clasp ing the hair of the host, with the first two pairs of legs being somewhat club-like at the ends (see Fig. 13.67, C).

The second pair of legs of *M. musculi* and *R. affinis* ends with claw-like features referred to as **empodia**. The empodia of *M. musculi* and *M. musculinus* are long and single (Fig. 13.68, A), whereas *R. affinis* has a shorter pair of empodia of unequal length on the second set of legs (see Fig. 13.68, B). This feature distinguishes *R. affinis* from both *M. musculi* and *M. musculinus*.

Adult females of *M. musculi* are about 400 to 500 μm long and 200 μm wide. Males are similarly shaped but proportionately smaller. *R. affinis* is similar in size and shape to *M. musculi*. Adult females of *M. musculinus* are smaller than those of other fur mites of mice, measuring 300 $\times$ 130 μm . The male is 190 $\times$ 135 μm .

Technician's Note



The second pair of legs end with claw-like features referred to as **empodia**. Empodia of *M. musculi* and *M. musculinus* are longer than those of *R. affinis*.

Fur mite eggs can be found attached near the base of the host's hairs. The eggs are oval and about 200 μm long (Fig. 13.69).



Fig. 13.66 *Lynxacarus radovskyi*, the feline fur mite, attaches to hair shafts on the back, neck, thorax, and hind limbs of cats.

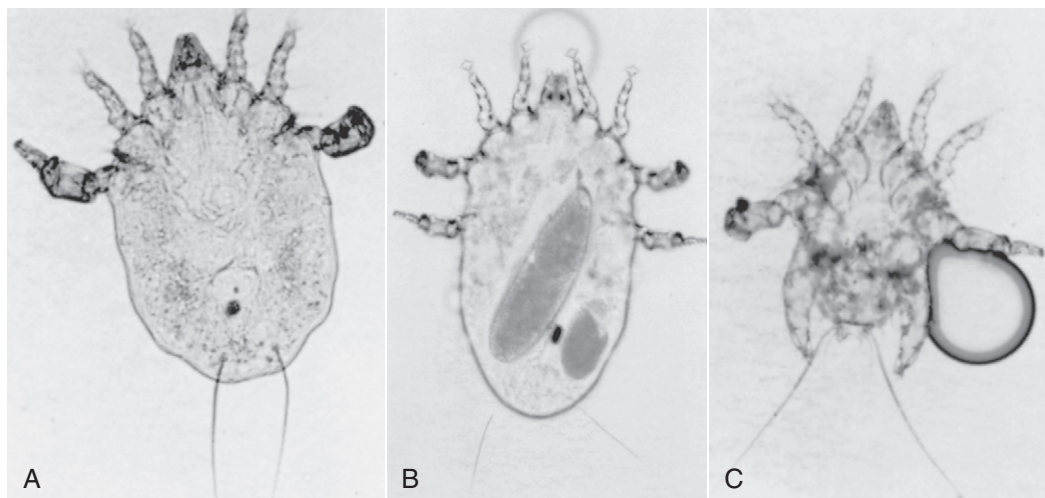


Fig. 13.67 *Myocoptes musculinus*, fur mite of mice. **A**, Nymphal female. Note the absence of adult's hind legs. **B**, Adult female. The oval shape within is an egg. **C**, Adult male with an air bubble artifact.

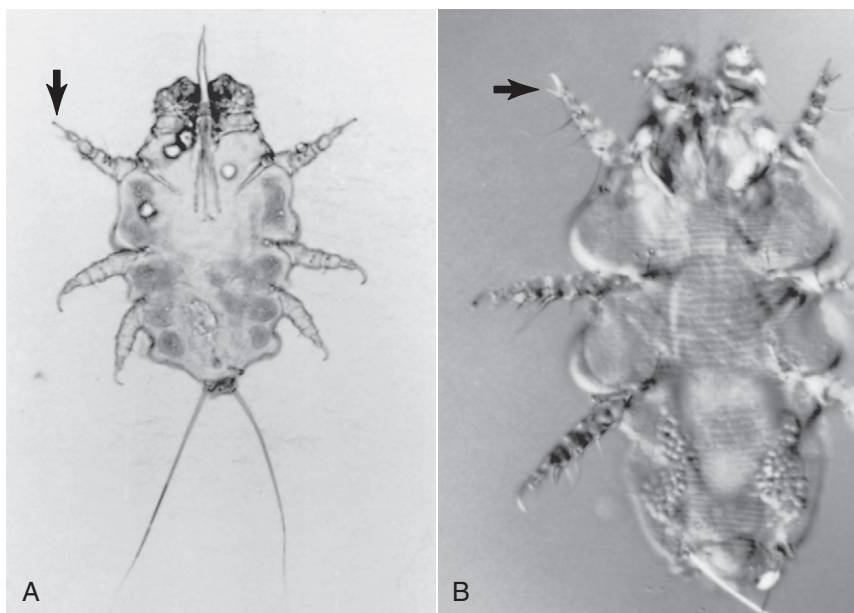


Fig. 13.68 **A**, Eight-legged nymphal form of *Myobia musculi* showing a single long empodial claw on the second pair of legs (arrow). The extended mouthpart is typical of the nymphal form. **B**, *Radfordia affinis* showing paired empodial claws on the second leg pair (arrows).

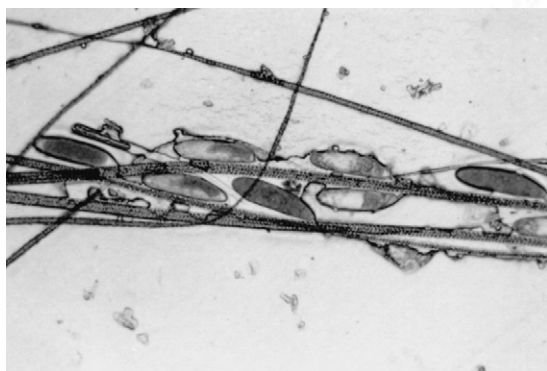


Fig. 13.69 Nits of *Myocoptes musculinus* attached to the hair shafts of a mouse.

To detect fur mites on a live mouse, fur can be obtained by plucking with forceps or by pressing the adhesive side of cellophane tape on the pelt of the mouse. The plucked fur can be placed in a drop of mineral oil on a glass slide and examined microscopically for mites or eggs. The cellophane tape can be placed adhesive side down on a drop of mineral oil on a glass slide and similarly examined. Fur samples should be taken from the neck or shoulder area because that is where the mites most often reside and produce lesions.

Postmortem detection of fur-inhabiting mites of mice may be approached as with the antemortem method, or the dead mouse may be placed under a warm lamp for a few minutes. The heat attracts the mites in the pelt, causing them to migrate to the tips of the hairs. A handheld magnifying glass, a head loupe, or a dissecting microscope aids in the detection of the mites. The mites may be collected on the tip of a metal probe or similar instrument that has been dipped in mineral oil, then placed in a drop of mineral oil on a glass slide and under a coverslip and examined microscopically.

Technician's Note



Diagnosis of mouse, rat and guinea pig fur mites can be made by plucking hairs or using the cellophane tape technique to find the mites under a microscope. Samples should be taken from the neck or shoulder areas.

The pathogenicity of mouse fur mites varies greatly with the host and the degree of infestation, similar to demodectic acariasis in dogs. Clinical signs may be absent or may include alopecia, pruritus, and ulceration. More severe lesions may be the result of host sensitivity to the mites, in which case few if any mites are observed.

Transmission of mouse fur mites is by direct contact. Although mites are generally host specific, the owner of multiple species of rodents should be advised that *M. musculi* and *R. affinis* may infest rats and guinea pigs housed in the same area with mice infested with *M. musculi* and *R. affinis*. The three species of mouse fur mites are not known to infest humans.

M. musculi and *M. musculus* are treated with ivermectin.

Parasite: *Radfordia ensifera*

Host: Rats

Location of Adult: Hair shafts

Distribution: Worldwide

Derivation of Genus: Unknown

Transmission Route: Direct contact from host to host

Common Name: Rat fur mite

Zoonotic: No

Radfordia ensifera (Rat Fur Mite)

Radfordia ensifera, a fur mite of rats, is similar to *M. musculi* and *R. affinis* (see Fig. 13.68). *R. ensifera* is distinguished from *M. musculi* and *R. affinis* by the empodial claws of the second pair of legs. *M. musculi* has a single, long empodial claw (see Fig. 13.68, A), whereas *R. ensifera* and *R. affinis* both have a pair of short claws. The two empodial claws of *R. ensifera* are of equal length (Fig. 13.70), whereas those of *R. affinis* are of unequal length (see Fig. 13.68, B).

Antemortem or postmortem, *R. ensifera* is detected using methods described for mouse fur mites. Light infestation of *R. ensifera* usually causes no clinical signs; however, self-inflicted trauma may be seen in heavy infestations. Transmission is by direct contact. *R. ensifera* is not known to infest humans.

Parasite: *Chirodiscoides caviae*

Host: Guinea pig

Location of Adult: Within the pelt

Distribution: Worldwide

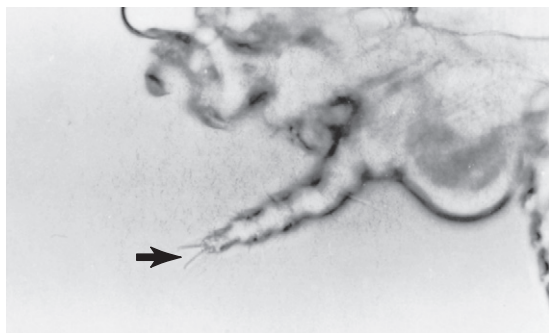


Fig. 13.70 Second leg of *Radfordia ensifera* showing equal length of the empodial claws (arrow).

Derivation of Genus: Disk-like hand

Transmission Route: Direct contact from host to host

Common Name: Guinea pig fur mite

Zoonotic: No

Chirodiscoides caviae (Guinea Pig Fur Mite)

The fur mite that typically infests guinea pigs is *Chirodiscoides caviae*. *C. caviae* is an elongated mite, with a triangular cranial portion that appears similar to the head of the mite. All eight legs are adapted for grasping on to hair. There are no empodial claws on the first two pairs of legs. The male is about $363 \times 138 \mu\text{m}$ (Fig. 13.71), and the female is $515 \times 164 \mu\text{m}$ (Fig. 13.72).

C. caviae is somewhat difficult to observe antemortem with the unaided eye. It may be detected by pulling hairs, either with forceps or by the cellophane tape method, then examining the specimen microscopically. *C. caviae* is found in the pelt and occurs in the greatest numbers in the area over the rump. Postmortem, a piece of the pelt from the rump of the dead animal may be placed in a Petri dish to cool and then examined with a handheld magnifying glass or dissecting microscope for mites at the tip of the hairs.

There are usually no clinical signs unless infestation is severe, when alopecia and pruritus may be seen. Although *C. caviae* is not considered transmissible to humans, transient infestation causing a pruritic, papular urticarial skin condition has been reported.

M. musculus and *R. affinis* are also transmissible to guinea pigs (see previous discussion).

Parasite: *Listrophorus gibbus*



Fig. 13.71 Male *Chirodiscoides caviae*, a fur mite of the guinea pig.

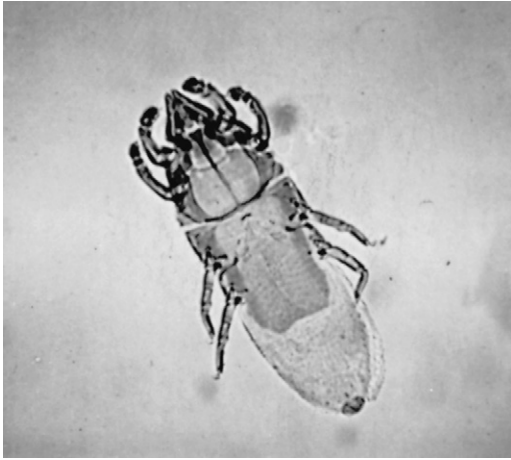


Fig. 13.72 Female *Chirodiscoides caviae*, a fur mite of the guinea pig.

Host: Rabbits

Location of Adult: Hair shafts

Distribution: Worldwide

Derivation of Genus: Not found

Transmission Route: Direct contact from host to host

Common Name: Rabbit fur mite

Zoonotic: No

Listrophorus gibbus (Rabbit Fur Mite)

Similar to *C. parasitivorax* (see Fig. 13.65), *Listrophorus gibbus* is a small, nonburrowing fur mite of rabbits. *L. gibbus* females are about 435 μm long, and males are 340 μm long. Both species have a dorsal hood-like projection covering the mouthparts. Males are further characterized by the clasping organs at their caudal end.

In the same manner as for *C. parasitivorax*, *L. gibbus* may be detected by pulling fur with forceps or cellophane tape and then examining the hairs under a dissecting microscope. Combing or brushing of the fur may also be used to obtain mites for identification. *L. gibbus* mites are most likely located on the back and abdomen of rabbits. This mite appears to produce no clinical signs, even in heavy infestations.

L. gibbus is transmitted by direct contact. Infestation with *L. gibbus* is treated with malathion dips or ivermectin (not approved for rabbits). This mite is more often associated with wild rabbits than with domestic species, so owners should be aware that control of this parasite depends on controlling the rabbit's environment. *L. gibbus* is not a known vector of disease and has no zoonotic significance in humans.

Technician's Note

The rabbit fur mite is more commonly associated with wild rabbits than with pet rabbits.

Ticks of Veterinary Importance

Ticks are small to medium-sized acarines with dorsoventrally flattened, leathery bodies. The tick's head, the capitulum, has two cutting, or lacerating, organs called **chelicerae**; a penetrating, anchor-like sucking organ, the **hypostome**; and two leg-like accessory appendages, the **pedipalps**, that act as sensors or supports when the tick fastens to the host's body. The tick's body may be partially or entirely covered by a hard, chitinous plate, the **scutum**. Mouthparts may be concealed under the tick's body or may extend from the anterior border of the body. Most ticks are **inornate**, meaning solid-colored (reddish or mahogany) and unpatterned.

Some species are **ornate**; that is, they demonstrate distinctive white patterns on the dark reddish or mahogany background of the scutum. Larval ticks have six legs, and nymphal and adult ticks have eight legs with strong claws on the ends.

Technician's Note

The tick's body has a capitulum (head) with chelicerae (two cutting or lacerating organs), a hypostome (penetrating and anchor-like sucking organ), and pedipalps (two leg-like accessory appendages) that act as sensors or supports when the tick fastens to the host's body.

Ticks are important parasites because of their voracious blood-feeding activity. They are also important because they are capable of transmitting many parasitic, bacterial, viral, rickettsial, and other pathogenic diseases, such as **borreliosis** (Lyme disease), among animals and from animals to humans. These pathogenic organisms may be transmitted passively, or the tick may serve as an obligatory intermediate host for certain protozoan parasites.

Ticks are also important because the salivary secretions of some female ticks are toxic and can produce a syndrome known as **tick paralysis** in humans and domestic and wild animals. Tick species associated with tick paralysis are *Dermacentor andersoni*, the Rocky Mountain spotted fever (RMSF) tick; *Dermacentor occidentalis*, the Pacific Coast tick; *Ixodes holocyclus*, the paralysis tick of Australia; and *Dermacentor variabilis*, the wood tick.

Technician's Note

Ticks are important veterinary parasites because they are voracious blood-feeders and act as vectors for transmitting various parasitic, bacterial, viral, rickettsial, and other pathogenic diseases, as well as causing tick paralysis.

The ticks of veterinary importance can be divided into two families, the **argasid**, or **soft ticks** and the **ixodid**, or **hard ticks**. Argasid ticks lack a scutum, the hard, chitinous plate that covers the body of the tick. The mouthparts of the adult soft tick cannot be seen when viewed from the dorsal aspect. Ixodid ticks, on the other hand, have a hard, chitinous scutum that covers all the male tick's dorsum and about a third or less of the female tick's dorsum, depending on the degree of engorgement. As a rule of thumb, male ticks are much smaller than female ticks.

Among the argasid ticks, two species are important: *Otobius megnini*, the spinose ear tick, and *Argas persicus*, the fowl tick. In the ixodid tick family, there are 13 economically important tick species. These include *Rhipicephalus sanguineus*, *Ixodes scapularis*, *Dermacentor* species, and *Amblyomma* species. Of these species, *R. sanguineus* infests buildings such as dwellings and kennels; the other ticks attack their hosts in outdoor environments.

Technician's Note

There are two families of ticks: the argasid ticks (ticks with soft bodies) and the ixodid ticks (ticks with hard bodies).

Specific identification of ticks is difficult and should be performed by a veterinary parasitologist or trained acarologist or arthropodologist. Ticks are usually identified by the shape and length of the capitulum or mouthparts, the shape and color of the body, and the shape and markings on the scutum. Male and unengorged female ticks are easier to identify than engorged female ticks. It is most difficult to speciate larval or nymphal ticks. The common species can be identified by their size, shape, color, body markings, host, and location on the host.

There are four major stages in the life cycle of ticks: egg, larva, nymph, and adult. After their engorgement on the host, female ticks drop off the host and seek protected places, such as cracks and crevices or under leaves and branches, to lay their eggs (Fig. 13.73). The six-legged larvae, or **seed ticks**, hatch from the eggs and feed on the host (Fig. 13.74). The larva molts to the eight-legged



Fig. 13.73 Adult female *Dermacentor variabilis* laying hundreds of eggs.



Fig. 13.74 Six-legged larva, or seed tick, of *Rhipicephalus sanguineus* hatches from the egg and feeds on the host.

nymphal stage, which resembles the adult stage but lacks the functioning reproductive organs of adult ticks. After one or two blood meals, the nymph becomes mature and molts to the adult stage. During the larval, nymphal, and adult stages, ticks may infest one, two, three, or even many different host species (Fig. 13.75). This ability to feed on several hosts during the life cycle plays an important role in the transmission of disease pathogens among hosts. It is important to remember that any infestation of domestic animals by either mites or ticks is referred to as **acariasis**.

Technician's Note

There are four stages to the tick life cycle: egg, larval, nymphal, and adult. In addition, ticks can be one-, two-, three-, or many-host ticks—meaning the tick uses different host and numbers of host to complete the ticks life cycle.

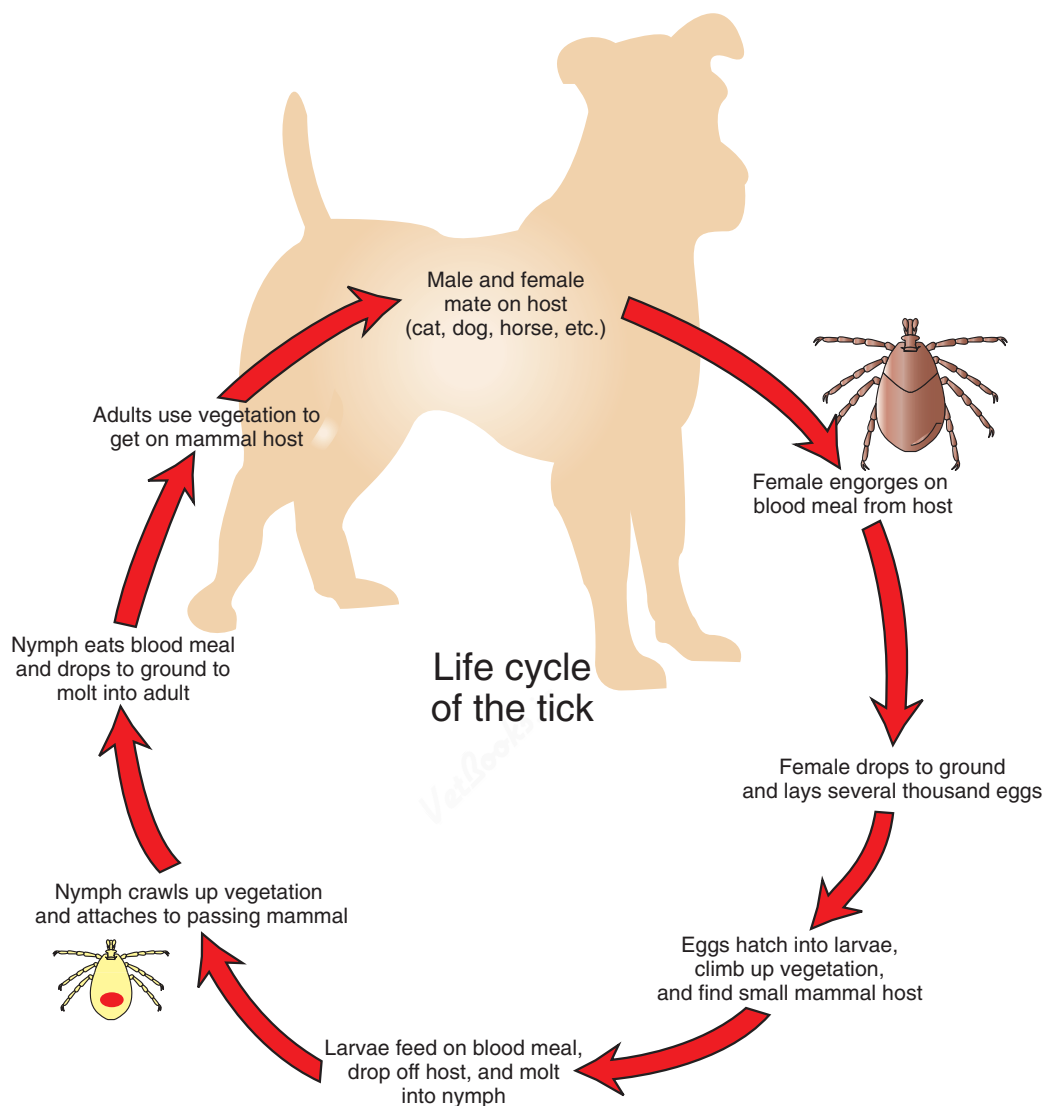


Fig. 13.75 Life cycle of the tick.

Most ticks do not tolerate direct sunlight, dryness, or excessive rainfall. They can survive as long as 2 to 3 years without a blood meal, but female ticks require a blood meal before fertilization and subsequent egg deposition. Tick activity is restricted during the cold winter months but increases dramatically during the spring, summer, and fall seasons.

Tick prevention is the best way to avoid acariasis by ticks. Prevention includes inspecting the animal for ticks each time the animal is outside and removing the ticks as soon as possible. Tick products, such as Frontline or Frontline

Plus and Advantix, will kill some species of ticks and are applied once a month. Amitraz is an effective dip for ticks, although there is no long-term residual benefit. Amitraz may also be purchased as a tick collar and is effective against ticks. New monthly preventatives and collars are being developed constantly.

Argasid (Soft) Ticks

Parasite: *Otobius megnini*

Host: Horses, cattle, sheep, goats, and dogs

Location of Adult: Environment of the animal; only larval and nymphal stages feed on the external ear canal of the animal

Distribution: Associated with arid and semiarid regions of the southwestern United States but can be found throughout North America

Derivation of Genus: Ear way of life

Transmission Route: Direct contact with infested environment

Common Name: Spinose ear tick

Technician's Note



Otobius megnini can attach to humans and cause tick paralysis. (NOTE: Every tick has the potential to cause tick paralysis.)

Otobius megnini (Spinose Ear Tick)

O. megnini, the **spinose ear tick**, is an unusual soft tick in that only the larval and nymphal stages are parasitic. The eight-legged adult stages are not parasitic but instead are free-living and are found in the environment of the definitive host, usually in dry and protected places, in cracks and crevices, and under logs and fence posts. The larval and nymphal stages feed on horses, cattle, sheep, goats, and dogs. These ticks are associated with the semiarid or arid areas of the southwestern United States; with widespread interstate transportation of animals, however, this soft tick may occur throughout North America. As with most soft ticks, the mouthparts may not be visible when viewed from the dorsal aspect (Fig. 13.76). The nymphal stage of *O. megnini* is widest in the middle and is almost violin shaped. It is covered with tiny backward-projecting spines, thus the name *spinose*. The larval and nymphal forms are usually found within the ears of the definitive host, thus the name *ear tick*. The body of the larval stage is covered with stout, tiny spines, whereas the nymphal stage resembles the adult tick on a smaller scale.

Technician's Note



Only the larval and nymphal stages of *Otobius megnini* feed on the animal host, where they can consume large amounts of blood without engorging or swelling.

Spinose ear ticks are extremely irritating to the definitive host. They often occur in large numbers deep within the external ear canal. These ticks imbibe large amounts of host blood; however, because they are soft ticks, they do not engorge or swell. Large numbers of these ticks may produce

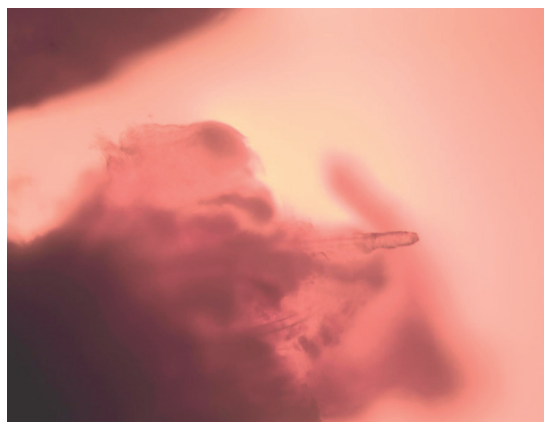


Fig. 13.76 Only the larval and nymphal stages of *Otobius megnini*, the spinose ear tick, are parasitic. The mouthparts of this soft tick may not be visible when viewed from the dorsal aspect.

ulcerations deep within the external ear. The ears become highly sensitive, and the animals may shake their heads. The pinnae may become excoriated by the constant shaking and rubbing of the animal's head.

The ticks may be visualized in situ with an otoscope. Any waxy exudate should be examined for the presence of larval (six-legged) and nymphal (eight-legged) stages of the spinose ear tick.

Parasite: *Argas persicus*

Host: Chickens, turkeys, and wild birds

Location of Adult: Attached to the skin of the bird when feeding and in the bird's environment when not actively feeding

Distribution: Worldwide

Derivation of Genus: Named for the 100-eyed monster that Hermes slew in Greek mythology

Transmission Route: Direct contact with infested environment

Common Name: Fowl tick

Argas persicus (Fowl Tick)

Argas persicus, the **fowl tick**, is a soft tick of chickens, turkeys, and wild birds. These ticks are periodic parasites, hiding in cracks and crevices during the day and becoming active during the evening hours when they feed intermittently on the avian host. The adults are 7 mm long and 5 mm wide. In the unengorged state, they are reddish brown, but after engorgement, they take on a slate-blue color. These ticks are flat and leathery, and the tegument is covered with tiny bumps. Because they are soft ticks, they lack a scutum. The mouthparts are not visible when the adult tick is viewed from the dorsal aspect.

Birds heavily infested with *A. persicus* may develop significant anemias. These ticks are worrisome to birds, particularly during the evening hours. The feeding activity of these ticks may cause the birds' egg laying to decrease or even cease.

All stages of *A. persicus* may be collected from infested birds, but it is most often found in cracks, crevices, and contaminated bedding in poultry houses.

Technician's Note



Argas persicus adults are reddish brown before feeding, but after feeding, they turn slate blue.

Ixodid (Hard) Ticks

Parasite: *Ixodes scapularis*

Host: Larval and nymphal stages: mice and voles; adult stage: horses, dogs, deer, and humans

Location of Adult: Attached to host for feeding, environment when not feeding, and can be found on tips of vegetation waiting for a host

Distribution: United States east of the Ohio River Valley

Derivation of Genus: Sticky, like bird-lime

Transmission Route: Direct contact with life stage on tip of vegetation

Common Name: Deer tick

Ixodes scapularis (Deer Tick)

Ixodes scapularis, the deer tick, is a hard-bodied three-host tick. The deer tick is found in regions east of the Ohio River Valley in the eastern United States. The adult ticks have eight legs that lack **festoons** (indentations or folds along the margin of an external body part such as the scutum, the posterior edge of the body, or the legs). The palps (mouthparts) are long, and the anal groove surrounds the anus anteriorly. The adult females have a small scutum, whereas the males have a large scutum. Adult females engorge or swell up when they take a blood meal. The eggs laid by the female are tiny and round. The larvae have six legs, whereas the nymphs have eight legs like the adult tick.

Technician's Note



Deer ticks can be found from the Atlantic Ocean to the Ohio River Valley and can be vectors in transmitting several bacteria and parasites.

I. scapularis is a bloodsucking tick that requires a blood meal before developing to the next life stage or laying eggs. These ticks are vectors for bacterial diseases such

as tularemia, *Babesia microti*, *Borrelia burgdorferi* (Lyme disease), and granulocytic ehrlichiosis (in humans). All developmental stages can be collected from the tips of vegetation, where they await the opportunity for a host to pass by so they can attach themselves to the host. The adults can attach to humans and transmit Lyme disease, tularemia, and babesiosis to the human host. The tick does not cause disease itself, although it can cause tick paralysis, but serves as a vector and intermediate host for the bacteria and parasites that do cause disease.

Technician's Note



Ixodes scapularis is the vector for spreading Lyme disease to dogs, horses, and humans.

Parasite: *Rhipicephalus sanguineus*

Host: Dogs

Location of Adult: Attached below the hair coat on the body but especially the external ear canal and between the toes

Distribution: North America

Derivation of Genus: Fan head

Transmission Route: Direct contact with infested environment

Common Name: Brown dog tick

Rhipicephalus sanguineus (Brown Dog Tick)

Rhipicephalus sanguineus, the brown dog tick, is an unusual hard tick in that it invades both kennel and household environments. This tick is widely distributed throughout North America. It has an inornate, uniformly reddish-brown scutum and feeds almost exclusively on dogs, thus the common name, **brown dog tick**. The adult can be found in the hair coat all over the dog's body but is especially fond of the external ear canal and the area between the toes. *R. sanguineus* also has a distinguishing key morphologic feature: Its basis capitulum (or head) has prominent lateral extensions that give the structure a decidedly hexagonal appearance (Fig. 13.77). The engorged female is often slate gray. In southern climates, the tick is found outdoors, but in northern climates, it becomes a serious household pest, breeding indoors in both home and kennel environments.

The bites of this tick can be very irritating to the dog. In severe infestations, heavy blood loss may occur. This tick is also an intermediate host for *Babesia canis*, the etiologic agent that causes canine piroplasmiasis.

Technician's Note



Rhipicephalus sanguineus ticks do not transmit any zoonotic diseases but can cause tick paralysis in humans.

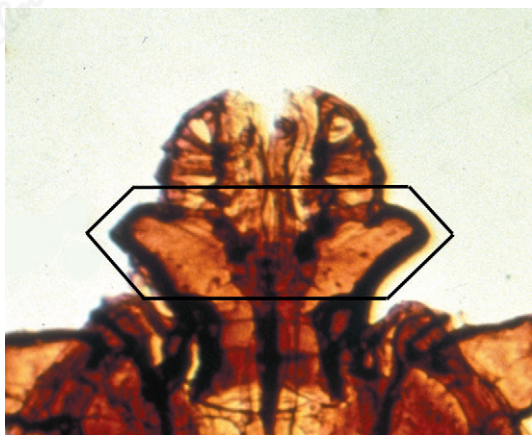


Fig. 13.77 The area including the basis capitulum of *Rhipicephalus sanguineus* has a unique hexagonal shape. (From Bowman DD: *Georgis' parasitology for veterinarians*, ed 10, 2013, Elsevier.)

R. sanguineus can be identified (with dichotomous keys) by its inornate brown color and characteristic lateral projections of the basis capitulum. These ticks are unique in that they can be found in an indoor or a kennel environment. Treatment can be accomplished by foggers that kill ticks or a house spray labeled for use against ticks. This treatment kills ticks indoors or in the kennel.

Parasite: *Dermacentor variabilis*

Host: Small mammals, dogs, and humans

Location of Adult: Attached to skin when feeding

Distribution: Primarily the eastern two-thirds of the United States but can be found throughout the United States

Derivation of Genus: Skin stabber or skin puncturer

Transmission Route: Direct contact with life stage at tip of infested vegetation

Common Name: American dog tick or wood tick

***Dermacentor variabilis* (American Dog Tick, Wood Tick)**

Dermacentor variabilis, the **American dog tick or wood tick**, is found primarily in the eastern two-thirds of the United States; however, with the increased mobility of American households, the tick may become distributed throughout the country. Unlike *R. sanguineus*, the *D. variabilis* tick inhabits only grassy, scrub-brush areas, especially roadsides and pathways. This three-host tick initially feeds on small mammals such as field mice and other rodents. However, dogs and humans can serve as preferred hosts for this ubiquitous tick. *D. variabilis* can serve as a vector of RMSF, tularemia, and other microbes. It has also been associated with tick paralysis



Fig. 13.78 Engorged adult female *Dermacentor variabilis*. Unfed adults are approximately 6 mm long; engorged adult females are about 12 mm long and blue-gray.

in domestic and wild animals and in humans. This tick has an ornate scutum that is dark brown with white striping. The adults have eight festooned legs, and the hypostome and palps are somewhat shortened. Unfed adult ticks are approximately 6 mm long; the adult engorged female is about 12 mm and is blue-gray (Fig. 13.78). *D. variabilis* is a seasonal annoyance to humans and domestic animals.

Technician's Note



The American dog tick is commonly found on dogs in the United States. *Dermacentor variabilis* can transmit Rocky Mountain Spotted Fever, tularemia, and other microbes. It can also produce tick paralysis.

D. variabilis can be diagnosed by its key morphologic features (with a dichotomous key) and the rectangular base of the capitulum and characteristic white markings on the dorsal shield.

Parasite: *Dermacentor andersoni*

Host: Larval and nymphal stages: small rodents; adult stage: dogs, horses, cattle, goats, sheep, and humans

Location of Adult: Attached to the skin surface

Distribution: Rocky Mountain regions but can travel on host to other parts of the United States and North America

Derivation of Genus: Skin sticker or skin puncturer

Transmission Route: Direct contact with infested vegetation

Common Name: Rocky Mountain wood tick

***Dermacentor andersoni* (Rocky Mountain Wood Tick)**
Dermacentor andersoni, or the **Rocky Mountain wood tick**, is typically seen in the Rocky Mountain regions, but with

the ease of travel, the host is able to carry it to other regions in the United States and North America. This is an ornate tick, and the adult has eight festooned legs. The hypostome and palps are short, with the female having a small scutum and the male having a large scutum. The eggs tend to be tiny and round. The female tick can lay as many as 4000 eggs in her lifetime. The larval stage has six legs, whereas the nymph has eight legs.

Technician's Note



Dermacentor andersoni is the Rocky Mountain wood tick that is considered the primary vector for the spread of Rocky Mountain Spotted Fever.

The larval (seed ticks) and nymphal stages are found on many small mammals, especially rodents. The adult stages are found on large mammals that include horses, dogs, cattle, sheep, goats, and humans. The male and female ticks are blood-feeders that can serve as vectors for a variety of animal and human pathogens. All life stages can be collected from the tips of vegetation, where they await a host to pass by.

These ticks can be identified by matching their short palps and hypostome, festooned legs, and ornate scutum with a dichotomous key. These ticks are capable of transmitting RMSF to animals and humans and are considered the primary vector for the transmission of RMSF.

Technician's Note



Dermacentor andersoni, being a three-host tick, is an excellent vector for spreading diseases of animals and humans.

Parasite: *Dermacentor occidentalis*

Host: Larval and nymphal stages: small mammals; adult stage: large mammals such as dogs, deer, cattle, horses, sheep, rabbits, and humans

Location of Adult: Attached to the skin of the host when feeding

Distribution: Sierra Nevada Mountains to the Pacific Ocean

Derivation of Genus: Skin stabber or skin puncturer

Transmission Route: Direct contact with infested vegetation

Common Name: Pacific Coast dog tick

***Dermacentor occidentalis* (Pacific Coast Dog Tick)**

Dermacentor occidentalis, or the Pacific Coast dog tick, is a brown tick with eight festooned legs. The adult has

short palps and a hypostome. The female has a small scutum, whereas the male possesses a large scutum. This tick is found in the United States between the Sierra Nevada Mountains and the Pacific Ocean from Oregon to southern California.

The eggs are tiny and round, and the larvae have six legs. The nymphal stage resembles a smaller version of the adult tick with eight legs. The larval and nymphal stages can be found feeding on small mammals, especially rodents. The adults are typically found feeding on large mammals, including horses, deer, cattle, donkeys, rabbits, sheep, and humans. All developmental stages can be collected from the tips of infested vegetation, where they await a host to pass by so that they can attach to it.

All developmental stages are blood-feeders and can act as vectors or intermediate hosts for a variety of animal and human pathogens, including tularemia. In addition, the tick can serve as a cause for tick paralysis in animals and humans.

Technician's Note



Dermacentor occidentalis, or the Pacific Coast dog tick, is typically found between the Sierra Nevada Mountains and the Pacific Ocean. However, with the ease of travel, the host can be carried to other regions of the United States and North America.

Parasite: *Amblyomma americanum*

Host: Larval and nymphal stages: small mammals; adult stage: wide range of mammal hosts including humans

Location of Adult: Attached to the skin of the host, particularly the ear

Distribution: Southern United States, Midwest, and Atlantic Coast of the United States

Derivation of Genus: Dull eye

Transmission Route: Direct contact with infested vegetation

Common Name: Lone star tick

***Amblyomma americanum* (Lone Star Tick)**

Amblyomma americanum demonstrates a characteristic white spot on the apex of its scutum, thus its common name, the **lone star tick**. The spot is more conspicuous on male than female ticks. This tick is distributed throughout the southern United States but is also found in the Midwest and on the Atlantic coast. All developmental stages can be collected from infested vegetation, where they await a host to pass by so that they can attach to it.

This three-host tick is found most often in spring and summer, parasitizing the head, belly, and flanks (the ear is the favored site) of wild and domestic animal hosts. It also

will feed on humans and is said to have a painful bite. It can produce anemia and has been incriminated as a vector of tularemia and RMSF.

A. americanum is easily diagnosed by the white spot on its scutum.

Technician's Note



Amblyomma americanum is a vector for the transmission of tularemia and Rocky Mountain Spotted Fever in animals and humans. It can be identified by a single white spot on its scutum.

Parasite: *Amblyomma maculatum*

Host: Larval and nymphal stages: ground birds; adult stage: cattle, horses, sheep, dogs, and humans

Location of Adult: Attached to the skin of the host when feeding

Distribution: Regions of high humidity such as the Atlantic and Gulf coasts of the United States

Derivation of Genus: Dull eye

Transmission Route: Direct contact with infested vegetation

Common Name: Gulf Coast tick

Amblyomma maculatum (Gulf Coast Tick)

Amblyomma maculatum, the **Gulf Coast tick**, is a three-host tick found in the ears of cattle, horses, sheep, dogs, and humans. It occurs in areas of high humidity on the Atlantic and Gulf coast seaboards. It produces severe bites and painful swellings and is associated with tick paralysis. This tick has silvery markings on its scutum. The larval and nymphal stages occur on ground birds throughout the year. The numbers of adult ticks on cattle decreases during winter and spring and increases in summer and fall. When the ear canals of cattle and horses are infested, the pinnae may droop and become deformed.

A. maculatum is easily diagnosed by the silvery markings on its ornate scutum (Fig. 13.79).

Technician's Note



Although *Amblyomma maculatum* is not associated with the transmission of any diseases in humans, it can cause tick paralysis.

Parasite: *Rhipicephalus* (formerly *Boophilus*) *annulatus*

Host: Cattle

Location of Adult: Attached to the skin of host while feeding

Distribution: Mexico or enzootic areas of the United States (from Mexican cattle crossing the border areas)



Fig. 13.79 Ornate adult male, *Amblyomma maculatum*. *A. maculatum* is easily diagnosed by the silvery markings on its scutum.

Derivation of Genus: Cattle lover

Transmission Route: Direct contact from host to host; all stages are found on the host

Common Name: Texas cattle fever tick or North American tick

Rhipicephalus annulatus (Texas Cattle Fever Tick)

Rhipicephalus annulatus, the **Texas cattle fever tick** or **North American tick**, uses only one host. This tick has historical significance in that it was the first arthropod shown to serve as an intermediate host for *Babesia bigemina*, a protozoan parasite of cattle. This tick, therefore, marks a milestone in veterinary parasitology. *R. annulatus* had been nearly eradicated from the United States. However, if it is ever diagnosed by a veterinary diagnostician, that fact *must* be reported to the proper regulatory agencies. The tick should be identified by a specialist and the appropriate control methods applied. *R. annulatus* enters the United States from Mexican cattle crossing the border lines in pasture.

The engorged *R. annulatus* female is 10 to 12 mm in length, and the male is 3 to 4 mm. The mouthparts are very short, and there are no festoons on the posterior aspect of the abdomen. It is an inornate tick.

Technician's Note



In 1892, Theobald Smith and the veterinarian F. L. Kilbourne found that *Rhipicephalus annulatus* was the first arthropod to be proven to serve as an intermediate host for a protozoan parasite (*Babesia bigemina*).

Because this is a one-host tick, larvae, nymphs, and adult ticks may be found on cattle. They do not leave the host to complete the life cycle. Animals with heavy infestations are

restless and irritated. To rid themselves of ticks, they rub, lick, bite, and scratch. Irritated areas may become raw and secondarily infested. If ticks are numerous, anemia may occur.

The veterinary diagnostician must use a key to identify adults of *R. annulatus*. Again, ticks identified as such must be reported to both state and federal authorities. Determining the origin of suspect ticks is of paramount importance. Most often, these ticks may be collected from within an enzootic area in the United States or from animals originating from Mexico.

Parasite: *Haemaphysalis leporispalustris*

Host: Larval and nymphal stages: rabbits, birds, and occasionally dogs, cats, and humans; adult stage: rabbits

Location of Adult: Attached to the skin of the host when feeding

Distribution: Worldwide

Derivation of Genus: Blood bladder or blood bubble

Transmission Route: Direct contact with infested vegetation

Common Name: Continental rabbit tick

Haemaphysalis leporispalustris (Continental Rabbit Tick)

Although numerous kinds of ticks may infest rabbits, most have a limited geographic distribution and are generally recognized by veterinarians in each geographic area. This discussion centers on *Haemaphysalis leporispalustris*, the **continental rabbit tick**. This tick has the widest geographic distribution of rabbit ticks in the Western Hemisphere. *H. leporispalustris* is a three-host tick, meaning that each developmental stage (larva, nymph, and adult) requires a separate host for a blood meal. Although rabbits may serve as the host for each stage, they seem to be the definitive host for only the adult stage. Larval and nymphal stages also feed on birds, occasionally on dogs and cats, and rarely on humans. Feeding on birds is thought to account for much of the wide geographic distribution of *H. leporispalustris* because these birds are often migratory.

Technician's Note

Haemaphysalis leporispalustris is a three-host tick that may use the rabbit in all developmental stages, but the rabbit is usually the definitive host for the adult stage of the tick.

H. leporispalustris is a small, eyeless tick and is distinguished in all stages of the life cycle by the laterally pointed angles formed at the base of the mouthparts, the basis capitulum. The basis capitulum causes the mouthparts to resemble a triangular head. Males are 2.2 mm long, and females are 2.6 to 10 mm long, depending on whether they are engorged with blood. The ticks may be found in the external ear canal and on the pinnae but are more frequently seen on the head and neck.

In extreme cases, large numbers of these ticks may produce emaciation and death. These rabbit ticks may spread diseases such as RMSE, Q fever, and tularemia. In general, *H. leporispalustris* occurs more frequently on wild than domestic rabbits, so owners should be warned of the disease potential for domestic rabbits that are not kept safely away from wild rabbits and birds.

Technician's Note

The continental rabbit tick is known to harbor and spread Q fever, Rocky Mountain Spotted Fever, and tularemia to humans and can also cause tick paralysis.

There are three arthropod parasites that must be reported by veterinarians to both state and federal authorities (specifically the USDA and the state veterinarian). These three arthropods are *Cochliomyia hominivorax* (the primary screw-worm), *Psoroptes* species in large animals ("scabies mites"), and *Rhipicephalus annulatus* (the Texas cattle fever tick).

It is important for the veterinary technician to use the Internet as a resource for gathering information to specifically identify these three parasites, especially *R. annulatus*. The other two arthropods may be identified in any veterinary practice with the use of a compound microscope. *Rhipicephalus annulatus* is identified by using special USDA keys. As an aside, when an individual is in doubt regarding a possible reportable parasite, it is always wise to err on the side of caution and report one's suspicions—whether right or wrong. There is not a single veterinary administrator in any department of agriculture who will be angry if the individual reporting is incorrect in his or her suspicions regarding any reportable parasite or disease affecting domestic animals. The administrator will be impressed that that individual is cognizant of the economic importance that any reportable parasite or disease might have on the economy of a nation. However, there will be plenty of concern should someone fail to acknowledge the presence of any reportable parasite or disease.

Chapter Thirteen Test

MATCHING 1—Match the scientific term in the left column with the correct phrase or term in the right column.

A. Arthropodology	1. Egg of either an anopluran or a mallophagan
B. Crustaceans	2. Bedbug
C. Centipedes and millipedes	3. No-see-ums
D. Blister beetles (Spanish fly)	4. Cockroaches and grasshoppers
E. Caterpillars	5. Black flies
F. Kissing bugs	6. Importance: first intermediate host for <i>Paragonimus kellicoti</i> , <i>Diphyllbothrium latum</i> , <i>Spirometra mansonoides</i> , and <i>Dracunculus insignis</i>
G. <i>Cimex lectularius</i>	7. Head wider than widest part of thorax
H. Mallophagans (chewing lice)	8. Cantharidin
I. Anoplurans (sucking lice)	9. Sand flies capable of transmitting <i>Leishmania</i> species
J. Dictyopterans	10. The study of arthropods, creatures with jointed appendages
K. Nit	11. Head more narrow than widest part of thorax
L. Pediculosis	12. Intermediate host for <i>Trypanosoma cruzi</i> (Chagas disease)
M. <i>Simulium</i> species	13. Infestation with lice, either mallophagan or anopluran
N. <i>Lutzomyia</i> species	14. Urticating or stinging hairs
O. <i>Culicoides</i> species	15. Produce venomous substances

MATCHING 2—Match the scientific term in the left column with the correct phrase or term in the right hand column.

AA. <i>Chrysops</i> species, <i>Tabanus</i> species	1. Free-living dipteran fly larvae developing a parasitic dependence
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BB. <i>Stomoxys calcitrans</i>	2. Heel flies or ox warbles
CC. <i>Haematobia irritans</i>	3. Dipteran fly larvae or maggots within contaminated wounds
DD. <i>Melophagus ovinus</i>	4. Stable fly or biting housefly
EE. <i>Musca autumnalis</i>	5. Wolves or warbles in the skin of dogs and cats
FF. Myiasis	6. Housefly
GG. Facultative myiasis	7. Horn flies
HH. Obligatory myiasis	8. Blowflies or bottle flies
II. <i>Calliphora</i> , <i>Phaenicia</i> , <i>Lucilia</i> , and <i>Phormia</i> species	9. Primary screwworm; dipteran larvae reportable to U.S. Department of Agriculture
JJ. <i>Musca domestica</i>	10. Sheep ked
KK. Strike or fly strike	11. Face fly
LL. Posterior spiracular plate	12. Morphologic feature used to identify or speciate dipteran fly larvae
MM. <i>Cochliomyia hominivorax</i>	13. Infestation or infection with dipteran larvae or "maggots"
NN. <i>Cuterebra</i> species	14. Completely parasitic dipteran fly larvae
OO. <i>Hypoderma</i> species	15. Deerflies, horseflies

MATCHING 3—Match the scientific term in the left column with the correct phrase or term in the right column.

AAA. Gadding	1. Resemble tiny pearls; nonsticky, 0.5 mm long, white, oval, and rounded at both ends
BBB. <i>Gasterophilus</i> species	2. Ear canker mite of rabbits
CCC. <i>Oestrus ovis</i>	3. Colloquial term used to describe cattle running or evading adult heel flies
DDD. <i>Ctenocephalides felis</i>	4. Feline scabies mite
EEE. <i>Echidnophaga gallinacea</i>	5. Guinea pig mite
FFF. Larval siphonapterans	6. Horse bots

GGG. Flea eggs	7. Cat flea
HHH. Flea frass	8. Infestation with either mites or ticks
III. Pedicel	9. Scaly leg mite of budgerigars (parakeets)
JJJ. Acariasis	10. Sticktight flea of poultry
KKK. Scabies	11. Stalk at the tip of a sarcoptiform mite's leg: They can be long or short, jointed or unjointed
LLL. <i>Notoedres cati</i>	12. Infection with <i>Sarcoptes scabiei</i>
MMM. <i>Cnemidocoptes pilae</i>	13. Resemble tiny fly maggots, sparsely covered with tiny hairs
NNN. <i>Trixacarus caviae</i>	14. Nasal bot fly of sheep and goats
OOO. <i>Psoroptes cuniculi</i>	15. Reddish-black, pepper-like specks found with dog or cat's hair coat; actually dried flea feces

MATCHING 4—Match the scientific term in the left column with the correct phrase or term in the right column.

aa. <i>Psoroptes</i> species of large animals	1. Tick reportable to the U.S. Department of Agriculture (USDA); Texas cattle fever tick
bb. <i>Chorioptes</i> species	2. Spinose ear tick
cc. <i>Otodectes cynotis</i>	3. Mite reportable to the USDA

dd. <i>Demodex canis</i>	4. American dog tick
ee. <i>Trombicula</i> species	5. Feline fur mite
ff. <i>Pneumonyssoides caninum</i>	6. Foot and tail mite; itchy leg mite
gg. <i>Ornithonyssus bacoti</i>	7. Hard ticks with scutum with a pattern of white on a dark background
hh. <i>Cheyletiella</i> species	8. Follicular mite of dogs
ii. <i>Lynxacarus radovskyi</i>	9. Lone star tick
jj. Argasid ticks	10. Hard ticks with a dark-colored scutum
kk. Ixodid ticks	11. Tropical rat mite
ll. <i>Otobius megnini</i>	12. Canine and feline ear mite
mm. <i>Argas persicus</i>	13. Soft ticks
nn. <i>Rhipicephalus sanguineus</i>	14. Rabbit tick
oo. <i>Dermacentor variabilis</i>	15. Walking dandruff of dogs, cats, and rabbits
pp. <i>Amblyomma americanum</i>	16. Hard ticks
qq. <i>Boophilus annulatus</i>	17. Fowl tick
rr. <i>Haemaphysalis leporispalustris</i>	18. Nasal mite of dogs
ss. Ornate ticks	19. Brown dog tick
tt. Inornate ticks	20. Chiggers

Questions for Thought and Discussion

- Of all the arthropods in this chapter, which do you think is the best practice builder in a small animal veterinary clinic?
- Of all the arthropods in this chapter, which do you think is/are the most important parasites to be able to successfully identify with respect to your reputation or standing with your state veterinarian or with the U.S. Department of Agriculture?
- One of the major ways in which arthropods are important is that they are capable of serving as intermediate hosts for both protozoan and helminth parasites. List 10 arthropods and link them to the protozoans or parasites with which they are associated.
- Describe the morphologic features or characteristics that can be used to identify the following:
 - Adult dipteran flies
 - Larval dipterans (maggots)
 - Sarcoptiform mites
 - Ticks

Introduction to the Phylum Arthropoda, Subphylum Pentastomida

OUTLINE

Pentastomes (Parasites of Reptiles)	238
Morphology	238
Life Cycle	239
Diagnosis	240
Adult Pentastome That Infects Nasal Passages and Turbinates of a Mammalian Host	241
Diagnosis	242

LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Describe the life cycle of the pentastomes.
- Understand the zoonotic potential for reptilian pentastomes and the importance of thorough handwashing after contact with snake feces.

KEY TERMS

Larval pentastome	Pentastome
Linguatuliiasis	Pentastomiasis
Linguatulids	Pleomorphic
Linguatulosis	Tongue worms
Nymphal pentastome	

Pentastomes (Parasites of Reptiles)

Reptiles have served as hosts to protozoan and metazoan parasites for eons. One of the oldest continuing host-parasite relationships is that between snakes and pentastomes. Pentastomes are almost exclusively parasites of the reptilian

respiratory system. According to theory, the pentastomes' ancestors were once land animals that invaded the respiratory passages of reptiles. These rare parasites hold serious zoonotic consequences for humans, who can unwittingly serve as incidental hosts.

Pentastomes have lost most of their morphologic similarity to other major phyla; they are a taxonomist's dilemma. During their life cycle, pentastomes are **pleomorphic** (demonstrating a variety of morphologic forms). They resemble acarines (mites) during their larval stage but look like annelids (earthworms) during their nymphal and adult stages. It is difficult to assign them to either phylum, which probably means that they possess a common ancestor with annelids and arthropods. Therefore these creatures have been assigned to the subphylum Pentastomida.

Technician's Note



Pentastomes resemble mites during their larval stage and annelids during their nymphal and adult stages; therefore they have been assigned to the subphylum Pentastomida.

Morphology

The name **pentastome** (*penta* meaning "five" and *stome* meaning "mouth," thus "five mouths") was chosen because, as adults, these parasites have a mouth that is surrounded by four hooked claws on the anterior end. Early investigators erroneously believed these claws to be four additional mouths; one mouth plus four mouths equals five mouths. Pentastomes have also been called **tongue worms** and **linguatulids** because of their distinct tongue shaped appearance, being wider anteriorly than posteriorly (Fig. 14.1).



Fig. 14.1 Distinctive tongue shaped appearance of a pentastome. Because these strange parasites are flattened and wider anteriorly than posteriorly, they are often referred to as *tongue worms*. The canine pentastome, *Linguatula serrata*, has a transversely striated cuticle. The female is 8 to 13 cm long, and the male is 1.8 × 2 cm.



Fig. 14.2 Assorted adult reptilian pentastomes from the respiratory tracts of snakes. *Left to right*, mature *Kiricephalus* species, immature *Kiricephalus* species, and mature *Armillifer* species.

Infection with pentastomes is referred to as **pentastomiasis**, **linguatuliasis**, **linguatulosis**, or rarely **porocephalosis** or **porocephaliasis** (after *Porocephalida*, one of two orders composing the subphylum Pentastomida).

Grossly, pentastomes resemble helminths; however, they are often grouped with the phylum Arthropoda because of the mite-like larval stage that appears during their life cycle.

Pentastomes are almost always parasites of reptiles; the exceptions to this rule are species of *Linguatula serrata* (which parasitize carnivores) and *Reighardia sterna* (a parasite of seagulls and terns). Within the phylum are nine genera that parasitize snakes, three that parasitize lizards, four that parasitize crocodiles, and two that favor turtles. Among snakes, the most common genera are *Armillifer* species that parasitize pythons and vipers, *Kiricephalus* that parasitize cobras, and *Porocephalus* that parasitize boas and rattlesnakes (Fig. 14.2).

Technician's Note

With the exception of two species of pentastomes, almost all pentastomes parasitize reptiles.



Life Cycle

Adult reptilian pentastomes are dioecious parasites; they have separate sexes, and there are both male and female pentastomes. Pentastomes are parasites that occur almost exclusively within the lungs, trachea, and nasal passages of the reptilian definitive host, feeding on tissue fluids and blood cells. Female pentastomes produce several million fully embryonated eggs, each containing a single

larva with two or three pairs of rudimentary clawed legs. Eggs are “coughed up,” swallowed, and passed to the outside environment within the host feces. The oval, tailed **larval pentastome** with four to six stumpy legs, each with one or two retractable, pincer-like claws, hatches from the egg and is infective for the intermediate host. Fig. 14.3 shows the life cycle of a reptilian pentastome.

Intermediate hosts include rodents, herbivores, carnivores, nonhuman primates, and humans. The larval pentastome bores through the intestinal wall of the intermediate host and passes with the blood to the mesenteric lymph nodes, the liver, the lungs, the omentum, or other internal organs, where it becomes encysted. The larva becomes “quiescent” and changes into the annelid (worm-like) nymphal stage, which can pass through as many as five molts. The reptilian definitive host becomes infected by ingesting the intermediate host with its encysted **nymphal pentastomes**. The infective nymphs penetrate the host’s intestine and bore into the lungs, where they become sexually mature adult parasites. The life cycle of the typical pentastome is an oddity in that the organism serving as the intermediate host (e.g., a mammal) is *higher* in the phylogenetic classification scheme than the definitive host (the reptile); this situation is uncommon among the life cycles of parasites. With most parasites, the organism serving as the intermediate host is *lower* in the phylogenetic classification scheme than the host that serves as definitive host.

Technician's Note

The intermediate hosts for reptilian pentastomes include rodents, herbivores, carnivores, nonhuman primates, and humans.



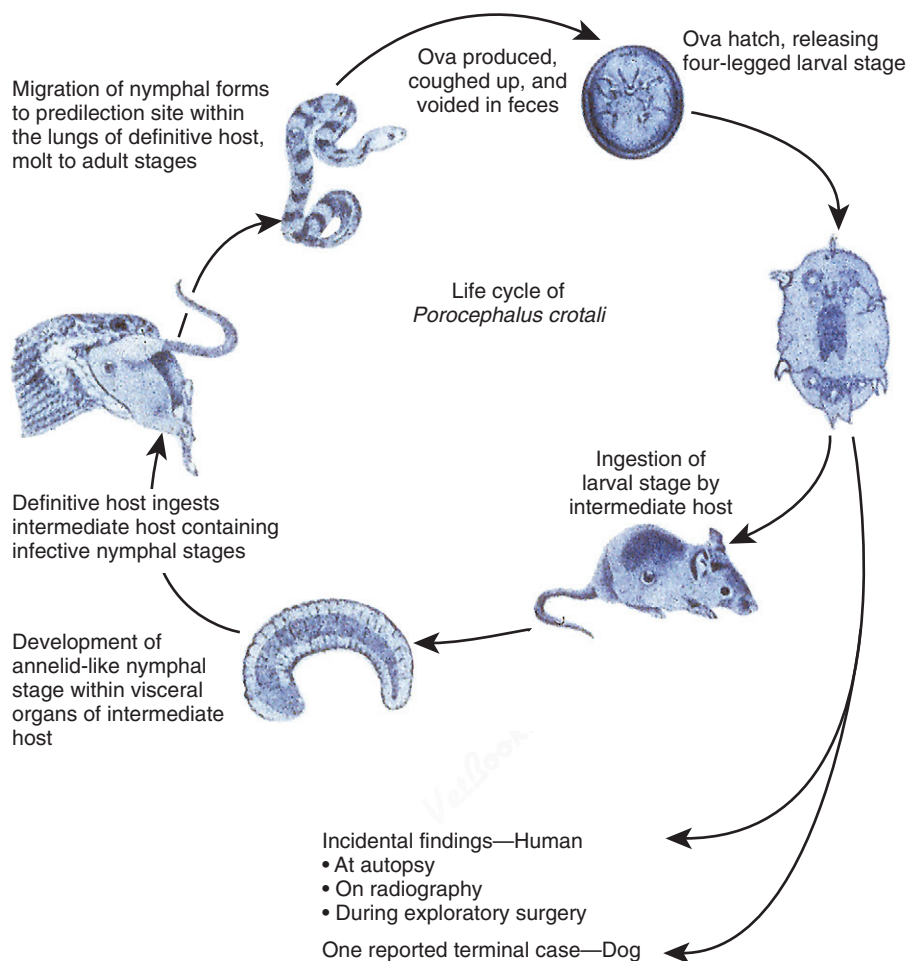


Fig. 14.3 Life cycle of *Porocephalus crotali*, a pentastome of rattlesnakes.

Diagnosis

Definitive Host

Clinical signs of reptilian pentastomiasis include lethargy, anorexia, dyspnea, and production of blood-tinged sputum or mucus within the pharynx or the trachea. The sputum can contain eggs that microscopically appear to contain four-legged to six-legged larvae with retractable claws. These pentastome eggs also can be found in the feces of the definitive host. Hematologic studies might demonstrate leukocytosis and eosinophilia. Radiographic examination might reveal adult worms or remnants of calcified cysts.

Adult reptilian pentastomes are not confined to the lungs. Adult and juvenile pentastomes might attempt to exit the host through the reptile's nostrils or mouth or through the body wall and skin whenever the reptile is

stressed. Reptilian pentastomiasis also can be diagnosed by biopsy of infected tissues or recovery of the parasite at necropsy.

Technician's Note



Pentastome eggs can be found on standard fecal flotation procedures on the feces of the definitive host.

Incidental Host

In contrast to pentastomid infections in natural intermediate hosts, infections in incidental hosts are striking. An incidental host is usually asymptomatic to nymphal

invasion; nymphs are often found during radiographic examination, during surgery, or at necropsy. Nymphs can affect vital structures and produce pathology that leads to the demonstration of related clinical signs. Death can result.

A case of incidental nymphal pentastomiasis has been reported in dogs. Eosinophilic inflammatory responses were noted in thoracic and abdominal cavities. These responses were presumably caused by the extensive migratory paths of the pentastomes. During exploratory surgery, it was noted that all peritoneal and visceral surfaces were covered with 3- to 5-mm, C shaped, cystic structures, each of which contained an elongated, coiled nymph. The nymphs were identified as those of *Porocephalus crotali*, a pentastome of rattlesnakes.

Humans also are incidental mammalian hosts of pentastomids. The fact that humans can serve as intermediate hosts for reptilian pentastomes is sufficient reason for veterinarians to recognize the zoonotic potential of these parasites. Human infections with reptilian pentastomes have been reported from all continents but are most common in Africa and Malaysia. Almost all recorded infections in humans have been incidental findings during radiographic examination (pentastomes often die in tissue locations and become calcified), exploratory surgery, or autopsy. Those pentastomes recovered during autopsy are usually not related to the cause of death; however, under certain circumstances, nymphs may cause significant pathology because of the organ location, the large number of nymphs involved, or their extensive tissue migrations.

Technician's Note



With the exception of humans, incidental infection with pentastomes can cause death to the incidental host related to the migration of larval and nymphal stages and the damage to organs that these migrations produce.

On histopathologic examination of tissue, the characteristic C shape of the nymph can be seen. Pentastomid nymphs have a pseudosegmented body with a prominent body cavity, a striated musculature, a digestive tract with numerous villi, and acidophilic glands surrounding the intestine. The nymphal pentastome's cuticle may be spiny, smooth, or annulated and may possess numerous acidophilic skin glands that communicate with the cuticle through sclerotized openings. Most of these morphologic features can be identified by either a trained pathologist or a parasitologist.

Antemortem diagnosis of pentastomiasis in the intermediate host can be accomplished by radiographic examination. In these hosts, pentastomes may die in their tissue sites and become calcified; these calcified pentastomes may be visible on radiography.

Technician's Note



Diagnosis of pentastomiasis in the intermediate host can be made by radiographic examination for calcified pentastomes.

Adult Pentastome That Infects Nasal Passages and Turbinates of a Mammalian Host

Parasite: *Linguatula serrata*

Host: Dogs

Location of Adult: Nasal passages and sinuses

Distribution: Worldwide

Intermediate Host: Cats, rats, porcupines, guinea pigs, rabbits, hedgehogs, pigs, and ruminants

Derivation of Genus: Small tongue

Transmission Route: Ingestion of infective intermediate host

Common Name: Canine pentastome

Zoonotic: Yes

Linguatula serrata, the canine pentastome, is found in the nasal passages and sinuses of dogs and other canids. Intermediate hosts are cats, rats, porcupines, guinea pigs, rabbits, hedgehogs, pigs, and wild and domestic ruminants. In North America, rabbits are the most common intermediate hosts. Both adult and nymphal stages of this parasite may infect humans. Humans harbor nymphal stages after ingesting eggs from contaminated feces. Nymphs may be found in a variety of organs—the spleen, liver, and mesenteric lymph nodes. Humans become definitive hosts by eating raw or undercooked meat or meat by-products that contain the nymphal stages.

Technician's Note



In North America, the rabbit is the common intermediate host for *Linguatula serrata*; humans can harbor nymphal stages after ingesting eggs from contaminated snake feces.

Diagnosis

Definitive Host

Usually there are no signs of infection; however, dogs may exhibit catarrhal or suppurative rhinitis and bleeding of the nose, usually related to inflammatory damage. Restlessness, sneezing, difficulty breathing, and a reduced sense of smell have been observed. The adult parasite may be observed in its predilection site or may be sneezed out or coughed up. The adult parasite resembles a helminth (worm), but as with all pentastomes, it is an arthropod. The parasite is tongue shaped and flattened and has a transversely striated cuticle. The female is 8 to 13 cm long, and the male is 1.8 × 2 cm in size (see Fig. 14.1).

Eggs may be observed on fecal flotation or nasal swabs. Eggs are yellow-brown, oval, and 70 × 90 μm and have a thick chitinous shell. An embryo with two pairs of irregularly arranged, chitinous claws may be observed on the inside of the egg. Each egg is initially enclosed in a thin, bladder-like envelope containing a clear fluid. This envelope is usually removed during passage through the gastrointestinal tract (Fig. 14.4).

Intermediate Host

Nymphs of *L. serrata* in the intermediate host are detected by biopsy, exploratory laparotomy, postmortem examination, and subsequent histopathology.

The veterinarian must remember that pentastomes are rare, unusual parasites of snakes and dogs. It is important to note that the hands should *always* be washed after

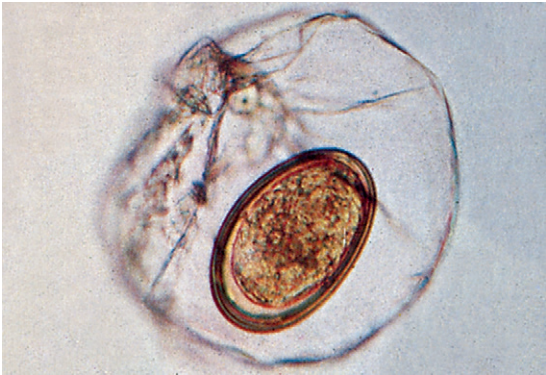


Fig. 14.4 The eggs of *Linguatula serrata* are yellow-brown, oval, and 70 × 90 μm and have a thick chitinous shell. An embryo with two pairs of irregularly arranged chitinous claws may be observed on the inside of the egg. Each egg is initially enclosed in a thin, bladder-like envelope containing clear fluid. This envelope is usually removed during passage through the gastrointestinal tract.

handling snake feces. Humans can serve as an intermediate host for this strange parasite.

Technician’s Note



Although pentastome infections are rare, hands should always be washed after handling snake feces as a precautionary measure.

Chapter Fourteen Test

MATCHING—Match the scientific term in the left hand column with the correct phrase or term in the right hand column.

A. Pentastomes	1. Derivation of the term <i>pentastome</i>
B. Pentastome’s larval stage	2. Thorough handwashing after handling of snakes or snake feces
C. Pentastome’s nymphal or adult stage	3. Tongue worms or linguatulids
D. Reptiles	4. Rattlesnake pentastome
E. <i>Porocephalus crotali</i>	5. Very similar to an annelid; they are very worm-like in appearance
F. <i>Linguatula serrata</i>	6. Site of infection for canine pentastomes
G. Prevention of human pentastomiasis	7. Characteristic trait of pentastome nymph in histopathologic section
H. Acidophilic glands around the intestine	8. Very similar to a mite; it has jointed appendages
I. Nasal passages and sinuses	9. Principal definitive hosts for pentastomes
J. Five mouths	10. Canine pentastome

Questions for Thought and Discussion

1. Snakes are becoming increasingly popular with the public at large. From a public health view, how might one counsel a client with regard to maintaining a snake in the home?
2. What should a veterinarian tell the owner of a dog infected with adult *Linguatula serrata*?

Chapter

15

The Phylum Annelida

OUTLINE

Hirudinea (Leeches)	244
Morphology	244
Life Cycle of the Leech	245

LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Describe the morphology of leeches.
- Describe the pathology associated with hirudiniasis.
- Describe the beneficial use of leeches in both human and veterinary medicine.

KEY TERMS

Annelids	<i>Hirudo medicinalis</i>
Hirudin	Pseudosucker
Hirudineans	Stepping
Hirudiniasis	

Kingdom: Animalia
Phylum: Annelida
Class: Hirudinea

Leeches and earthworms are **annelids**. Leeches are not considered to be true helminths but are often described as parasitic worms. As external parasites of humans and domesticated and wild animals, leeches are members of the phylum Annelida and the class Hirudinea.

Technician's Note



Although leeches are considered ectoparasites, one species, *Hirudo medicinalis*, is used for medicinal purposes.

Hirudinea (Leeches)

Leeches or **hirudineans** can be predatory or scavenging. Most often, they are parasitic on a wide variety of vertebrates and invertebrates. The ectoparasitic leeches feed on blood from fish, crustaceans, frogs, turtles, mollusks, and birds, as well as land animals such as cattle, horses, assorted primates, and humans. These ectoparasites range in size from tiny species that are 5 mm long to varieties such as *Haemopsis sanguisuga*, the horse leech, which has been reported to be as long as 45 cm when extended and swimming.

Morphology

Leeches have slender, leaf shaped bodies that lack bristles. The typical leech has two suckers, a large, adhesive posterior sucker and a smaller anterior sucker. The anterior sucker is actually a **pseudosucker** and surrounds the mouth. As a member of the phylum Annelida, the leech is segmented and lacks a hard exoskeleton; in its place, the leech has a thin, flexible cuticle. Because of this thin cuticle, leeches dry out quickly and must always be closely associated with water. A few leeches are found in saltwater; a few terrestrial (land) leeches are found in moist, damp locations. For the most part, leeches should be considered aquatic animals.

Technician's Note



The leech has a segmented body that lacks a hard exoskeleton. Instead, it has a thin, flexible cuticle.

As a result of these different habitats, leeches have developed two widely different locomotory habits, swimming and stepping. **Swimming** is the method of locomotion used when the leech is in water. The leech's body becomes

flattened dorsoventrally as waves of muscular contraction pass down its length. The result is an undulating motion that propels the leech forward.

Stepping is the method of locomotion used when the leech is on solid ground. While in this mode, the leech moves in an “inchworm-like” manner, using its cranial and caudal suckers as organs of attachment to move along the substrate (surface). The layer of circular muscle just beneath the epidermis contracts, and the leech becomes long and thin. The cranial sucker then attaches to the substrate, the caudal sucker releases, and the longitudinal muscle layer beneath the circular muscle brings the caudal sucker up to the vicinity of the cranial sucker, where it attaches. The overall effect is “stepping.”

Technician's Note



When on land, the leech moves using an inchworm-like motion called *stepping*. It alternates using its cranial and caudal suckers to attach to and move along surfaces.

While the leech is attached to the host with its caudal sucker, it uses the cranial sucker to explore the host's skin to locate a suitable feeding site and to attach tightly. Three rows of jaws with approximately 100 teeth are found in the cranial sucker. These teeth operate similar to a circular saw, penetrating through the skin to a depth of 1.5 mm. The wound produced by the leech bite is a characteristic Y shaped skin incision. When the incision is made, the host feels very little pain.

In the past, analgesia was thought to be caused by the release of an anesthetic in the leech saliva, but it is now believed that leech saliva does *not* contain an anesthetic. The ability of a leech to feed is made easier by the secretion of powerful anticoagulants into the site of attachment. A histamine-like substance is added to the wound to prevent the collapse of adjacent capillaries. As blood passes through the mouth, the anticoagulant hirudin is added to it. **Hirudin** is a 64-amino acid peptide with a function similar to that of antithrombokinase. It has been described as the most powerful anticoagulant known. Active agents in the saliva of various species of leeches include a hyaluronidase, a collagenase, and two fibrinases.

Technician's Note



Hirudin, one of the most powerful anticoagulants known, is secreted into the bite wound of the leech to keep the host bleeding as the leech feeds.

When engorged with blood, the leech is dark and bloated; some leeches can ingest blood meals that are 900% of their body weight. True bloodsucking leeches require a blood meal only occasionally; consumed blood is used very slowly, so slowly that some leeches have been kept in captivity for more than 2 years without being fed. The mouth leads to a pharynx with salivary glands that secrete hirudin, a crop where ingested blood is stored, a stomach, an intestine, a rectum, and an anal pore near the caudal sucker.

Life Cycle of the Leech

As with the flatworms (flukes and tapeworms), leeches are hermaphroditic. Because male and female organs are located on adjacent body segments, self-fertilization is impossible, and cross-fertilization must take place. After copulation, both partners are fertilized. Eggs are laid in cocoons. The cocoon of each species of leech has a characteristic shape and design. **Hirudo medicinalis**, the medicinal leech, produces from one to seven cocoons, each of which may contain 5 to 15 eggs. Depending on the species of leech, cocoons may be attached to the parent's body or adhere to solid surfaces within the aquatic environment. Young leeches hatch from the eggs, feed for a few days on the yolk, and develop to the adult bloodsucking mode. Adult leeches can live for as long as 18 to 27 years.

The term **hirudiniasis** is derived from the classic Linnaean nomenclature and can be defined as invasion of the nose, mouth, pharynx, or larynx by leeches or the attachment of leeches to the skin. The terrestrial, or land, varieties of leeches are primarily found in the tropical regions of the world, particularly Southeast Asia, the Pacific Islands, the Indian subcontinent, and South America. Land leeches are found on the surface of trees and grasses and under stones in damp places. One terrestrial leech, *Haemopsis terrestris*, has been plowed up in fields in the mid-western United States.

Technician's Note



Land leeches are found on the surface of trees and grasses or under stones in damp places. They mostly occur in tropical regions of the world.

Punctures made in the skin by land leeches are painless, remain open, and continue to bleed long after the leech has detached. Land leeches in Southeast Asia and India congregate in such large numbers on the legs of cattle, horses, and other native animals that they interfere with the ambulation of the host. Because leeches can ingest so much blood,

further complications for the host include anemia and even death from blood loss.

Terrestrial leeches that attach to the skin should never be pulled off but instead must be induced to detach. If pulled off, these leeches may leave their jaws embedded in the skin; such remnants can induce ulceration and serve as a site of infection. Drops of concentrated salt solution, alcohol, or strong vinegar applied around the mouth of the leech, or heat with a lighted match or cigarette applied to the leech's body will cause land leeches to release their hold. The open wound should be treated with a styptic and an antiseptic.

Technician's Note



Never pull an attached leech off of a host; instead, the leech must be induced to detach on its own. Pulling the leech off can result in leaving mouthparts in the skin, causing ulceration of the site and possibly infection.

Aquatic leeches can be external or internal parasites. Two genera of aquatic leeches (*Limnatis* and *Dinobdella*) have veterinary significance because they parasitize monkeys and domestic animals. *Theromyzon tessulatum* parasitizes wild and domestic aquatic birds. These genera reside in fresh water, where they come in contact with the vertebrate host.

Leeches entering the mouth or nostrils of the host can pass to the nasopharynx, epiglottis, esophagus, trachea, and bronchi. After attaching itself to the mucous membranes, the leech secretes its anticoagulant and engorges. Depending on the site of attachment, leeches may cause the host to exhibit nosebleeds or cough up or vomit blood. A leech attached in the laryngeal region may produce a cough with a bloody discharge, difficulty in breathing, pain, and even suffocation. A leech localized in the region of the epiglottis may cause difficulty in swallowing. In severe breathing disturbances, the host's neck may be extended, and the animal may exhibit open-mouthed breathing.

Technician's Note



Aquatic leeches can attach to the nasopharynx, epiglottis, esophagus, trachea, and bronchi, causing nosebleeds and the coughing up or vomiting of blood.

Parasite: *Hirudo medicinalis*

Host: Humans

Location of Adult: On the skin

Distribution: Worldwide for medicinal use but native to Europe, Asia, and South America

Derivation of Genus: Leech

Transmission Route: Intentional placement for medicinal purposes

Common Name: Medicinal leech

Zoonotic: No

Several species of leeches have proved to be beneficial to humans. Perhaps the best-known leech used for bloodletting is *Hirudo medicinalis*, the European medicinal leech. This leech is a native of Europe, parts of Asia, and (after its introduction) South America. It possesses a distinct green pattern of pigmentation with brown stripes and ranges in size from less than 1 cm to more than 20 cm in length (Figs. 15.1 and 15.2). On its anterior end is a muscular sucker that contains three sharp chitinous jaws armed with saw shaped teeth; its caudal end has a characteristic sucker-like disk. This species can ingest an amount of blood up to five times its own weight. When the leech has taken a blood meal from the host, it may take as long as 200 days for digestion. This leech is reported to have gone without food for as long as 18 months.

Technician's Note



Medicinal leeches, *Hirudo medicinalis*, can consume blood up to five times their own weight.

H. medicinalis has been the leech used most often for bloodletting purposes throughout history. Its present use in reconstructive and microvascular surgery in humans is gaining impetus. Medicinal leeches have also been used in applications in both veterinary surgery and medicine. Recently, there has been revived interest in these unique ectoparasites.

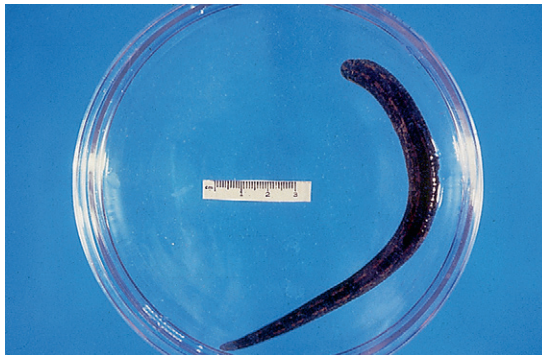


Fig. 15.1 Extended *Hirudo medicinalis* in a Petri dish. Note that the narrow end is the cranial end and has an oral sucker. The wide end is the caudal end with a sucker.



Fig. 15.2 Contracted *Hirudo medicinalis* in a Petri dish. Note the external segmentation on the body.

Technician's Note



Medicinal leeches are most often thought of in conjunction with bloodletting throughout history.

H. medicinalis serves as an important medical tool because it can produce a small bleeding wound that mimics venous outflow in tissues with impaired venous circulation (Fig. 15.3). Leeches are indicated only for tissues with such impairment. The leech's main benefit is not the average 5 mL of blood removed during attachment but rather the volume of blood (reportedly as much as 50 mL) that continues to ooze for 24 to 48 hours after the leech has detached. This local bleeding is related to pharmacologically active anticoagulants and vasodilator substances introduced by the leech bite. Each bite can be encouraged to bleed further by gently removing clots that form. Research has demonstrated that new vessels begin to grow around the flap margins after approximately 72 to 120 hours.



Fig. 15.3 *Hirudo medicinalis* feeding on a full-thickness skin graft in a cat 24 hours after surgery. Surgical techniques used were a single-pedicle advancement flap and full-thickness mesh with graft bed. Note the congested area in the rostral portion of the pedicle flap.

Thus the leeches can demonstrate both pathogenic and beneficial effects on humans and wild and domesticated animals.

Technician's Note



The benefit of the medicinal leech is not in the blood it ingests but in the bleeding that occurs after it releases. This blood seems to help mimic the venous flow of blood to impaired tissues.

Chapter Fifteen Test

MATCHING—Match the scientific term in the left hand column with the correct phrase or term in the right hand column.

A. Class Hirudinea	1. 64–amino acid peptide with a function similar to that of antithrombokinase; the most powerful anticoagulant known
B. <i>Haemopsis sanguisuga</i>	2. Method of locomotion when a leech is in the water
C. Swimming	3. The European medicinal leech
D. Stepping	4. Reconstructive and microvascular surgery in both humans and animals
E. Leech bite	5. Y shaped skin incision
F. Hirudin	6. Leeches
G. Hirudiniasis	7. Method of locomotion when a leech is on land
H. <i>Hirudo medicinalis</i>	8. The horse leech
I. Beneficial use of leeches	9. Concentrated salt solution, strong vinegar, or touching with a lighted match or cigarette
J. Incentive for leech to release	10. Invasion of the nose, mouth, pharynx, or larynx by leeches or attachment of leeches to the skin

Questions for Thought and Discussion

1. Compare pediculosis, siphonapterosis, acariasis, and linguatulosis with hirudiniasis. Why do you think these terms are important?
2. What was once old-fashioned is now back in style! What were leeches used for during the eighteenth and nineteenth centuries? Discuss the potential for their use in the twenty-first century.

Parasites of Public Health Importance in Veterinary Parasitology

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LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Detail the types of zoonotic diseases that might be encountered in a veterinary clinical practice.
- Communicate the symptoms, diagnostic procedures, and prevention of major zoonotic diseases that might be encountered in a veterinary clinical practice.
- Understand that veterinarians and veterinary technicians should never provide direct treatment for a human patient infected with a zoonotic disease.
- Understand that veterinarians and veterinary technicians should act only in an advisory capacity regarding zoonotic diseases.

KEY TERMS

Acquired toxoplasmosis	toxoplasmosis
Bradyzoites	Creeping eruption
Canine scabies	Cryptosporidiosis
Coccidiostats	Cutaneous larva
Congenital	migrans (CLM)

Dermal larva migrans	Paratenic host
Diethyltoluamide (DEET)	Pernicious anemia
Dipylidiasis	Plumber's itch
Dwarf tapeworm	Pulmonary dirofilariasis
Ground itch	Rat tapeworm
Human scabies	Sandworms
Hydatid disease	Schistosome cercarial dermatitis
Hymenolepiasis	Sparganum
Incidental nymphal pentastomiasis	Swimmer's itch
Measly beef/beef measles	Tachyzoites
Measly pork/pork measles	Toxocaral larva migrans
Multilocular hydatid cyst	Toxoplasmosis
Neural larva migrans	Trichinosis/trichinellosis
Neurocysticercosis Ocular larva migrans (OLM)	Trichostrongyliasis
Oncosphere	Unilocular hydatid cyst
Papules	Vesicles
	Visceral larva migrans (VLM)
	Zoonosis

Chapter 1 defines zoonosis as any disease or parasite that is transmissible from animals to humans. In veterinary clinical practice, it is important for veterinarians to inform their clients concerning zoonotic diseases or parasites that may be transmitted from their domestic animals. Such zoonotic parasites include *Toxoplasma gondii*, *Trichinella spiralis*, *Ancylostoma caninum*, and *Toxocara canis*. This chapter discusses the major parasitic diseases that are of public health importance in veterinary clinical practice.

It is often the veterinarian's role (and also the role of the veterinary diagnostician) to diagnose a parasite in a domestic animal. The veterinary diagnostician must also communicate to the public and often to medical personnel, such as physicians, laboratory personnel, and other public health workers, the significance of many of the zoonotic parasites. It is important for veterinary personnel to understand that in suspected cases of zoonotic parasites or conditions, the client should always be referred to a physician, family practitioner, obstetrician, or public health worker as appropriate for diagnosis or treatment. In no instance should a veterinarian or veterinary technician attempt to diagnose or treat any of these zoonotic parasites in humans. The veterinary professional's role is to inform, not to treat. Attempting to diagnose or treat a human is a violation of state veterinary practice acts across the United States. Treatments are included in this chapter strictly for the purpose of advising human health care workers and not for the purpose of treating human patients.

Technician's Note



It is the role of the veterinarian or technician to educate the client or owner about zoonotic parasites and diseases, not to treat the client or owner for any zoonosis.

For each zoonotic parasite discussed here, the following areas are addressed:

- Symptoms of parasitic infection in humans and the ways in which infection is diagnosed.
- Treatment of the parasitic condition in humans.
- Prevention of the transmission of zoonotic parasites, conditions, or syndromes from animals to humans.

Just as parasites are broken down into major groups in previous chapters, the important zoonotic parasites are divided into zoonotic protozoans, zoonotic trematodes, zoonotic cestodes, zoonotic nematodes, zoonotic arthropods, and zoonotic pentastomes. The acanthocephalans and the leeches have no zoonotic significance.

Protozoans of Public Health Importance

Toxoplasma gondii (Toxoplasmosis)

Toxoplasmosis in humans is an extremely rare protozoan disease with which humans (particularly a pregnant woman and her developing fetus) can become infected. It is an important zoonotic parasite because a very popular domestic pet, the cat, is the only definitive host for this parasite. The cat can serve as a source of infection for the pregnant woman and her unborn child. Toxoplasmosis can infect the fetus in the womb and produce serious birth defects. This parasite can also wreak havoc in individuals with acquired immunodeficiency syndrome (AIDS).

Technician's Note



The cat is the only definitive host for *Toxoplasma gondii* and can serve as a source of infection in humans, especially pregnant women and their unborn children.

Although this is a very rare parasite, several precautions must be taken to prevent infection. To sell papers, the "sensational press" often exploits this parasite in its headlines, alarming the general public. As a result, the veterinary clinical practice may receive phone calls regarding this parasite. Also, uninformed clients may request that veterinarians find a new home for (or even euthanize) the family cat. It is important for the veterinarian to alleviate the client's concerns and to work in conjunction with the obstetrician-gynecologist to answer questions, thwart this parasite, and prevent toxoplasmosis. It is important to note that almost every warm-blooded animal can become infected with *T. gondii*.

Technician's Note



The news media exploits toxoplasmosis to sell papers and magazines; it is the job of the veterinary professional in conjunction with physicians to prevent and thwart this disease with proper client education.

Human Infection With Toxoplasmosis

Humans become infected with toxoplasmosis in one of two ways: congenitally (in the case of unborn babies) or through acquisition. **Congenital toxoplasmosis** occurs when a woman becomes infected during her pregnancy; the woman ingests sporulated oocysts of *T. gondii* found in the feces of the cat. The domestic house cat with access to the outdoors (and predation) serves as the definitive host for *T. gondii* and will shed unsporulated oocysts in its feces. These unsporulated oocysts sporulate (or become infective) in 1 to 5 days. If a pregnant woman accidentally ingests the sporulated oocyst, the parasite's **tachyzoites** (rapidly multiplying stages) can infect the developing fetus.

Acquired toxoplasmosis occurs when a human ingests the sporulated oocyst containing tachyzoites or ingests infected meat or tissue stages containing bradyzoites. Many domesticated animals (e.g., cattle, pigs, sheep) serve as intermediate hosts for *T. gondii*. Within their muscle tissue, these intermediate hosts harbor **bradyzoites** (slowly multiplying stages) that can infect various tissue sites, including the lymph nodes, meninges, eyes, and heart, of humans. The infected human ingests the bradyzoites, which then infect a variety of tissue sites.

Technician's Note



Unborn babies can be infected with toxoplasmosis if their mothers become infected by ingesting tachyzoites and the infection spreads to the fetus (congenital toxoplasmosis). Acquired toxoplasmosis occurs when humans ingest tachyzoites (in cat feces) or bradyzoites (in meat or muscle).

Symptoms and Diagnosis

If congenital infection occurs early in the pregnancy, miscarriage is common. If this infection occurs late in the pregnancy, the central nervous system (CNS) may become infected, and a variety of neurologic abnormalities may result. These include cerebral calcification, chorioretinitis, hydrocephaly, microcephaly, and psychomotor irregularities. The child may be born dead or alive. If alive, the child may be developmentally delayed.

Infected humans with acquired toxoplasmosis exhibit lymphadenopathy, malaise, fever, lymphocytosis, and myocarditis. Most cases, however, are characterized by mild fever and slight enlargement of the lymph nodes.

Diagnosis of clinical toxoplasmosis in humans is quite difficult. Diagnosis relies on the demonstration of organisms or antibodies against it. The best diagnostic test is the inoculation of suspected material into mice and demonstration of the organism multiplying in the mice. Serologic tests are also available. The veterinary diagnostician must remember that these tests need to be delegated to a more sophisticated diagnostic laboratory.

Technician's Note



The diagnosis of toxoplasmosis in humans is difficult and involves testing for the presence of multiplying organisms or antibodies against the organisms in inoculated mice. Serologic tests are also used.

Treatment

There is no completely satisfactory treatment for toxoplasmosis in humans, although pyrimethamine has been found effective. This drug, in conjunction with triple sulfa drugs, has shown good results in ocular toxoplasmosis. Remember that suspected cases of toxoplasmosis in humans should *always* be referred to a neonatologist, pediatrician, gynecologist, obstetrician, or family practitioner. The Centers for Disease Control and Prevention (CDC) has many specialists who are qualified to answer questions about the most complex issues of toxoplasmosis in humans.

Prevention of Transmission to Humans

Transmission of *T. gondii* to pregnant women is prevented by having someone else empty the cat's litter box for the duration of the woman's pregnancy. This step eliminates the woman's potential exposure to the sporulated oocysts of *T. gondii*. A person should always wash his or her hands after handling a cat and before eating. Litter boxes should never be placed in the kitchen or dining area. Gloves should be worn while gardening because feral cats often defecate in flower beds. If a child's sandbox is present in the backyard, it should remain covered when not in use. After gardening, hands should be thoroughly washed. Cats should never be allowed to roam freely and hunt. Likewise, uncooked meat should never be fed to cats. Rodent prey or uncooked meat may contain the tissue stages of *T. gondii*, which will set the life cycle in motion in the cat. Likewise, to avoid acquired infection with *T. gondii* (and a variety of pathogenic bacteria), humans should be wary of undercooked infected meat.

Technician's Note

Prevention of toxoplasmosis involves reducing exposure in pregnant women by having someone else clean the litter box, washing hands after cleaning the litter box or handling raw meat, covering sandboxes, wearing gloves when gardening, and not eating undercooked meat.

Technician's Note

Cryptosporidiosis is diagnosed in humans with fecal flotation techniques using zinc sulfate or Sheather solution to identify oocysts.

***Cryptosporidium parvum* (Cryptosporidiosis)**

Cryptosporidiosis is a rare protozoan disease that produces a prolific, painful, watery diarrhea in humans. This protozoan parasite has been reported in the news because it has contaminated the drinking water supplies of several major metropolitan areas throughout North America and the world. As with toxoplasmosis, cryptosporidiosis is especially harmful in individuals with AIDS. For this reason, it is also an important parasite. Cryptosporidiosis was first reported in farmworkers and individuals who worked around very young calves. This organism is spread by ingestion of infective oocysts in calf feces.

Human Infection With Cryptosporidiosis

Humans become infected with cryptosporidiosis by ingestion of oocysts from feces of young calves or from contaminated supplies of drinking water.

Symptoms and Diagnosis

Cryptosporidiosis produces a transient, painful, watery diarrhea in humans, and all ages are susceptible. The duration of clinical signs in affected individuals varies considerably. Acute cases last from 3 to 7 days, and chronic wasting syndromes can persist for weeks to a few months. The development of natural immunity against the parasite determines the duration of the clinical signs. Most humans infected with *Cryptosporidium* species develop immunity and recover from the infection.

Infections with *Cryptosporidium* species may persist indefinitely in people with immunodeficiencies, particularly AIDS. The prognosis for immunologically compromised individuals with cryptosporidiosis is poor.

Fecal flotation and concentrating solutions such as zinc sulfate and Sheather sugar solution may be used to identify oocysts of *Cryptosporidium* species. These parasites are extremely tiny, less than 5 μm in diameter, and thus may be easily overlooked. Acid-fast stains such as Ziehl-Neelsen or Kinyoun can be used, as well as auramine-rhodamine, Giemsa, and methylene blue. All these stains may be used to improve the identification of the parasite in fecal flotation.

There are several commercially available enzyme-linked immunosorbent assay (ELISA) tests. These tests have a higher degree of sensitivity and specificity in diagnosing infections with *Cryptosporidium* species than can be obtained from stained fecal flotation smears. A commercially available indirect fluorescent antibody test has been shown to be quite effective in diagnosing infection with *Cryptosporidium* species.

Treatment

Although cryptosporidiosis is caused by a protozoan parasite with a life cycle similar to that of coccidia, **coccidiostats** have shown minimal to no efficacy when used to treat infected cattle. An effective chemotherapeutic means of eliminating the parasite is not available.

Human cryptosporidiosis is treated symptomatically. Individuals who become dehydrated should be given appropriate fluids either intravenously or orally. Clinical improvement has been demonstrated in patients treated with dialyzable leukocyte extract from calves immunized with *Cryptosporidium* species.

Technician's Note

Cryptosporidiosis in humans is treated symptomatically.

Prevention of Transmission to Humans

Infection with *Cryptosporidium* species can be prevented by good sanitation and hygiene practices when handling young animals, particularly calves. Infants, young children, or immunologically compromised individuals should not handle animals with diarrhea. Immunocompromised individuals should be advised to wash their hands after handling pets, especially before eating, and should avoid contact with their pet's feces. Many of the agents and processes used to sanitize public drinking water have little effect on *Cryptosporidium* species.

Technician's Note

Prevention of cryptosporidiosis is best accomplished with good hygiene habits and sanitation.

Trematodes of Public Health Importance

Schistosomes of Wild Migratory Birds (Schistosome Cercarial Dermatitis, Swimmer's Itch)

Swimmer's itch is a highly pruritic skin condition in humans caused by repeated penetration of the cercariae of the schistosomes (blood flukes) of wild migratory aquatic birds and small mammals native to the water's edge. On first exposure of the cercariae, there is mild redness and edema in the skin; with repeated exposure, however, there is severe pruritus (itching) and a papular or pustular dermatitis (a pus-filled pimple). This dermatitis may persist for several days or even weeks and can become secondarily infected.

Human Infection With Swimmer's Itch

Migratory waterfowl frequently harbor schistosomes (blood flukes) in their blood vasculature. These schistosomes produce eggs that pass in the bird's feces to the watery environment. The eggs hatch, producing miracidia, which in turn penetrate aquatic snails. Within the snail, the miracidia undergo asexual reproduction and produce thousands of cercariae. These cercariae exit the snail to penetrate the definitive host, the migratory waterfowl.

Humans serve as incidental hosts for these avian schistosomes. During summer, people swim or wade in the lakes, ponds, rivers, and even ocean waters frequented by wild birds. These waters are home to aquatic snails. The cercariae produced within the snails penetrate the skin of humans instead of the skin of migratory birds. The cercariae cannot complete the migration in the human host, and the host's immune system kills the cercariae. At the same time, the cercariae release allergenic substances that cause severe dermatitis. Repeated exposure produces the highly pruritic papular or pustular dermatitis, or **schistosome cercarial dermatitis** (swimmer's itch). This condition may have many other regional or colloquial descriptive names.

Technician's Note

Avian schistosomiasis in humans tends to be self-limiting but can cause severe dermatitis when the cercariae that cause the dermatitis release allergenic substances.

Symptoms and Diagnosis

After the cercaria penetrates the skin, a reddened spot appears at the point of entry. The diameter of this spot

increases, and the itching commences. If the area becomes raised, it is called a **papule** and will reach its maximum size in about 24 hours. In severe cases the affected individual may develop a fever, become nauseated, and spend several sleepless nights. The papule itches for several days before subsiding, but in a week or so, the symptoms disappear.

Swimmer's itch can be diagnosed by the observation of typical lesions in skin that has come in contact with pond, lake, stream, or ocean water containing infective cercariae from the snail intermediate host. A history of swimming in infested waters also aids in diagnosis. Laboratory findings usually have no role in establishing a diagnosis of swimmer's itch.

Treatment

Suspected cases of swimmer's itch in humans should *always* be referred to a dermatologist or family practitioner. Antihistamines are prescribed to relieve the itch and topical steroid creams to reduce the swelling. Remember that these are prescription drugs and must be prescribed by a physician or dermatologist.

Prevention of Transmission to Humans

During the seasonal occurrence of swimmer's itch, many public health agencies post warnings about swimmer's itch on beaches adjacent to ponds, lakes, streams, or the ocean. The public should heed these warnings and comply with the ban on swimming in infested waters. Swimming in water away from the shore will reduce the chance of contact with the cercariae; cercariae tend to congregate close to the shoreline. If contact is suspected, the swimmer should towel off immediately after leaving the water.

For those who must work in such waters, protective waterproof clothing is available. Repellents such as benzyl benzoate and dibutylphthalate are available. Molluscicides (snail-killing compounds) are available; however, they may have adverse effects on plants and other animals in the environment.

Technician's Note

The best prevention for swimmer's itch is to avoid water contaminated with schistosomes.

Cestodes of Public Health Importance

Taenia saginata (Beef Tapeworm)

Taenia saginata, the beef tapeworm, parasitizes the small intestine of humans. Its larval or metacestode stage, *Cysticercus bovis*, is found in the musculature of beef cattle, the intermediate host.

Human Infection With Beef Tapeworm

Humans become infected with the beef tapeworm by ingesting the musculature of beef cattle that contains the cysticercus, or bladder worm, the larval (metacystode) stage for this tapeworm. This cysticercus stage has a scientific name, *C. bovis*, and may be found in a variety of sites in the bovine musculature: skeletal and heart muscle, masseters, diaphragm, and tongue. Humans are infected by ingesting raw or undercooked cysticercus-infected beef. This meat is often referred to as **measly beef** or **beef measles**. The covering of the cysticercus is digested away, and the young tapeworm is released and attaches to the wall of the small intestine. This young tapeworm begins to grow its proglottids. The gravid proglottids are released to the outside environment. Each gravid proglottid contains about 80,000 eggs. In the outside environment the gravid proglottids rupture, and the released eggs may be ingested by a beef cow. The eggs hatch, and the embryos penetrate the intestinal mucosa and enter into the general circulation; they are then distributed throughout the musculature of the beef cow.

Technician's Note



Humans become infected with *Taenia saginata* by ingesting undercooked beef muscle that contains the cysticercus stage of the tapeworm.

Symptoms and Diagnosis

Adult *T. saginata* in the small intestine of humans may cause a variety of nonspecific abdominal signs, such as diarrhea, constipation, and cramps. About 10 gravid proglottids are passed in the feces each day; this fact is quite evident to the infected individual. These proglottids are quite motile and will migrate a few centimeters over the human host's body, clothes, or bedding.

The gravid proglottids from human feces are unusual in appearance. Each proglottid has a prominent uterus with 14 to 32 lateral branches. The uterus contains approximately 80,000 eggs. Perianal swabs may be used to detect these eggs. Diagnosis of cysticerci in cattle is usually made by meat-inspection procedures.

Technician's Note



A human infection with *Taenia saginata* will be very evident when the gravid proglottids are seen in the stool specimen upon defecation.

Treatment

Suspected cases of the beef tapeworm in humans should *always* be referred to a family practitioner or internist. The treatment of choice is praziquantel or niclosamide.

Prevention of Transmission to Humans

All infected humans should be treated by a physician. Feedlot employees should be educated concerning the transmission of bovine cysticercosis and personal hygiene practices. Adequate and accessible toilet facilities must be provided for all workers. Meat inspection should be thorough. Infected carcasses may be condemned for human consumption or treated by freezing for 10 days to 2 weeks at -10°C or by cooking at 50°C to 60°C . Likewise, humans should be wary of undercooked meat to avoid acquired infection with *T. saginata* (and a variety of pathogenic bacteria).

Technician's Note



Proper sanitation, personal hygiene, and thorough meat inspection help prevent infection with the beef tapeworm.

Taenia solium (Pork Tapeworm)

Taenia solium, the pork tapeworm, parasitizes the small intestine of humans. The larval, or metacystode, stage of this tapeworm, *Cysticercus cellulosae*, is found in the musculature of pigs, the intermediate host. This is an unusual parasite in that humans can also harbor the larval stage, which may occur not only in the musculature but also within the eye and brain. Therefore humans can serve as both the definitive and the intermediate host for this parasite.

Human Infection With Pork Tapeworm

Humans become infected with the pork tapeworm by ingesting the musculature of pigs that contains the cysticercus, or bladder worm, the larval (metacystode) stage. This cysticercus stage has a scientific name, *C. cellulosae*, and may be found in a variety of muscle sites: skeletal and heart muscle, masseters, diaphragm, and tongue. Humans are infected by ingesting raw or undercooked cysticercus-infected pork. This meat is often referred to as **measly pork** or **pork measles**. The covering of the cysticercus is digested away, and the young tapeworm is released and attaches to the wall of the small intestine. This young tapeworm begins to grow proglottids. The gravid (terminal) proglottids are released to the outside environment. Each gravid proglottid contains about 40,000 eggs. In the outside environment, the gravid proglottid ruptures; the released eggs must be

ingested by a pig. The eggs hatch, and the embryos penetrate the intestinal mucosa and reach the general circulation, to be distributed throughout the musculature of the pig.

Technician's Note



Pork tapeworm can infect humans if humans ingest undercooked pork meat that contains the cysticercus stage of the tapeworm.

If a human ingests one of the eggs, the egg hatches in the intestine. This embryo penetrates the intestinal mucosa and reaches the general circulation, to be distributed not only throughout the musculature of the human but also in subcutaneous sites and within the brain and eye. In such sites, tremendous damage can result.

When the metacestode stage develops in the brain, the condition is known as **neurocysticercosis**. The parasite usually develops in the ventricles and is proliferative.

Technician's Note



If humans ingest pork tapeworm eggs, the eggs can hatch in the intestine, and the resulting embryo can reach the general circulation, ending up in the brain, eye, and subcutaneous sites, as well as the musculature.

Symptoms and Diagnosis

Adult *T. solium* in the small intestine of humans may cause a variety of nonspecific abdominal signs, such as diarrhea, constipation, and cramps. Chains of gravid proglottids do not leave the host spontaneously but are passed in the feces each day; this fact is quite evident to the infected individual. These proglottids are quite motile and will migrate a few centimeters over the human host's body, clothes, or bedding.

Neurologic symptoms vary with the site of the offending cysticercus in the nervous tissue. Pain, paralysis, and epileptic seizures have been associated with neurocysticercosis. Ocular lesions may result in blindness.

The gravid proglottids from human feces are unusual in appearance. Each proglottid has a prominent uterus with fewer than 16 lateral branches. The uterus contains approximately 40,000 eggs. Diagnosis of cysticerci in pigs is usually made by meat-inspection procedures.

Sophisticated radiographic imaging techniques, such as computed tomography (CT) and magnetic resonance imaging (MRI), may reveal the presence of cysticerci within the brain and other sites in the CNS.

Technician's Note



The symptoms of pork tapeworm infection in humans vary by where the cysticercus ends up in the human (in the case of ingestion of the eggs). Intestinal infection can produce nonspecific abdominal symptoms such as diarrhea, cramps, and constipation.

Treatment

Suspected cases of pork tapeworm in humans should *always* be referred to a family practitioner, neurologist, surgeon, or internist. The treatment of choice is praziquantel. Because of the infectivity of the eggs for humans and the resulting CNS involvement, these cases must be handled with great care. Treatment of human cysticercosis is by surgical removal of the offending lesion.

Prevention of Transmission to Humans

All infected humans should be treated by a physician. Feedlot employees should be educated concerning the transmission of porcine cysticercosis and personal hygiene practices. Household workers such as maids and cooks should be educated regarding proper hygiene, such as handwashing before the preparation of a meal. Adequate and convenient toilet facilities must be provided for all workers. Meat inspection should be thorough. Infected carcasses may be condemned for human consumption or treated by freezing for 10 days to 2 weeks at -10°C or by cooking at 50°C to 60°C . Likewise, humans should be wary of undercooked meat to avoid acquired infection with *T. solium* (and a variety of pathogenic bacteria).

Technician's Note



Pork tapeworm infection can be prevented by proper sanitation, personal hygiene, and thorough meat inspection, as well as by not eating undercooked pork.

***Echinococcus granulosus* and *Echinococcus multilocularis* (Unilocular and Multilocular Hydatid Disease)**

Hydatid disease is a syndrome characterized by the development of the larval, or metacestode, stage of *Echinococcus* species, a genus of tapeworm found in the small intestine of dogs and cats, the definitive hosts. Hydatid disease is characterized by the formation of large fluid-filled cysts in the internal organs of the intermediate host. There

are two species of importance in veterinary parasitology: *Echinococcus granulosus*, a tapeworm that produces a **unilocular** (large, singular, thick-walled, fluid-filled) **hydatid cyst**, and *Echinococcus multilocularis*, a tapeworm that produces a **multilocular** (multiple, extremely invasive, thin-walled, fluid-filled) **hydatid cyst**. These hydatid cysts may occur in a variety of internal organs in the human intermediate host: the liver, lungs, kidney, spleen, bone, and brain.

Technician's Note



The hydatid cysts produced by *Echinococcus* species can develop in a variety of organs in the human intermediate host.

Human Infection With Hydatid Disease

Humans become infected with hydatid disease by ingesting the egg of *Echinococcus* species. Once ingested, the egg hatches in the intestine of the human intermediate host. The released **oncosphere** ("growth ball") penetrates an intestinal venule or lymphatic lacteal and reaches the liver, lungs, or other internal organs. Once in these extraintestinal sites, the oncosphere develops into the hydatid cyst. *E. granulosus* produces a unilocular hydatid cyst. This cyst has a thick, multilayered wall that keeps the developing cyst restricted to a single compartment. The hydatid cyst may grow up to 50 cm in diameter; however, it will not invade the surrounding tissues of the parasitized organ. *E. multilocularis* produces a multilocular hydatid cyst. In contrast to the unilocular hydatid cyst of *E. granulosus*, this hydatid cyst lacks the thick, multilayered wall. Without this cyst wall, the developing cyst is capable of "budding off," or producing additional compartments, which in turn bud off other compartments. As a result, this type of hydatid cyst readily invades the surrounding tissues. This multilocular hydatid cyst takes on a "malignant," invasive role.

Symptoms and Diagnosis

The symptoms of infection with hydatid disease depend on the site where the organism develops; these sites include the liver, lungs, kidney, spleen, bone, and brain. Neurologic symptoms vary with the site of the offending cysticercus in the nervous tissue. Pain, paralysis, and epileptic seizures have also been associated with echinococcosis.

In humans, examination of histopathologic sections of unilocular hydatid cysts reveals the unique structure of the germinal membrane supported by a thicker, acellular, laminated membrane. Protoscolices are contained in the sac-like brood capsules. When viewed macroscopically, these brood capsules look like sand. Humans with *E. multilocularis* develop tumor-like masses, or nodules, in their livers.

When sectioned, these masses reveal the alveolar-like microvesicles containing protoscolices.

Sophisticated radiographic imaging techniques, such as CT and MRI, may reveal the presence of hydatid cysts within the brain and other organ sites throughout the body.

Technician's Note



Diagnosis of echinococcosis in humans can be made by histopathologic sectioning or a CT or MRI scan.

Treatment

Suspected cases of echinococcosis in humans should always be referred to a surgeon, internist, or neurologist. Surgical intervention is recommended for the disease syndromes caused by *E. granulosus* and *E. multilocularis*. For patients in whom the hydatid cyst cannot be removed or for whom surgery is not an option, there may be new therapeutic alternatives. Treatment with mebendazole has shown varied success, although albendazole has been more promising.

State public health officials should be notified when canine or feline echinococcosis is diagnosed. Additionally, the CDC should be notified. The CDC has many specialists who are qualified to answer the most complex questions regarding both unilocular and multilocular hydatid disease in humans.

Technician's Note



State public health officials and the CDC should be notified if canine or feline echinococcosis is diagnosed.

Prevention of Transmission to Humans

Handwashing, particularly for children, should be emphasized. It is important to prevent exposure to the eggs of *Echinococcus* species. Dogs should never be fed raw livestock viscera or allowed to roam freely to feed on wild rodents.

Dipylidium caninum (Human Dipylidiasis)

Human Infection With *Dipylidium*

Humans, especially children, can become infected with the common tapeworm of dogs and cats, *Dipylidium caninum*, by ingesting dog or cat fleas containing cysticercoids of this common canine and feline tapeworm.

Symptoms and Diagnosis

As in the canine or feline host, proglottids are passed in the feces or are found around the anus (if the child is an infant

and is still wearing diapers). Most infections occur in children under 8 years of age. Most patients are asymptomatic, but diarrhea, abdominal pain, and anal pruritus may occur. The child may have moderate eosinophilia.

Technician's Note



Humans, especially children, can be infected with *Dipylidium caninum* by ingesting an infective flea.

Treatment

Suspected cases of *D. caninum* in humans should *always* be referred to a family practitioner or internist. This human disease occurs rarely; humans appear to be highly resistant to the infection, given the high frequency of flea infestation on dogs and cats. Suspected cases of **dipylidiasis** in children should always be referred to a pediatrician or general practitioner. The drugs of choice for human dipylidiasis are praziquantel and niclosamide. Because the method of transmission is by ingestion of dog or cat fleas containing the infected cysticercoids, the child probably is the only family member infected with this canine parasite. It would not be necessary to treat other family members for infection with this canine and feline cestode. All household pets should be treated with anthelmintics; a rigorous flea-control program should be instituted for all dogs and cats.

Prevention of Transmission to Humans

Infection in humans or animals by *D. caninum* requires ingestion of the intermediate host, the dog or cat flea containing the larva (cysticercoid) of the tapeworm. Many cases in humans are asymptomatic. Dipylidiasis affects mainly infants and young children who may swallow a flea that hops up while they are crawling on the floor or cuddling the family pet. Again, humans appear to be highly resistant to the infection, given the high frequency of flea infestation on dogs and cats and the relative rarity of human disease.

***Spirometra mansonoides* (Benign Plerocercoidosis/Malignant Sparganosis)**

Human Infection With *Spirometra* Species

Although human infection with *Diphyllbothrium latum* is an intestinal infection, human infection with *Spirometra* species is usually associated with a variety of extraintestinal tissue sites. Humans may become infected with the plerocercoid stage, or sparganum, of *Spirometra* species within

the tissues. The human is actually serving as the second intermediate host. Infection with the plerocercoid stage of the pseudotapeworm is referred to as *sparganosis*.

There are two forms of infection with *Spirometra* species that may occur in the second intermediate host: the nonproliferative form and the proliferative form. Most infections are of the nonproliferative form (benign plerocercoidosis) and are associated with the presence of a single larva of *Spirometra mansonoides*. Proliferative sparganosis (malignant sparganosis) is caused by the presence of an asexual replication of larvae within host tissues and the subsequent migration of these larvae to new tissue sites, where they grow and repeat the process *ad infinitum*.

Symptoms and Diagnosis

For benign plerocercoidosis, the human ultimately acts as a dead-end host. Symptoms depend on the site(s) of infection.

Proliferative sparganosis in humans may occur in sites from subcutaneous tissue sites to deep visceral forms, involving a variety of internal organs: ocular, CNS, auricular, pulmonary, intraosseous, and intraperitoneal sites. Again, symptoms depend on the severity and site of infection. Once infected with the malignant form, the human may ultimately die. Infections of both benign plerocercoidosis and proliferative sparganosis have been reported primarily in Asia and South America; however, two cases were reported in the United States in the early twentieth century.

Treatment

It would be prudent for a physician to report any occurrence of human sparganosis, especially the malignant form, to the CDC in Atlanta, Georgia.

Depending on the tissue sites where benign plerocercoidosis is occurring in the infected human, surgical intervention may be possible.

In humans infected with proliferative sparganosis, treatment with praziquantel and mebendazole has proven ineffective. Adverse side effects to these anthelmintics include severe nausea, vomiting, gastritis, sinus tachycardia, muscle tenderness, and a burning sensation at the injection site. Nitazoxanide is an antiprotozoal drug approved for use in humans that has been shown in preclinical trials to be effective against cestodes.

Prevention of Transmission to Humans

Because sparganosis is zoonotic, precautions must be undertaken to prevent infection through consumption of infected water containing the first intermediate host: a

Cyclops species, an aquatic crustacean containing the proceroid stage. Humans may also become infected by ingesting poorly cooked fish containing the plerocercoid (sparganum) stage. Finally, humans may become infected during the application of medicinal poultices to open wounds; such poultices could contain the plerocercoid stage, which could infiltrate and ultimately infect the open wound.

Although this parasite is not a reportable parasite, it would be wise to report the occurrence of human sparganosis to local public health authorities because of the severity of infection, particularly with malignant sparganosis, that may develop in humans.

***Hymenolepis nana* (Hymenolepiasis)**

Human Infection With *Hymenolepis*

Hymenolepis nana, the **dwarf tapeworm**, is usually found in rodents, primates, and humans. It is common in children under 3 years of age throughout the world and can be passed from human to human. The tapeworms are usually regarded as hand-to-mouth parasites. *Hymenolepis diminuta*, the **rat tapeworm**, is primarily a parasite of rodents and humans. Children become infected with *Hymenolepis* species by ingesting insects (e.g., rat fleas, mealworms, cockroaches) containing cysticercoids of these tapeworms.

Technician's Note



The dwarf tapeworm and rat tapeworm are regarded as hand-to-mouth parasites.

Symptoms and Diagnosis

Large numbers of tapeworms can cause necrosis and desquamation of the intestinal epithelial cells. Light infections cause no significant damage to the mucosa and are either asymptomatic or cause vague abdominal complaints. Young children frequently have loose bowel movements or frank diarrhea with mucus. Bloody diarrhea is rare; diffuse, persistent abdominal pain is the more common complaint. A pruritic anus is another common complaint among infected individuals. Many children also have headaches, dizziness, sleep and behavioral disturbances, which resolve after therapy. Serious neurologic disturbances have been reported. A moderate eosinophilia (5% to 10%) may be associated with **hymenolepiasis**.

Diagnosis is by finding the characteristic eggs in fecal flotation. Proglottids are usually not found because they degenerate before passage in the stool.

Treatment

In suspected cases of *H. diminuta*, humans should *always* be referred to a family practitioner or internist. Praziquantel is the drug of choice.

Prevention of Transmission to Humans

Control depends on improved personal and environmental hygiene. Within institutions, all children should be treated.

Technician's Note



Prevention of the dwarf and rat tapeworm depends on improved personal and environmental hygiene.

***Diphyllobothrium latum* (Diphyllobothriasis)**

Human Infection With *Diphyllobothrium*

The broad fish tapeworm, or *D. latum*, is often found in many areas of the world where raw, insufficiently cooked, or lightly pickled freshwater fish are consumed. Infected fish contain the plerocercoid, or **sparganum**, stage; this is the stage eaten by the human. These parasites are often found in northern temperate and subarctic regions. The adult tapeworms are found within the small intestine of the host; humans may also become infected with the plerocercoid (sparganum) stage. When a homeopathic doctor uses an infected piece of fish as a poultice, the sparganum moves into the wound and sets up an infection in the subcutis, the connective tissue of the muscles, or in other sites within the body.

Symptoms and Diagnosis

Intestinal infections in humans are often asymptomatic. Often the diagnosis is made during routine fecal examination when eggs or chains of proglottids are observed in the feces. Infection in humans may also cause nonspecific abdominal symptoms. Some individuals may complain of abdominal pain, bloating, allergic reactions, hunger pains, loss of appetite, or increased appetite. On rare occasions, mechanical intestinal obstruction may result from tapeworms becoming entangled; intussusception may result. Diarrhea may occur, and infected individuals may pass long sections of spent proglottids in the stool.

Technician's Note



Intestinal infections in humans with the broad fish tapeworm are often asymptomatic or exhibit nonspecific abdominal symptoms.

Adult tapeworms in the small intestine may successfully absorb vitamin B₁₂ from the gut; this loss of vitamin B₁₂ produces megaloblastic anemia or **pernicious anemia**. This condition manifests itself as a macrocytic hypochromic anemia.

Infection with the sparganum, or sparganosis, produces a severe inflammatory reaction and fibrosis of the infected tissues. Clinical signs include urticaria, painful edema, and irregular nodules containing the plerocercoids. If spargana infect the eye, the infection may lead to exophthalmos, swelling of the eyelids, lagophthalmos, and corneal ulcers.

Treatment

Suspected cases of the intestinal form of the broad fish tapeworm in humans should *always* be referred to a family practitioner or internist. Praziquantel and niclosamide are the drugs of choice.

Suspected cases of the sparganum (plerocercoid) form of the broad fish tapeworm in humans should *always* be referred to a surgeon. Spargana within tissue sites in humans must be surgically removed.

Technician's Note

As with all human zoonotic parasite infections, a physician should be seen for treatment. The broad fish tapeworm can be treated with praziquantel or niclosamide; however, sparganum infection should be referred to a surgeon.

Prevention of Transmission to Humans

Proper cooking of freshwater fish eliminates all possibility of human infection. Likewise, domestic animals such as dogs, cats, and pigs should not be fed raw fish. Freezing at -10°C will kill the infective plerocercoid (sparganum) stage. In the United States, smoked salmon is brined before hot smoking; this process eliminates salmon as a source of infection. Food handlers should never taste raw fish while preparing it for cooking. Practitioners of natural medicine should be discouraged from applying poultices made of fish to openings in the skin or to the eye.

Nematodes of Public Health Importance

Toxocara canis and *Toxocara cati* (Toxocaral Larva Migrants, Visceral Larva Migrants, Ocular Larva Migrants)

Toxocaral larva migrants is a disease of humans caused by the migration of certain parasitic larvae in the organs and

tissues. The most incriminated nematodes are the common ascarids of dogs and cats, *T. canis* and *Toxocara cati*, respectively. *Baylisascaris procyonis*, an ascarid of raccoons, causes a similar syndrome.

Human Infection With Toxocaral Larva Migrants

Humans become infected with toxocaral larva migrants when they ingest eggs of *Toxocara* species from the soil or on contaminated hands or other objects. *Toxocara* species require 2 or more weeks before infective larvae develop within the eggs. Persons should also take precautions when handling young puppies still being nursed by their dams. The entire litter area (and their hair coats) may often become extremely contaminated with their aged feces, which may contain infective eggs.

Technician's Note

Humans become infected with toxocaral larva migrants by ingesting eggs of *Toxocara* species of canine and feline roundworms.

Symptoms and Diagnosis

Infection by a few larvae is usually asymptomatic. Two distinct syndromes are produced by *Toxocara* species: **visceral larva migrants (VLM)** and **ocular larva migrants (OLM)**. VLM results from the migration of larvae through the human's somatic tissues and organs, including the liver, lungs, heart, and brain. The human is actually serving as a **paratenic host** for *Toxocara* species. VLM is characterized by fever, leukocytosis, persistent eosinophilia, hypergammaglobulinemia, and hepatomegaly. Pulmonary involvement, with symptoms that include bronchiolitis, asthma, or pneumonitis, may be common. Fatalities may result when the myocardium or CNS becomes involved.

OLM results when larval *Toxocara* species invade the eye. Ocular disease may be seen in the absence of VLM and is often seen in young children. Faulty vision may result; blindness may also occur.

VLM may be diagnosed on the basis of demonstration of lesions and the larvae in biopsy material. Serum samples may be sent to the CDC for serodiagnostic confirmation of toxocariasis. With OLM, the larvae may be observed during an ophthalmic examination.

Technician's Note

Visceral larva migrants or ocular larva migrants can be seen in humans infected with toxocariasis.

Treatment

Suspected cases of toxocaral larva migrans in humans, particularly young children, should always be referred to a family practitioner, pediatrician, internist, or ophthalmologist. No proven treatment is available. Suggested drugs of choice include mebendazole and diethylcarbamazine. Prednisone helps to control symptoms.

Prevention of Transmission to Humans

Three major methods are used to prevent the transmission of *Toxocara* species from dogs and cats to humans. First, it is important to prevent the fouling of backyards and public places, especially playgrounds, with dog and cat feces. All fecal material should be disposed of properly. Second, pet owners should be educated regarding the potential health hazards of roundworms in cats and dogs. Pet owners should be informed of the methods of transmission and of the special risks associated with puppies and their nursing mothers. After handling any young puppy, hands should be thoroughly washed in soap and warm water. Third, it is important that all cats and dogs be routinely tested for intestinal parasites such as ascarids. If infected, pets should be treated with an appropriate anthelmintic.

Technician's Note



Prevention of toxocariasis uses three methods: prevent fouling of the backyard and public places with dog and cat feces (use proper disposal of fecal material), client education, and routine examination of feces in dogs and cats.

***Baylisascaris procyonis* (Neural Larva Migrans, Cerebrospinal Nematodiasis)**

Neural larva migrans, a variation of VLM, is the prolonged migration and persistence of parasite larvae of *B. procyonis* (an ascarid that normally resides in the small intestine of the raccoon) in the brain and spinal cord of humans and animals. In this case, the human or other animal is serving as a paratenic host. This syndrome is similar to that of VLM and OLM of *Toxocara* species of both dogs and cats.

Human Infection With Larvae of *Baylisascaris procyonis*

Humans become infected with the larvae of *Baylisascaris procyonis* by accidentally ingesting eggs that contain its infective second-stage larvae. The eggs are ingested from the environment; from raccoon feces; or from contaminated soil, water, fomites, or hands. The source of these

ascarid eggs is the raccoon, a wild animal that should *never* be maintained in any interior or exterior household environment. These eggs are extremely resistant and can remain viable in the environment for several months to years. This resistance increases the likelihood of transmission from animals to humans.

Technician's Note



Humans contract neural larva migrans by accidental ingestion of eggs containing infective second-stage larvae from raccoon feces in the environment.

Symptoms and Diagnosis

As mentioned, *B. procyonis* can produce VLM and OLM in humans, similar to that produced by *Toxocara* species of both dogs and cats. However, these larvae tend to be more pathogenic because they can migrate through the CNS. Typically, the extent of the infection depends on the number of infective larvae ingested and their locations and behavior in the body. When only a few larvae are ingested, individuals probably are asymptomatic, visceral damage is minor, and most larvae become encapsulated (walled off) in noncritical sites such as skeletal muscle or connective tissue. If larger numbers of larvae are ingested, however, the host may exhibit nonspecific clinical signs or more classic signs attributable to those of classic VLM: fever, leukocytosis, persistent eosinophilia, hepatomegaly, and pneumonitis. These larvae also have an affinity for migration into neurologic tissues, and depending on the location and extent of migration, neurologic signs vary. If enough larvae are ingested, progressive CNS disease can develop rapidly, producing signs such as sudden lethargy, loss of muscle coordination, decreased head control, torticollis, ataxia, and nystagmus. These signs progress to stupor, extensor rigidity or hypotonia, coma, and finally death. Clinical signs of OLM include unilateral loss of vision and photophobia.

Because neither eggs nor larvae of *B. procyonis* are found on fecal flotation or in blood samples from humans, diagnosis of *B. procyonis* in humans must be made on the basis of history, clinical findings, and serologic testing. A history of exposure to raccoons or their feces is important. Clinical findings of VLM include leukocytosis, persistent eosinophilia, hypergammaglobulinemia, hepatomegaly, and pneumonitis. CNS disease may present suddenly and develop progressively. Eosinophilia may be present in both the peripheral blood and the cerebrospinal fluid. OLM may be diagnosed by ophthalmologic examination that reveals inflammatory tracks in the retina and inflammation of the vitreum and choroid. A specific diagnosis may be made by identification of characteristic morphologic features of

larval *B. procyonis* in histopathologic section. Serologic tests, such as indirect immunofluorescence, protein immunoblotting, and ELISA, are being evaluated.

Technician's Note



Diagnosis of neural larva migrans in humans is based on history, clinical findings, and serologic tests.

Treatment

Any person who has contact with raccoons or raccoon feces and develops visual or CNS disturbances should be examined by a physician, who should be alerted to the possibility of infection with *B. procyonis*. Suspected cases of cerebrospinal nematodiasis in humans should *always* be referred to a neurologist, ophthalmologist, internist, or family practitioner. It is unfortunate that effective anthelmintic treatments do not exist for VLM or OLM or for cerebrospinal nematodiasis. Patients with the ocular form of this syndrome can be treated with a laser if the larvae can be localized and visualized with the eye.

Prevention of Transmission to Humans

B. procyonis is more prevalent in raccoons from northern states than in raccoons from southern states, especially those states in the Deep South. Nevertheless, precautions should be taken around raccoons in all areas of the United States.

First, in regard to prevention, raccoons are *not* suitable pets. Wild raccoons should not be encouraged to visit or frequent urban, suburban, or rural dwellings or environments.

For those who rehabilitate raccoons and return them to nature, it is important to prevent shedding of the eggs and to limit exposure of humans and other animals to contaminated areas. Raccoons should be quarantined away from other animals in cages or enclosures that could be decontaminated if needed. All raccoons should be on a strict anthelmintic program to eliminate adult *B. procyonis* from the small intestine.

Technician's Note



Raccoons should never be kept as pets and should not be encouraged to visit or frequent human environments.

Access by humans, especially children, to known or potentially contaminated areas should be restricted. Raccoon feces should be removed and disposed of daily in a manner that prevents contact with humans and

animals. The feces should be destroyed. Contaminated areas, cages, or traps that have held infected raccoons should be decontaminated. Gloves and rubber boots should be worn by individuals who clean these cages, and hot, soapy water should be used. Protective coveralls should be worn, and these should be washed in near-boiling water and bleach.

***Ancylostoma caninum*, *Ancylostoma braziliense*, *Ancylostoma tubaeforme*, and *Uncinaria stenocephala* (Cutaneous Larva Migrans, Creeping Eruption, Plumber's Itch)**

Cutaneous larva migrans (CLM) is a skin condition caused by the migration of hookworm larvae into the skin of humans (Fig 16.1). It is also known as **creeping eruption**, **dermal larva migrans**, **ground itch**, **plumber's itch**, **sandworms**, and many other regional or colloquial names. It is a serpentine, reddened, elevated pruritic skin lesion usually caused by the larvae of *Ancylostoma braziliense*, a hookworm of both dogs and cats. Other nematode parasites of domestic and wild animals have been implicated in causing similar lesions in humans. These nematodes include *A. caninum*, the canine hookworm; *Uncinaria stenocephala*, the northern hookworm of dogs; *Bunostomum phlebotomum*, the cattle hookworm; *Gnathostoma spinigerum* (a genus of nematode); *Dirofilaria* species (such as aberrant *Dirofilaria immitis*, the heartworm); *Strongyloides procyonis*, a parasite of raccoons; and *Strongyloides westeri*, an equine parasite. Even the larvae of some of the myiasis-inducing flies (*Gasterophilus* and *Hypoderma* spp.) have been associated with the condition. However, hookworm larvae (*Ancylostoma* spp., particularly *A. braziliense*) are the pathogens most often incriminated.

Technician's Note



Cutaneous larva migrans is caused by skin penetration of larvae of *Ancylostoma* species and *Uncinaria stenocephala*.

Human Infection With *Cutaneous Larva Migrans*

Humans become infected with larvae of canine and feline hookworms when these larvae penetrate unprotected skin. This usually happens when human skin (usually of the bare feet) contacts moist, sandy soil contaminated with larval hookworms. Larval hookworms penetrate and migrate within the skin; in most cases, they do not complete their life cycle or mature to adults in the small intestine.



Fig. 16.1 *Cutaneous larva migrans* in the sole of a man's foot. This skin condition is caused by migration of hookworm larvae in the skin of humans. It is also known as *creeping eruption*, *dermal larva migrans*, *ground itch*, *plumber's itch*, and *sandworms*.

Three scenarios have been developed regarding cutaneous hookworm infections in humans. The first scenario involves young children and adults who go barefoot in areas frequented by hookworm-infected pets. Children may also become exposed to contaminated sand or soil for extended periods (e.g., by playing in sandboxes or dirt containing larvae).

Technician's Note



No matter which scenario of contact is involved, *cutaneous larva migrans* results from the hookworm larvae penetrating the skin of the affected individual.

The second scenario involves travelers returning from exotic vacation sites around the world and who may have walked barefoot or been nude in the sand for an extended time. Third-stage hookworm larvae developing from eggs passed from parasitized dogs and cats can penetrate the naked skin and cause CLM. This dermatitis usually occurs in individuals who frequent beaches; therefore the persons infected are said to be parasitized with sandworms.

The third scenario concerns plumbers, electricians, masons, and technicians working in the crawl space beneath houses, and horticulturists tending flower beds and vegetable gardens. If hookworm-infected dogs or cats have been allowed access to these moist sites and have defecated there, infective larvae may penetrate the laborer's skin. These workers are most often infected on their knees, elbows, buttocks, and shoulders. CLM acquired in this manner is also known as *plumber's itch*.

Symptoms and Diagnosis

The skin-penetrating larval hookworms migrate in the dermis of humans and cause distinct symptoms. The human is an abnormal, or incidental, host. The severity of skin lesions is directly related to the degree of exposure to infective larvae. Symptoms are characterized by red, tunnel-like migration tracks with severe pruritus; therefore the common name for the condition is *creeping eruption*. After skin penetration, the larvae reside in the superficial layers of the skin, actively producing and secreting hyaluronidase, an enzyme that aids their tunneling activity. Hookworm dermatitis is characterized by blisters, red bumps, and red tracts within a few days of initial penetration. The reddened site is usually 3 to 4 cm away from the penetration site, with the larva itself 1 to 2 cm ahead of the lesion. Within weeks to months after the initial infection, the larva dies and is resorbed by the host.

The skin condition is diagnosed by the observation of typical lesions in skin that has come in contact with moist soil containing infective hookworm larvae. A history of contact with the soil also aids in diagnosis. Laboratory findings usually have no role in the establishment of a diagnosis of CLM.

Technician's Note



Cutaneous larva migrans is a self-limiting disease because the larvae cannot survive in the human incidental host for more than a few weeks to months.

Treatment

Suspected cases of CLM in humans should *always* be referred to a dermatologist or family practitioner. Patients often receive both oral and topical treatment with thiabendazole. Pruritus often ceases rapidly for all patients after treatment with this anthelmintic. Surgical treatment to extract migrating larvae is often unsuccessful. Because the larva is situated 1 to 2 cm ahead of the visible tract, it cannot be localized and removed surgically. The application of liquid nitrogen has been advocated; however, the larvae may continue to migrate. Hookworm larvae are capable of surviving temperatures as low as -21°C for more than 5 minutes.

Technician's Note



Cutaneous larva migrans has been successfully treated with topical and oral thiabendazole.

Prevention of Transmission to Humans

Pets should be routinely examined for the presence of parasites and treated appropriately with anthelmintics. Pet owners should not allow their pet's feces to accumulate in the lawn or garden environment. Children's sandboxes should remain covered when not in use.

The seaside resort, with its moist, sandy environment, is an excellent locale for propagating larval hookworms. Pet owners should not allow dogs or cats infected with intestinal parasites to frequent beaches either at home or abroad. Infected pets residing in seaside communities are most likely to transmit CLM to humans. Seaside communities should also have leash laws, and well-trained animal control officers should regularly patrol beaches and remove free-roaming dogs and cats.

If an infected pet on a leash defecates in a public area, the feces should be promptly removed from the area, preferably by use of a disposable plastic bag. Burial of feces on the beach is not sufficient because tides and shifting sands are capable of exposing feces at a later time.

Travelers to exotic (or even local) beaches without enforced leash laws are at increased risk of contracting infective hookworm larvae if sandals or appropriate attire are not worn. Likewise, a person should never sit directly in the sand on beaches where infected animals have been allowed to roam and defecate freely.

Technician's Note



Prevention of *cutaneous larva migrans* can be accomplished by cleaning the yard of feces on a daily basis before infective larvae are hatched, covering sandboxes when not in use, not allowing infected cats or dogs to walk on beaches, and wearing footwear when traveling, especially in suspected areas of infection.

Ancylostoma caninum (Enteric Hookworm Disease)

Infective larvae of the canine and feline hookworms that penetrate the skin usually produce a cutaneous manifestation. Recently *A. caninum* has been found to grow to the adult stage within the intestine of humans. Human enteric infections with *A. caninum* have been reported in Australia and more recently in the United States. Pulmonary involvement and corneal opacities also have been reported in humans infected with *A. caninum*, and an *Ancylostoma* larva has been recovered from the muscle fiber of a patient with CLM.

Technician's Note



Although hookworms produce *cutaneous larva migrans* in humans, *A. caninum* has been able to grow to the adult stage in the human intestines.

Human Infection With Enteric Hookworm Disease

Humans become infected with hookworm when the larval hookworms penetrate unprotected skin. This usually happens when skin (usually of the bare feet) contacts moist, sandy soil contaminated with larval hookworms. Larval hookworms penetrate and migrate within the skin; in most cases, they do not complete their life cycle or mature to adults in the small intestine. In the case of enteric hookworm disease, however, they do complete the life cycle and mature to adults in the small intestine.

Symptoms and Diagnosis

It is interesting that *A. caninum* has caused enteric infections in humans residing in developed, urban communities in northeastern Australia. Although the infections may be subclinical, the chief symptom is abdominal pain, which is frequently severe and has a sudden onset. After biopsy, the chief pathologic finding is focal or diffuse eosinophilic inflammation resulting from a type 1 hypersensitivity response to secreted antigens. Additionally, two cases of eosinophilic enterocolitis attributable to canine hookworms have been reported in the United States. Canine hookworms adapt poorly in the human host; the infection is scant, and the worms do not produce eggs. Therefore fecal flotation will not reveal the presence of hookworm eggs.

Technician's Note



The common symptom of human hookworm infection is abdominal pain.

A. caninum also has been reported to occur sporadically in the human intestine in several locales throughout the world, such as the Philippines, South America, and Israel. In these instances, *A. caninum* did not produce clinically evident disease, was not fully developed, or was not capable of producing eggs. Three cases of infection with a single adult *A. caninum* were reported in eastern Australia, with results confirmed by ELISA and Western blot testing. Not all recent cases of canine hookworm infection in humans

have been restricted to Australia, however. Cases of eosinophilic enterocolitis in two female children were reported in the United States in Louisiana.

Technician's Note



Enteric hookworm infection has been reported in two female children in the United States.

Treatment

Suspected cases of enteric hookworm infection in humans should *always* be referred to a family practitioner or gastroenterologist. In the Australian study, canine hookworms were extracted using biopsy forceps during either laparotomy or colonoscopy. After removal of the worms, all patients recovered and remained well. Both patients in the United States were treated with mebendazole with repeated treatment in 2 to 6 weeks.

Prevention of Transmission to Humans

Human exposure to the infective third-stage larvae of hookworms is directly related to the prevalence of the parasite in the local canine population. The same precautions as listed for CLM should be observed. Because most of the world's population shares the environment with dogs infected with *A. caninum*, hookworms could be encountered widely as a human enteric pathogen. As more physicians and human pathologists become aware of this condition, enteric infections with hookworms acquired from pets will become recognized as a major zoonosis. This zoonosis also stresses the need for awareness among public health workers, veterinarians, and pet owners.¹

Technician's Note



Prevention of enteric hookworm infection can be accomplished by cleaning the yard of feces on a daily basis before infective larvae are hatched, covering sandboxes when not in use, not allowing infected cats or dogs to walk on beaches, and wearing footwear when traveling, especially in suspected areas of infection.

Strongyloides stercoralis (Strongyloidiasis)

Strongyloidiasis is a disease in humans caused by *Strongyloides stercoralis*, the threadworm. Humans can be

infected with this parasitic nematode by dogs, cats, and other carnivores that have the parasite.

Human Infection with *Strongyloides stercoralis*

The female parasite lays eggs in the intestines of the host, where the eggs hatch into larvae. The larvae are typically passed in the feces. The larvae develop into third-stage infective larvae, which can then penetrate the skin of a human host and migrate to the intestines. There will often be inflammation at the site of skin penetration. The larvae can migrate through the lungs on their way to the intestine. Once in the intestine, the larvae mature to an adult worm. The adult worms then produce eggs that hatch in the human intestinal tract. In immune-compromised patients, the larvae can remain in the patient, repenetrate the intestinal mucosa, and develop into adult worms (autoinfection). This autoinfection increases the number of adult worms in the intestines, thus making the disease and symptoms worse.

Symptoms and Diagnosis

The larvae can migrate through the lungs on their way to the intestines, causing respiratory symptoms such as coughing and other symptoms associated with respiratory disease. These symptoms can include mild to severe pneumonia. Once in the intestines, the larvae can cause inflammation of the intestinal mucosa and diarrhea. The diarrhea can lead to exhaustion and emaciation in the human host. The human patient can be asymptomatic, or the worms can cause a mild to severe infection, even causing death. Most fatal infections have been linked to autoinfection, which increases the worm burden and causes the symptoms to become more severe.

Technician's Note



Symptoms of strongyloidiasis can include death to the host, most often occurring from autoinfection, which causes a significant increase in the worm burden in the host.

Diagnosis in humans is essentially the same as seen in animals. A direct fecal smear can be used to identify the larvae in the feces. Fecal flotation or the Baermann technique can also be used for identification of the larval stage of the parasite.

Treatment

All suspected infections of *S. stercoralis* in humans should be referred to the individual's family physician or

¹See www.emedicine.com, www.peteducation.com, and www.diagnosis-me.com.

gastroenterologist. Ivermectin given orally for 1 to 2 days has been successful in many human patients. Thiabendazole given every 12 hours for 2 days has also been successful in human patients. However, thiabendazole may need to be given for 7 to 10 days with hyperinfection caused by autoinfection.

Technician's Note



Physicians can administer ivermectin subcutaneously if oral administration does not build up enough serum levels.

Prevention of Transmission to Humans

Human exposure to the infective third-stage larvae of threadworms is directly related to the prevalence of the parasite in the local canine or feline population. The same precautions as listed for CLM should be observed. Because most of the world's population shares the environment with dogs infected with *S. stercoralis*, threadworms could be encountered widely as a human enteric pathogen. This zoonosis also stresses the need for awareness among public health workers, veterinarians, and pet owners.²

Trichostrongylus axei (Trichostrongyliasis)

Human Infection With *Trichostrongylus axei*

The stomach worm of horses, or *Trichostrongylus axei*, is commonly seen in large animals around the world. According to the CDC and Stanford University resources, trichostrongyliasis has been reported in humans. Humans in the livestock industries are more at risk than other human hosts. Livestock animals, such as horses, cows, sheep, and goats, pass the eggs in the feces. The eggs hatch into the larval stage, which molts through two more larval stages to reach the infective stage. When a human ingests the infective larvae, the larvae attach to the small intestinal mucosa and mature to adults. Humans are an incidental host for *T. axei*.

Symptoms and Diagnosis

Human infections are diagnosed with fecal flotation techniques. Because human infections tend to be light, concentration techniques such as centrifugal flotation are recommended by the CDC. Because the eggs of *T. axei* closely resemble the eggs of *A. caninum* and other hookworm species, care needs to be taken to positively identify the genus and species of the parasite egg.

²See www.emedicine.com, www.peteducation.com, and www.diagnosis-me.com.

Human infections with *T. axei* are often light and asymptomatic. However, heavy infections can produce anemia, anorexia, diarrhea, and abdominal pain.

Treatment

Suspected cases of human infection with *T. axei* should be referred to the family physician or internist. According to the CDC, the drugs of choice for human infection are albendazole and pyrantel pamoate. In addition, ivermectin has been used successfully.

Prevention of Transmission to Humans

Proper pasture management and good deworming programs will reduce the spread of *T. axei* to other animals and humans. Good hygiene practices in conjunction with pasture management and deworming programs will further reduce risk to humans. In endemic areas, humans should refrain from eating raw vegetables.

Trichinella spiralis (Trichinosis or Trichinellosis)

Trichinosis (also known as trichinellosis) is a disease caused by parasitic nematodes of the genus *Trichinella*. The most common cause of clinical trichinosis in humans is *T. spiralis*, a parasite acquired from domestic pigs.

Human Infection With Trichinosis

Humans become infected with trichinosis by eating pork products containing infective larvae of *T. spiralis*. Pork products have been found to be the cause of approximately two-thirds of the reported cases and disease episodes of trichinosis. These products usually are obtained through commercial outlets. Humans become infected by eating lightly processed, partially cooked, or raw pork sausage or spiced pork. Home-raised or locally purchased swine also serve as an important source for human infection. Another important source of infection in humans is the consumption of wild game, particularly bear and boar.

Technician's Note



Human trichinosis infection is caused primarily by eating lightly processed, undercooked, or raw pork sausage or spiced pork.

Symptoms and Diagnosis

The severity and clinical outcome of the disease are related to the number of larvae ingested, the species of *Trichinella*,

and a variety of host factors, such as age, gender, ethnic group, and immune status. Most cases of trichinosis in humans are subclinical, related to the low infection level. Mild, moderate, and severe cases also occur. These clinical manifestations increase in severity and may be life threatening. The clinical manifestation can be classified into two types: early abdominal syndrome and later general trichinosis syndrome. In early abdominal syndrome, clinical signs may commence 2 to 7 days after infection and may last for many weeks. This syndrome is typified by an enteritis caused by the development and maturity of the worms parasitizing the small intestine and by the penetration of the newborn larvae into the intestinal wall. Infected humans may exhibit malaise, nausea, vomiting, anorexia, mild fever, abdominal pain, or diarrhea. Diarrhea may become persistent.

Technician's Note



The severity of symptoms is directly linked to the number of larvae ingested by the human host, the species of *Trichinella*, and the signalment of the host.

Later general trichinosis syndrome may appear weeks to months after the abdominal syndrome. On penetration of the intestine, the larvae migrate throughout the body via the circulatory system. Although these larvae invade various tissues, cysts are found only in striated skeletal muscle cells. Infected individuals develop an allergic vasculitis. This appears as vascular leakage and hemorrhage and may be observed as periorbital edema and fingernail bed and conjunctival hemorrhages. Myalgia (muscle pain) and muscle weakness are common signs related to invasion of the skeletal muscle, inflammation, and related damage. In severe cases, patients may also develop immune-mediated myocarditis, pneumonitis, encephalitis, and other, even more serious complications.

Human trichinosis is usually diagnosed during the muscle phase of the disease. Cases of trichinosis may be diagnosed by blood hemograms and serum chemistries. Persistent eosinophilia is a characteristic sign of trichinosis in humans. Patients may also exhibit a leukocytosis. Serum chemistries may reveal increased immunoglobulin E (IgE), creatine kinase, and lactate dehydrogenase values.

Treatment

Suspected cases of trichinosis in swine should *always* be reported by the veterinarian to both state and federal authorities. Humans infected with trichinosis should *always* be referred to a physician. The benzimidazole anthelmintics, particularly mebendazole, flubendazole, and cambendazole, are highly effective against the muscle larvae.

The CDC has many specialists who are qualified to answer questions about the most complex issues regarding trichinosis in humans.

Prevention of Transmission to Humans

Trichinosis can be contracted only by eating infected meat containing live *Trichinella*. People must assume that pork and wild game may be infected and should prepare the meat accordingly. Pork should be cooked at a uniform temperature of 140°F (60°C) throughout for at least 1 minute. Consumers at home are encouraged to cook pork at a temperature of 160°F (71°C), which ensures that all larval *Trichinella* are killed. Because microwave cooking often produces “cold spots” in meat, it is considered least effective for killing larvae. People must take care to ensure uniform heating of pork products in microwave ovens.

Technician's Note



Because trichinosis can be contracted only by eating infected meat, pork and wild game should be fully cooked, and hands should be washed after handling raw meat.

Larval *Trichinella* also may be killed by freezing. Meat less than 15.25 cm (6 inches) thick should be frozen to 5°F (−15°C) for 20 days, −10°F (−23°C) for 10 days, and −22°F (−30°C) for 6 days. Gamma irradiation of pork by the packing industry may also safeguard consumers from infection with this parasite.

Dirofilaria immitis (Pulmonary Dirofilariasis)

Only *Dirofilaria immitis*, the canine heartworm, causes pulmonary dirofilariasis in humans. **Pulmonary dirofilariasis** has been reported in more than 20 instances outside the United States and more than 90 times within the borders of the United States. Because humans are an incidental host for this parasite, most cases of pulmonary dirofilariasis result in the formation of a single, isolated nodule containing one necrotic (rotting) heartworm at its center.

Technician's Note



Pulmonary dirofilariasis is caused only by *Dirofilaria immitis* in humans.

Human Infection With Dirofilariasis

Mosquitoes are the intermediate host for *D. immitis*, the canine heartworm. Infected mosquitoes must readily attack

both the canine definitive host and the human incidental host. The infective third-stage larvae emerge from the proboscis of the mosquito and are contained in a small drop of the mosquito's body fluid. These moist larvae must be close to the puncture wound made by the mosquito; the larvae enter this wound. After passage through the puncture wound made by the mosquito, the larva continues to develop in the subcutaneous tissues and begins its wandering migration. Rather than residing in the right ventricle and pulmonary arteries, the larva finds its way to the lungs. In the lungs, the single larval *D. immitis* produces an infarction that results in a solitary pulmonary nodule. This infarction is caused by the occlusion (blockage) of an arteriole when a thrombus (blood clot) forms around an impacted worm. The nodule assumes a spherical shape from the secondary granuloma, and the fibrotic reaction that occurs when the antigen from the degenerating worm diffuses into the surrounding pulmonary tissues. These nodules have been reported to occur in every lobe of the lung.

Symptoms and Diagnosis

Most cases of pulmonary dirofilariasis in humans are asymptomatic. Infected patients usually are found by radiographic detection of a density or an opacity in the lung field after routine radiography of the chest. The patient is scheduled for exploratory thoracic surgery, and the nodule is excised. Histopathology usually reveals the presence of a single necrotic worm at the center of the fibrotic nodule. Special stains are available for identification of necrotic worm fragments. Tissue samples from suspected cases should be sent to a pathologist who is familiar with the appearance of these parasites in histopathologic section.

Technician's Note

Radiographs of the thorax will reveal a nodule or density in the lung field. Surgical histopathology will usually reveal the presence of a single necrotic worm at the center of the nodule.

Eosinophil counts vary considerably among humans with pulmonary dirofilariasis and consequently are of little value. Both immunoglobulin M and immunoglobulin G ELISAs for *D. immitis* antibodies have been used in studies of human populations. An ELISA has also been used to detect *D. immitis*-specific IgE in human sera.

Treatment

Suspected cases of pulmonary dirofilariasis in humans should *always* be referred to a thoracic surgeon or human

histopathologist. Additionally, the CDC has many specialists who are qualified to answer questions about the most complex issues of pulmonary dirofilariasis in humans.

Prevention of Transmission to Humans

The transmission cycle of dirofilariasis can be interrupted in several different ways. Veterinarians play an important role in the prevention of dirofilariasis in humans by encouraging pet owners to provide their dogs with preventive medicine. The daily or monthly administration of larvicidal drugs is an effective means of controlling the disease in dogs and preventing "spillover" infection in humans. These drugs are safe and effective. Because the weather in many southern states in the United States is mild, preventive medication should be given throughout the year. Control of stray and feral dogs also is an important consideration in the control of dirofilariasis. These animals represent a major reservoir for this disease.

Technician's Note

Human infection with canine heartworm can be prevented by the use of heartworm preventative to control the spread of the disease in dogs, mosquito-control methods, and the use of mosquito repellents.

Control of mosquitoes can reduce the exposure of humans and dogs and cats to these parasites. The removal of mosquito breeding sites and proper drainage of low-lying areas can be helpful. Mosquito larvicides may be used in some cases; however, resistance to these compounds can occur, and such compounds also disrupt the normal ecological balance in the area. Recently, the biologic control of mosquitoes has been attempted in some areas, and the use of various species of fish to reduce larval populations has been successful.

A final line of defense is the prevention of mosquito bites in both humans and animals. People can prevent mosquito bites by the application of repellents and by wearing protective clothing. All effective mosquito repellents contain diethyltoluamide (DEET). Walking dogs in the early evening hours when mosquitoes are most abundant should be avoided to reduce exposure in both humans and animals. Mosquitoes are not attracted to light, so electrocution devices are not helpful for their control; the use of these devices may actually be detrimental because they destroy insects that may feed on adult mosquitoes.

Technician's Note

Avoid walking dogs in the early evening hours when mosquitoes are most abundant.

Arthropods of Public Health Importance

Sarcoptes scabiei Variety *canis* (Canine Scabies)

Canine scabies is a zoonotic skin condition caused by the ectoparasitic, tunneling sarcoptiform mite *Sarcoptes scabiei*. Both human and canine varieties of this mite are found; these varieties are classified as *S. scabiei* variety *hominis* (human scabies) and *S. scabiei* variety *canis*, respectively. Although these varieties are morphologically identical, they are different in their primary definitive host and in the characteristic lesions they produce.

Human Infection With Canine Scabies

Humans become infected with canine scabies by coming into direct contact with infested dogs. During most of their life cycle, these mites tunnel in the cornified layer of the epidermis (the outermost layer of the skin). During a short period, however, they reside on the surface of the skin and are capable of transferring from one host to another. Infested dogs can pass mites to uninfested dogs or humans through direct contact. It is important to remember that this mite is transitory and does not establish itself in the skin of humans.

Technician's Note

Sarcoptes scabiei variety *canis* can be passed to humans but does not establish itself in the skin of the human incidental host.

Symptoms and Diagnosis

Canine scabies in humans, particularly children, is characterized by the presence of characteristic lesions on the trunk, arms, abdomen, and rarely, the face and genitalia. These lesions have been described as papules (red bumps) or vesicles (tiny blisters). Although these mites tunnel in the canine definitive host, they do not tunnel in human skin. The lesions caused by these mites are extremely pruritic; the onset of the pruritus commences with the appearance of the lesions.

Skin scrapings of the infested human's papular or vesicular lesions are rarely positive. The skin condition is diagnosed by the observation of typical lesions in skin that has come in contact with infested dogs. A history of contact with such dogs also aids in the diagnosis. Laboratory findings usually have no role in the establishment of a diagnosis of canine scabies.

Technician's Note

Typically, laboratory findings do not play a role in diagnosing human scabies infections caused by canine scabies mites.

Treatment

Suspected cases of canine scabies in humans should always be referred to a dermatologist or family practitioner. Antihistamines are prescribed to relieve the itch and topical steroid creams to reduce the papules and vesicles. Antibiotics may be administered to prevent secondary bacterial infection. Remember that these are prescription drugs and must be prescribed by a dermatologist or physician.

Prevention of Transmission to Humans

Transmission of this mite to humans can be prevented by avoiding contact with infested dogs harboring *S. scabiei* variety *canis*. Naturally, when one dog is diagnosed with this parasitic mite, all dogs in the household must be treated to kill the offending ectoparasite.

Pentastomes of Public Health Importance

Reptilian Pentastomiasis

Reptilian pentastomiasis is the presence of encysted, worm-like nymphal stages of snake pentastomes within the mesenteric lymph nodes, liver, lungs, omentum, and other visceral organs of humans. One mammalian pentastome, *Linguatula serrata*, the tongue worm of dogs, behaves similarly and should be handled with precautionary measures as thorough as those for the reptilian pentastomes.

Human Infection With Reptilian Pentastomes

Technician's Note

Humans can act as intermediate hosts for reptilian pentastomes when the infective larvae are ingested.

Adult reptilian pentastomes occur within the lungs, trachea, and nasal passages of the reptilian definitive host, feeding on tissue fluids and blood cells. Female pentastomes can produce several million fully embryonated eggs, each containing a single larval stage with two or three pairs of

rudimentary, jointed legs that are clawed. These eggs are “coughed up” by the host, swallowed, and passed to the outside environment in snake feces. An oval-tailed larva with four (or six) stumpy legs, each of which has two retractable pincer-like claws, hatches from the egg and is infective for the intermediate host. Intermediate hosts include rodents, herbivores, carnivores, nonhuman primates, and in this case, humans. The larva bores into the intestinal wall of the intermediate host and passes with the blood to the mesenteric lymph nodes, liver, lungs, omentum, or other visceral organs, where it becomes encysted. The larva becomes quiescent and metamorphoses into a worm-like nymphal stage. The reptilian definitive host is infected by ingesting the intermediate host with its encysted nymphal pentastomes. The infective nymphs penetrate the snake’s intestine, bore to the lungs, and become sexually mature adult parasites. It is important to note that humans serve as incidental intermediate hosts.

Symptoms and Diagnosis

Most cases of nymphal pentastomiasis in humans are asymptomatic; the patient is unaware of the infection. **Incidental nymphal pentastomiasis** in humans is diagnosed during exploratory surgery, on radiographic examination, and by histopathologic examination of autopsy specimens. The nymphal pentastome may assume a characteristic C shape during its development in the intermediate host. On histopathologic examination, certain morphologic features of the nymphal pentastome can be used for definitive diagnosis.

Antemortem diagnosis of pentastomiasis in humans can be accomplished by radiographic examination. Nymphal pentastomes often die in the human incidental intermediate host. In response, the human host calcifies the dead parasite. These dead, calcified parasites may be visible on radiographic examination. There are no satisfactory laboratory tests for antemortem diagnosis of nymphal pentastomiasis in humans.

Technician’s Note

Pentastomiasis in humans is diagnosed by radiographic examination findings of the calcified, dead nymphal stage.

Treatment

Persons having contact with snakes or snake feces and who suspect that they may be serving as an incidental host for reptilian pentastomes should be examined by an internist, who should be alerted to the possibility of pentastomiasis. In cases of limited infection in humans, free or encysted nymphs can be surgically removed. If tissues are removed for biopsy or autopsy purposes, a histopathologist should

be alerted to the suspicion. Additionally, the CDC has many specialists who are qualified to answer questions about the most complex issues of nymphal pentastomiasis in humans.

Prevention of Transmission to Humans

It is now “trendy” or “fashionable” to keep snakes and other reptiles as pets. Many individuals believe erroneously that reptiles are easier to maintain than either cats or dogs; reptiles do not require daily feeding. Many drawbacks await the unsuspecting owner, including the zoonotic potential of reptilian pentastomes.

In the United States, snakes and other reptiles can be easily obtained in pet stores in almost any mall or shopping center. The initial sources of these snakes often are unknown to the proprietor and owner. Snakes and other reptiles can originate from across town, from across the continent, or from the other side of the globe. The public is largely unaware of the potential risks involved in caring for snakes. It is the veterinarian’s duty to educate the client regarding the severity of incidental nymphal pentastomiasis and to instruct the owner in the proper care and husbandry of captive snakes and other reptiles.

Technician’s Note

The most important part of preventing pentastomiasis infection in humans is proper education of reptile owners.

A newly acquired reptile, whether purchased or collected from the wild, should be presented to the veterinarian for physical examination. This visit should include a routine fecal flotation. If the result of this initial fecal examination is negative, examinations should be performed on at least two successive fecal specimens to reduce the possibility of false-negative results. If pentastome eggs are present in the feces, the client should be warned of the zoonotic potential of these parasites and advised to select another reptile. Anthelmintic drugs are probably ineffective against pentastomes because of the location of the adult parasites within the lungs of snakes. Clients who insist on maintaining poisonous reptiles as pets should be referred to zoos or herpetaria for instructions regarding proper hygienic procedures and good husbandry techniques. Owners and veterinarians should wash their hands after handling snakes, snake feces, or cage and aquarium items. Water bowls and cages must be cleaned regularly.

Snake owners should be instructed about the intricate life cycle of the pentastomes. Because rodent intermediate hosts cannot be identified antemortem, the one practical preventive measure is to feed only clean, laboratory-reared rodents to captive snakes, lizards, crocodilians, and tuataras. Feeding wild, potentially pentastome-infected rodents to reptiles should be avoided.

Conclusion

Because of the public health significance of the parasites discussed in this chapter, it is the veterinarian's responsibility to inform and protect the general public in regard to pathogenic zoonoses.

Technician's Note



It is up to the veterinary professional to properly educate clients on the zoonotic potential of parasites that their pets may have.

Chapter Sixteen Test

MATCHING—Match the scientific term in the left hand column with the correct phrase or term in the right hand column.

A. Diagnosing or treating humans	1. Ingesting pork products containing infective larvae in muscle cysts
B. Cat	2. Ingesting fish containing plerocercoid, or sparganum, within fish muscle
C. Tachyzoites	3. Tiny blisters in the skin
D. Bradyzoites	4. Schistosome cercarial dermatitis from penetration of cercariae of bird flukes
E. Methods of acquiring cryptosporidiosis	5. Violation of state practice act
F. Swimmer's itch	6. Rapidly multiplying stages of <i>Toxoplasma gondii</i>
G. Acquiring <i>Taenia saginata</i>	7. Cerebrospinal nematodiasis
H. Acquiring <i>Taenia solium</i>	8. Definitive host for both <i>Taenia saginata</i> and <i>Taenia solium</i>
I. Neurocysticercosis	9. Red bumps in the skin
J. <i>Echinococcus granulosus</i>	10. Communication with human health care workers
K. Acquiring <i>Dipylidium caninum</i>	11. Ophthalmic examination
L. Acquiring <i>Diphylobothrium latum</i>	12. <i>Cysticercus cellulosae</i> in the brain of a human (serving as an intermediate host)
M. Pernicious anemia	13. Vitamin B ₁₂ deficiency resulting from <i>Diphylobothrium latum</i>
N. <i>Baylisascaris procyonis</i>	14. Only definitive hosts for <i>T. gondii</i>
O. <i>Ancylostoma braziliense</i>	15. Tongue worm of dogs
P. <i>Trichinella spiralis</i>	16. Cooking pork at a temperature of 160°F (71°C)
Q. Papules	17. Ingesting cysticercoids within flea intermediate host
R. Vesicles	18. Slowly multiplying stages of <i>T. gondii</i>
S. <i>Linguatula serrata</i>	19. Mosquito repellent
T. Prevention of trichinosis	20. Ingesting measly pork
U. Human	21. <i>Cutaneous larva migrans</i>
V. Raccoons	22. Ingesting oocysts from the feces of young calves or from contaminated drinking water
W. Paratenic host	23. Ingesting measly beef
X. Diagnosis of ocular larva migrans (OLM) in a child	24. Human infected with visceral larva migrans or OLM
Y. Diethyltoluamide (DEET)	25. Unilocular hydatid cyst in human intermediate host
Z. Advisory capacity	26. Definitive host for <i>Baylisascaris procyonis</i>

Questions for Thought and Discussion

1. There are 18 zoonotic parasites discussed in this chapter. Of these parasites, which three do you think would be most important in a small animal veterinary practice?
2. Of the 18 zoonotic parasites discussed in this chapter, which three do you think would be most important in a large animal veterinary practice?
3. Veterinarians and veterinary technicians should always be concerned about the zoonotic potential of parasites. Who do you think knows more about zoonotic diseases, veterinarians and their highly trained staff or other health care professionals?

Common Laboratory Procedures for Diagnosing Parasitism

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LEARNING OBJECTIVES

After studying this chapter, the reader should be able to do the following:

- Recognize the various types of diagnostic procedures that are used in a parasitology laboratory.
- Detail the types of parasites the various diagnostic procedures can be used to identify.
- Understand the importance of maintaining a well-managed, well-equipped diagnostic facility.
- Understand the importance of good parasitology practices in a diagnostic laboratory.

KEY TERMS

Accession number	Feathered edge
Aliquot	Fecal flotation
Amicrofilaremic	Fecal sedimentation
Aseptic	Field
Aseptically	Flotation solution
Baermann technique	Gastritis
Bot	Gravid Proglottid
Buffy coat preparation	Maggots
Calcereous bodies/ calcereous corpuscles	Magnesium sulfate solution
Cellophane tape preparation	Modified Knott technique
Central record book	Modified Wisconsin technique
Cestode	Nematode
Cysticerci	Occult blood
Direct smear	Occult infection
Ear smear procedure	Ocular micrometer

Parasite	Simple flotation
Pinworm	Skin scrapings
"Pooled" fecal samples from herds	Sodium nitrate solution
Preputial washes	Speciating
Proglottid	Specific gravity
Pseudoparasite	Sporulation
Qualitative fecal procedures	Stage micrometer
Quantitative fecal procedures	Thin blood smear
Saturated sodium chloride solution	Trematodes
Sheather solution	Trophozoite
	Trypanosomes
	Urine sedimentation
	Zinc sulfate solution

The term **parasite** represents many different types of organisms that live within or on animals, feeding on tissues or body fluids or competing directly for the animal's food. These parasites demonstrate amazing variety in size and appearance. Although no bacteria or viruses are visible to the naked eye, parasites range in size from those that must be observed with the most powerful microscopes to organisms that measure more than a meter in length. Parasites also show great variety in the locations in which they live within animals and the ways in which they are transmitted from one animal to another. Because of the wide variations in size and life cycles, there is no one particular diagnostic procedure to identify all parasites.

This chapter describes many of the procedures that a veterinary diagnostician may perform to diagnose both internal and external parasites. Generally, these procedures are used to detect the presence of parasites or their offspring—their eggs or larval stages—on the skin or in the animal's excretions or blood. Additionally, serologic tests are being used more frequently in veterinary clinical practice. Many of the diagnostic procedures described in this chapter are not in common use in most veterinary practices; however, they are mentioned because they may be useful to technicians employed in diagnostic or research laboratories.

Technician's Note



There are many procedures used to diagnose internal and external parasites. Some of these tests will not be performed in the clinic but will be of value to a technician working in a research laboratory or reference laboratory.

It is important to note that these tests by themselves are not totally reliable. Sometimes an animal is infected with parasites, but because the infection is slight, no detectable stages can be observed. If the wrong test is used, no parasite will be detected. For this reason, veterinary practitioners

use not only these tests but also the animal's history, clinical signs, and other laboratory tests, such as blood values, to arrive at a specific diagnosis of internal parasites.

Technician's Note



The tests described may not identify parasites if the parasite burden is low, the female is not actively producing eggs, or there are no detectable stages to be observed. Therefore if the results are negative, these tests should not be the only ones relied on to make a diagnosis of parasitism. Retesting is therefore encouraged.

Diagnosis of Parasites of the Digestive Tract

The following procedures can be used as aids in the diagnosis of parasitism of the esophagus, stomach, liver, bile ducts, and large and small intestines. They can also be used for the diagnosis of parasitic infections in other parts of the body when the eggs or the larval stages are passed by way of the digestive tract (e.g., the "coughed up and swallowed" eggs of lung parasites).

Collection of the Fecal Sample

Veterinary diagnosticians usually do not have the opportunity to collect fecal samples and must rely on samples brought in by clients or samples collected during farm calls. Regardless of how the samples are obtained, it is important to have fresh feces for testing; this fact must be emphasized to clients. Feces collected from the yard, pen, or litter box may be old, and as a result, parasite eggs may have embryonated or larvated, oocysts may have sporulated, or pseudo parasites may be present. Some protozoans are recognized by their distinctive movements, and in old feces, these parasites may have died. The need for fresh feces stems from the rapid development and changes that occur in some common parasites' eggs or larvae once they are passed from the animal. If fresh feces cannot be promptly submitted, clients should be advised to refrigerate the sample for no more than 24 hours.

Technician's Note



Fecal samples should be fresh when used for parasite diagnosis. The feces should not be older than 24 hours and should be as fresh as possible when collected; if necessary, the feces should be refrigerated to prevent eggs from larvating, oocysts from sporulating, or larvae from developing any further.

Feces should be submitted in a sealed glass or plastic container that is clearly marked with the time and date of collection, species of animal, animal's name, owner's name, and any other information relevant to the case. The condition of the stool should be noted for color, consistency, and the presence of parasites. Adult nematodes or tapeworm segments observed by the client may be overlooked by the veterinary practitioner.

Clients are often confused about the amount of feces needed to perform a fecal examination. An excellent rule of thumb is that the amount of feces submitted should be approximately the size of an adult man's thumb.

Small Animal Samples

For small animal samples, it is best that the client actually witness the animal defecating to be sure of the source of the sample and to note any straining, blood in the feces, or other problems. Again, all samples should be properly identified. In laboratories that process a large number of fecal samples, it is sometimes convenient to assign samples an "accession number" to ensure that they are processed in the order in which they are received and to aid in thorough recordkeeping.

Technician's Note



The owner should be instructed to collect a fecal sample that they actually observe being deposited by the animal to ensure the freshness of the sample.

Large Animal Samples

Large animal fecal samples should be collected directly from the animal's rectum if possible. While wearing a disposable plastic glove, the veterinarian performing the rectal examination of cattle or horses can grasp a handful of feces and retrieve it from the rectum. These feces can then be placed in a sealed container and the container appropriately marked with the owner's name, animal's name or number, and date and time of collection.

The practice of turning the disposable palpation glove inside out while removing it and tying the open end with a knot, thus containing the feces, should be discouraged. These makeshift containers are difficult to label, and the process of removing collected feces from such a flexible container can be difficult and distasteful.

Samples from pigs, feedlot cattle, or other grouped animals are often "pooled" fecal samples from herds; that is, several fecal samples are collected from a pen without the specific animal of origin being known. Again, these samples should be as fresh as possible, and each sample should

represent only one group of animals in direct contact with one another. Disposable, zipper-locking plastic bags make good containers for pooled large animal fecal samples. These samples should be labeled with the owner's name, specific location of the pen, number of animals, and date and time of collection. The basic rule of thumb is to always have clean containers that can be tightly sealed to prevent spillage or loss of samples. Any fecal sample that cannot be examined within an hour after collection should be refrigerated to slow down or stop the parasite's development and reduce unpleasant odors.

Technician's Note



Large animal samples should be taken fresh when the veterinarian is doing a rectal examination. In the case of group-housed animals, one "pooled" or collective sample per group is used. All samples should be properly labeled to avoid confusing the samples later.

Examination of the Fecal Sample

Several procedures commonly used to examine feces for internal parasites are described in this section. Before these procedures are attempted, the following rules should be remembered:

- *Always handle fecal samples carefully.* Some parasites, bacteria, and viruses in animal feces are a threat to human health. When examining the samples, the diagnostician should always wear appropriate outer clothing (e.g., a clean laboratory coat) and rubber or plastic gloves. If gloves are not available, hands should be washed thoroughly with a disinfectant soap when the diagnostic tests have been completed. Under no circumstances should food or drink be consumed or tobacco products used in the area where these tests are performed. Likewise, makeup or contact lenses should never be applied in the diagnostic laboratory.

Technician's Note



The technician should always wear latex or plastic gloves and proper laboratory attire such as a lab coat when handling feces because some parasites are zoonotic and can even enter through the skin.

- *Always clean up immediately after the tests have been performed.* Leaving spilled fecal material or dirty glassware or equipment lying about creates a source of contamination and can lead to serious infections in

both animals and humans. The surface top of the area should be thoroughly cleaned with Nolvasan solution or another parasiticide cleaning solution.

- **Always keep good records.** A **central record book** should be kept in the laboratory area, and every sample should be listed by date, owner's name, and animal's name or number. Any observations about the appearance of the fecal sample and any parasites found should be written down immediately. If no parasites are recovered, that fact should be reported; otherwise, it will appear that a particular diagnostic test has not been performed. In recording negative results, the phrase "No Parasites Observed" should be written in the results column. It is always important to transfer the results from the central record book to the animal's permanent veterinary medical record and to the clinic's central computer file.

The record book serves as a backup for veterinary medical records and provides a catalog of parasites that are prevalent in the pet and livestock population of that geographic area. An accurate diagnosis of parasitism is based primarily on the diagnostician's awareness of parasites prevalent within the geographic region. Because twenty-first-century humans are extremely mobile, however, the movement of pets and livestock to and from other geographic regions should also be considered when parasitism is suspected.

Technician's Note

Laboratory results should be recorded in a central laboratory results book and also recorded in the patient's medical record. The central results book is used as a backup to make sure tests were run. If results are not recorded in the central book or in the record, the tests were not performed. Ultimately lab results should be entered into the patients computerized record.

important to record the presence of blood because this assists the veterinary practitioner in identifying certain diseases.

- **Mucus.** Mucus on the surface of fresh feces may be associated with intestinal parasitism or some other metabolic disease.
- **Age of the feces.** If the feces appear old and dry, this should be noted. In aged samples, as noted earlier, parasite eggs may have embryonated or larvated, oocysts may have sporulated, or pseudoparasites may be present. Some protozoan parasites are recognized by their distinctive movements. In old feces, these parasites may have died.
- **Gross parasites.** Some parasites, portions of parasites, or larvae are large enough to observe with the naked eye. Probably the most common are the proglottids of tapeworms, entire roundworms, or even larval arthropods (horse bot fly larvae).

Technician's Note

The physical appearance of the feces should be recorded in the central laboratory record book and on the animal's medical record (i.e., color, consistency, presence of blood, gross parasites seen, and presence of mucus).

Gross Examination of Feces

The following characteristics of feces should be recorded and relayed to the attending veterinarians:

- **Consistency.** The condition of the feces, that is, soft, watery (diarrheic), or very hard (constipation), should be noted. This description will vary with the animal species. For example, cattle feces are normally softer than those of horses or sheep.
- **Color.** Unusual fecal colors should always be reported. For example, light-gray feces may indicate excessive fat in the feces, a sign of poor intestinal absorption.
- **Blood.** In fresh feces, blood may appear dark brown to black and tar-like or may demonstrate the red color associated with fresh blood. Blood may indicate severe parasitism, as well as other intestinal diseases. It is

Fig. 17.1 shows tapeworm segments (**proglottids**) in fresh feces. These should be gently removed from the feces with thumb forceps and examined with a handheld lens or dissecting microscope. Fig. 17.2 shows segments of two common tapeworms (*Dipylidium caninum* and *Taenia pisi-formis*) found in the feces of dogs and cats; their morphology, shape, size, and movement may aid in identification. Short segments of ruminant and equine tapeworms may



Fig. 17.1 Fresh dog feces containing tapeworm proglottids (segments). Proglottids may be motile and exit from the feces into the surrounding environment.

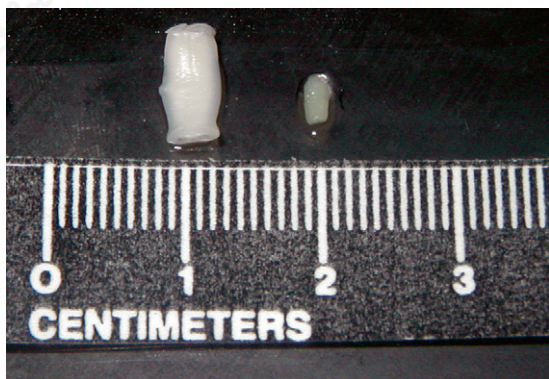


Fig. 17.2 Segments of two common tapeworms (*Dipylidium caninum* and *Taenia pisiformis*) found in the feces of dogs and cats. The morphology, shape, size, and movement of these common small animal tapeworms may aid in their identification.



Fig. 17.3 Chains and individual mature proglottids of tapeworms of ruminants, *Moniezia* species (left), and horses, *Anoplocephala* species (right).

also be recovered from feces (Fig. 17.3). Of interest, swine in the United States do not demonstrate adult tapeworm segments in their feces.

Occasionally, clients will bring in dried tapeworm segments that they have found in their pet's bedding or hair coat. For identification, these segments must be rehydrated by soaking for 1 to 4 hours in a Petri dish or small container of water or physiologic saline. These segments will resume their natural state and can then be identified by their morphologic features. Alternatively, they may be "teased"

open in a small amount of water on a glass microscope slide. If they are **gravid** (egg-containing) proglottids, they may release their eggs and be easily identified.

The diagnostician should always attempt to identify the parasite in terms of genus and species so that the veterinarian can use this information in the control and treatment of the tapeworm infection. The morphology of the segment can assist in the identification of the tapeworms. For example, with *D. caninum*, the tapeworm of dogs and cats that is transmitted by fleas, the diagnostician can observe with a handheld magnifying lens the "double-pored effect," the presence of a genital pore on both sides of every segment. Segments of tapeworms of the genus *Taenia*, which use rodents and mammals as intermediate hosts, have a single pore on each segment. These pores are irregularly alternating. Again, tapeworm segments can also be definitively identified by teasing them open and demonstrating the characteristic eggs they contain.

Technician's Note



Parasites should be identified by genus and species when possible so that the veterinarian can use proper control and treatment measures (i.e., some medications work for some types of parasites and not others, some types of parasites [tapeworms] have different intermediate hosts).

Segments of some uncommon tapeworm species may be "spent" proglottids; that is, the proglottids have dispelled their eggs, and the uteri are empty. If the diagnostician is confused about whether these are tapeworms, the suspect material can be macerated between two microscope slides and examined microscopically to determine whether the tissue has small mineral deposits (called **calcareous bodies** or **calcareous corpuscles**) that are unique to tapeworms (Fig. 17.4).

Other types of parasites are large enough to be observed in animal feces. These include adult worms expelled from their host by drug treatments or overcrowding by fellow parasites (Fig. 17.5). Horse feces may contain **bots**, which are the larvae of a certain type of fly (i.e., *Gasterophilus* species). The larval flies are parasitic in the stomach of horses and are passed in the feces to complete their life cycle outside the body of the equine host (Fig. 17.6).

Technician's Note



Aged feces may contain pseudoparasites picked up from the environment or nonparasitic larvae from flies that have grown after defecation occurred.

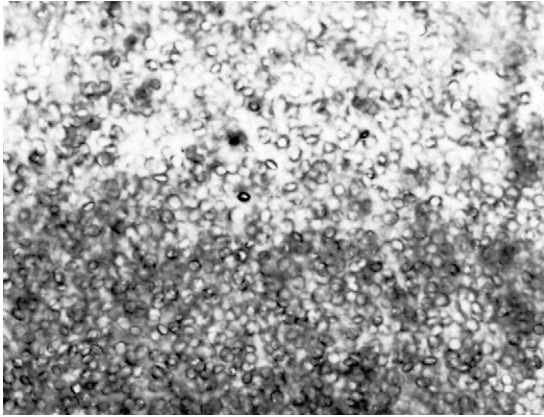


Fig. 17.4 Microscopic calcium deposits (calcareous bodies, or calcareous corpuscles) are unique to tapeworm tissue (140 $\times$ magnification).

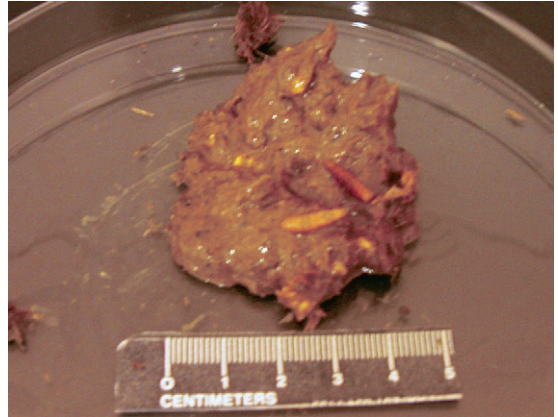


Fig. 17.7 Free-living fly larvae (maggots) in 2-day-old bovine feces.

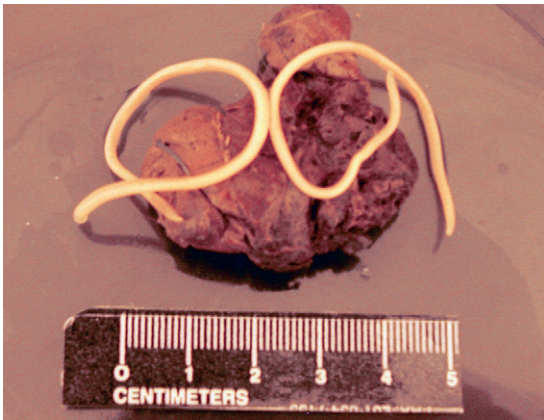


Fig. 17.5 Two roundworms (*Toxocara canis*) in canine feces after treatment with a nematocide.



Fig. 17.6 Two larvae (bots) of bot flies (*Gasterophilus* spp.) in equine feces.

Aged feces may also contain nonparasitic fly larvae called **maggots** (Fig. 17.7). The maggots do not live within the animal's intestines but instead develop from eggs laid by free-living adult flies after the feces have been passed. Flesh flies of the genus *Sarcophaga* deposit larvae (rather than eggs) on the feces of many domestic animals. Usually, fly maggots seen in feces voided more than 12 hours previously should not be mistaken for internal parasites; they should be considered **pseudoparasites**. There is one exception to this rule: *Gasterophilus* species, or horse bot fly larvae, may be found in fresh horse feces.

In general, when the veterinary diagnostician cannot identify parasite-like material (whether parasite or pseudoparasite) found within feces, the unidentified specimen should be sent to a diagnostic facility (a university or state diagnostic laboratory) for proper identification. These specimens should be preserved in 70% alcohol or 10% formalin and shipped as described later in this chapter. An up-to-date history should accompany each specimen.

Microscopic Examination of Feces

Compound microscopes used in a veterinary diagnostic setting vary widely in features and in the magnifications they provide. For parasitologic diagnostic examinations, objective lenses with magnification powers of 4 $\times$, 10 $\times$, and 40 $\times$ are most often used. Oil-immersion objectives (e.g., 100 $\times$ magnification) are occasionally used in veterinary practice, particularly in blood smear preparations. A mechanical stage is preferable and convenient for parasitologic work because it allows for smooth, uniform movement in a thorough search of the microscope slide. Regardless of how the slide is moved, the area under the coverslip must be thoroughly and uniformly searched (Fig. 17.8).

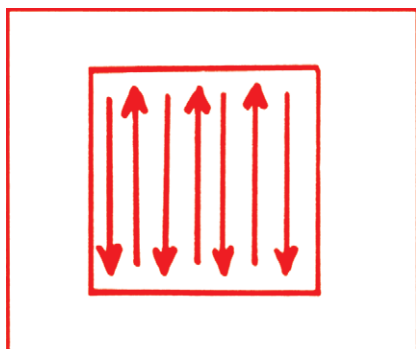


Fig. 17.8 Pattern of movement of microscopic field for thorough examination of the area under the coverslip.

Technician's Note

Compound microscopes with 4 $\times$, 10 $\times$, and 40 $\times$ objectives are usually sufficient for proper identification of parasite larvae, eggs, and oocysts.

To search the slide thoroughly, the diagnostician must begin using an objective lens that magnifies at least 10 $\times$ and, with experience, should be able to scan the slides more rapidly at 4 $\times$. The edge of the coverslip can be used for adjusting the coarse focus, and any debris under the coverslip can be used for fine focus adjustment. Each circular area of the slide seen through the coverslip is called a **field**. The slide should be moved so that the field follows either of the patterns of arrows shown in Fig. 17.8. Each time the edge of the coverslip is reached, a piece of debris or other object at the edge of the field (in the direction of the search) should be identified. The slide is then moved until the piece of debris or other object is at the edge of the field. In this manner, every field scanned slightly overlaps the previous field, and every area beneath the coverslip is examined. When the slide is being scanned in this manner, it is important to move the fine focus knob continually back and forth slightly to aid in the visualization of parasite eggs or cysts not in a single plane of focus. When a parasite egg or cyst is observed at low magnification, higher-power objectives (10 $\times$ or 40 $\times$) may be used to more closely examine it.

Calibrating the Microscope

The size of various stages of many parasites is often important for correct identification. Some examples are eggs of *Trichuris vulpis* versus eggs of *Capillaria* species and microfilariae of *Acanthocheilonema reconditum* versus microfilariae of *Dirofilaria immitis*. Accurate measurements are easily obtained by using a calibrated eyepiece on the microscope.

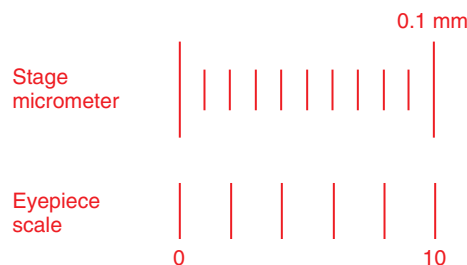


Fig. 17.9 Stage micrometer (upper scale) and eyepiece scale (lower scale) used to calibrate a microscope.

Calibration must be performed on every microscope used in the laboratory. Each objective lens (4 $\times$, 10 $\times$, 40 $\times$) of the microscope must be individually calibrated.

Instruments

The **stage micrometer** is a microscope slide etched with a 2-mm line marked in 0.01-mm (10- μ m) divisions (Fig. 17.9). Note that 1 micron (micrometer, μ m) equals 0.001 mm. Also note that the stage micrometer is used only once to calibrate the objectives of the microscope. Once the **ocular micrometer** within the compound microscope has been calibrated at 4 $\times$, 10 $\times$, and 40 $\times$, it is calibrated for the service life of the microscope; the stage micrometer will never be used again. Therefore it is a good idea not to purchase a stage micrometer but instead to borrow one from a university or some other diagnostic laboratory and return it after calibration.¹

Technician's Note

Microscopes with calibrated eyepieces should be calibrated for each objective for accurately measuring parasite larvae, ova, or oocysts.

The eyepiece scale (or ocular micrometer) is a glass disk that fits into and remains in one of the microscope eyepieces. The disk is etched with 30 hatch marks spaced at equal intervals (see Fig. 17.9). The number of hatch marks on the disc may vary, but the calibration procedure does not change.²

The stage micrometer is used to determine the distance in microns between the hatch marks on the ocular micrometer for each objective lens of the microscope being

¹Item numbers 59 to 1430; Carolina Biological Supply Company, Burlington, NC.

²Item numbers 59 to 1423 or 59 to 1425; Carolina Biological Supply Company, Burlington, NC.

calibrated. This information is recorded and firmly affixed to the base of the microscope for future reference.

Technician's Note



The calibration is used to measure the hatch marks on the ocular micrometer in the eyepiece. This is done at each objective power and is recorded and affixed to the microscope for future reference.

Procedure

Start at low power (10×) and focus on the 2-mm line of the stage micrometer. Note that 2 mm equals 2000 μm. Rotate the ocular micrometer within the eyepiece so that its hatch-mark scale is horizontal and parallel to that of the stage micrometer (see Fig. 17.9). Align the 0 points on both scales.

Determine the point on the stage micrometer aligned with the 10 hatch mark on the ocular micrometer. In Fig. 17.9, this point is at 0.1 mm on the stage micrometer.

Multiply this number by 100. In this example $0.1 \text{ mm} \times 100 = 10 \mu\text{m}$. This means that at this power (10×), the distance between each hatch mark on the ocular micrometer is 10 μm. Any object may be measured with the ocular micrometer scale, and that distance is measured by multiplying the number of ocular units by a factor of 10. For example, if an object is 10 ocular units long, its true length is 100 μm ($10 \text{ ocular units} \times 10 \mu\text{m} = 100 \mu\text{m}$).

This procedure should be repeated at each magnification (4× and 40×). For each magnification, this information is recorded and labeled on the base of the microscope for future reference.

Objective Distance between Hatch Marks (Microns)

4×–25 μm

10×–10 μm

40×–2.5 μm

Direct Wet Mount

Technician's Note



The simplest method of microscopic fecal examination for parasites is the direct wet mount.

The simplest method of microscopic fecal examination for parasites is the direct wet mount, which consists of a small amount of feces placed directly on the microscope slide (Box 17.1). The advantages of the direct wet mount

Box 17.1 Direct Fecal Smear Procedure

1. Place several drops of saline or fecal flotation solution on a slide with an equal amount of feces.
2. Mix the solution and feces together with a wooden applicator until the solution is homogeneous.
3. Smear the solution over the slide into a thin film. The film should be thin enough to read print through.
4. Remove any large pieces of feces.
5. Place a coverslip over the smear.
6. Examine the area of the slide under the coverslip with the compound microscope (see text), and record any protozoan cysts, eggs, larvae, or gross parasites seen.

are the short procedure time and minimal equipment needed. Some veterinary practitioners make direct wet mounts with only the amount of feces that clings to a rectal thermometer after the animal's temperature has been recorded. The direct wet mount allows the diagnostician to observe eggs and larvae undistorted by the procedures discussed later.

Technician's Note



The direct wet mount is a good diagnostic test for viewing the motile forms of protozoans that might be destroyed by using other methods.

A disadvantage to the direct wet mount technique is that the small amount of fecal material required for this procedure is not a good representative sample size; this procedure can be inaccurate. Such a small quantity of feces may not contain the larvae or eggs of the adult parasite the animal is harboring. The animal may be incorrectly assumed to be free of parasites. This procedure also leaves much fecal debris on the slide, which may be confusing to the veterinary diagnostician.

Concentration Methods for Fecal Examination

The greatest disadvantage of the **direct smear** procedure is the small amount of feces used, which greatly reduces the chance of finding parasite eggs or larvae or protozoan cysts. To overcome this problem, methods have been developed to concentrate parasitic material from a larger fecal sample into a smaller volume that can be examined microscopically. Two primary types of concentration methods are used in veterinary practice: **fecal flotation** and **fecal sedimentation**.

Technician's Note

Fecal concentration methods are preferred for identifying parasite ova, larvae, and oocysts in the feces because larger volumes of feces are used, making it more likely the developmental stages will be seen if present in the feces.

Fecal Flotation

Fecal flotation procedures are based on differences in the specific gravity of parasite eggs, cysts, and larvae and that of fecal debris. **Specific gravity** refers to the weight of an object (e.g., the parasite egg) compared with the weight of an equal volume of pure water. Most parasite eggs have a specific gravity between 1.1 and 1.2 (g/mL), whereas tap water is only slightly higher than 1 g/mL. Therefore parasite eggs are too heavy to float in tap water. To make the eggs float, a liquid with a higher specific gravity than that of the eggs must be used. Such liquids are called **flotation solutions** and consist of concentrated sugar or various salts added to water to increase its specific gravity. Flotation solutions usually have specific gravities between 1.2 and 1.25. In this range, fecal material, much of which has a specific gravity of 1.3 or greater, does not float (Fig. 17.10). The result of using flotation solutions is that parasite eggs float to the surface of the liquid and large particles of fecal material sink to the bottom, making the eggs easier to observe (Box 17.2).

Technician's Note

Fecal flotation solutions with a specific gravity of 1.2 to 1.25 are used to "float" parasite ova, cysts, and larvae while the fecal material sinks to the bottom of the container.

If the specific gravity is below the desired range (1.2 to 1.25), add more reagent until the hydrometer indicates this range. If the specific gravity is above 1.25, add water until the proper reading is obtained.

Sugar (Sheather solution), saturated sodium chloride (table salt), magnesium sulfate (Epsom salt), zinc sulfate, and sodium nitrate solutions are the flotation solutions most often used in veterinary practices. Veterinarians may select from among these solutions according to personal preference, availability of reagents, and target parasites.

Sheather solution is more efficient than sodium nitrate solution because it floats more eggs, but it is messy to work with (it is quite sticky). Sugar, however, is readily available and inexpensive, does not distort roundworm eggs,

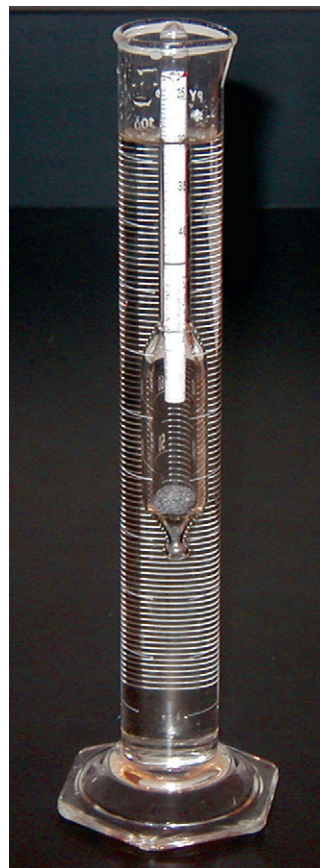


Fig. 17.10 Measuring the specific gravity of a flotation solution with a hydrometer.

and floats a higher percentage of the eggs. **Sodium nitrate solution** is a less efficient flotation solution, and it forms crystals and distorts the eggs after a time. Sodium nitrate may be difficult to acquire, but it can be purchased through chemical supply houses. Sodium nitrate solution is used in commercial fecal diagnostic kits and may be purchased already prepared in the form of refill bottles for these kits. Sodium nitrate solution is more expensive than sugar solution.

Saturated sodium chloride solution is the least desirable flotation solution. Its main disadvantages are that it corrodes expensive laboratory equipment, such as compound microscopes and centrifuges; forms crystals on the microscope slide; and severely distorts the eggs. Because it reaches a specific gravity of 1.2, some heavier eggs may not float in this solution. However, sodium chloride is inexpensive, easily prepared, and readily available.

Box 17.2 Preparation of Flotation Solutions**Sugar Flotation Solution (Sheather Solution)**

Determine the amount of sugar solution required, and use about half that amount of water. Use an appropriately sized pot (e.g., cooking pot). Heat the water, but be careful not to let it boil. Add granulated pure cane sugar (table sugar) to the water while stirring. About 454 g (1 lb) is required for every 355 mL (12 oz) of water. Add 6 mL of 40% formaldehyde solution or 1 g of crystalline phenol for every 100 mL of solution; these chemicals serve as preservatives and prevent mold from growing in the sugar solution. The solution's specific gravity should always be checked with a hydrometer (see Fig. 17.10), an instrument available from scientific supply houses.

Sodium Nitrate Flotation Solution

While stirring, add about 315 g of sodium nitrate for every liter of water. Heating is not necessary but hastens the dissolution process. Adjust the solution to a specific gravity of 1.2 to 1.25, as discussed for the sugar solution.

Zinc Sulfate Flotation Solution

While stirring, add 386 g of zinc sulfate for every liter of water. Heating the water is not necessary but hastens the dissolution process. Using a hydrometer, adjust the solution to a specific gravity of 1.2 to 1.25, as discussed for the sugar solution.

Magnesium Sulfate Flotation Solution

While stirring, add about 350 g of magnesium sulfate (Epsom salt) for every liter of water. Heating the water hastens the dissolution process. Using a hydrometer, adjust the solution to a specific gravity of 1.3, as discussed for the sugar solution.

Saturated Sodium Chloride Flotation Solution

Add sodium chloride (table salt) to boiling water until the salt no longer dissolves and settles to the bottom of the pot. There is no need to adjust the specific gravity because it cannot go above 1.2 with this solution.

Technician's Note

The fecal solutions of choice are Sheather sugar solution, sodium nitrate solution, and zinc sulfate solution; however, the specific gravity of the solution will determine how many different types of eggs, larvae, and cysts are able to be floated.

Zinc sulfate solution is similar in efficiency to sugar solution and can be purchased through chemical supply houses or from veterinary suppliers in ready-to-mix gallon containers. Cystic stages of intestinal protozoans such as *Giardia* are best concentrated with zinc sulfate solution. **Magnesium sulfate solution** (Epsom salt) also forms crystals on the microscope slide. It is an inexpensive solution and is easily prepared and readily available.

Simple Flotation

The **simple flotation** method is probably the second-most-common parasitologic test performed in veterinary practices, after the direct smear (Box 17.3). A specimen of 2 to 5 g of feces is placed in a suitable container, such as a paper cup. Flotation solution is added directly to the feces, mixed thoroughly with a tongue depressor, and strained through a metal tea strainer (or cheesecloth) into a second paper cup. The contents of the second paper cup are poured into a test tube, and the flotation medium is added until a meniscus is formed (Fig. 17.11). A glass coverslip

is placed over the meniscus and allowed to remain for 10 to 15 minutes (depending on the flotation medium used), after which the coverslip is removed and placed on a glass microscope slide. The parasite eggs are lighter than the solution and float to the top of the tube (or vial) of flotation solution. The coverslip is removed from the liquid and examined with a microscope. This method is less efficient than the centrifugal flotations described next, but it does not require a centrifuge.

Some veterinary diagnostics companies have packaged simple flotation kits consisting of a prepared flotation solution, disposable plastic vials, and strainers; examples include the Ovassay, Fecalyzer, and Ovatector (Fig. 17.12).³ Instructions for use are included with these kits. The main disadvantages to these kits are the expense and the environmental contamination created by the disposal of plastics.

Centrifugal Flotation

The centrifugal flotation procedure more efficiently recovers parasite eggs and cysts and requires less time than the simple flotation procedure (Boxes 17.4A and 17.4B and Fig. 17.13). However, it does require a centrifuge capable of holding 15-mL test tubes and producing a centrifugal force of 400× to 650× g. Most tabletop centrifuges are capable of

³Ovassay manufactured by Synbiotics Corp., San Diego, CA; Fecalyzer manufactured by EVSCO Pharmaceuticals, Buena, NJ; Ovatector manufactured by BGS Medical Products, Inc., Venice, FL.

Box 17.3 Simple Flotation Procedure

1. Place about 2 g (tsp) of the fecal sample in a 90- to 150-mL waxed paper cup. Add approximately 30 mL of flotation medium. Using a tongue depressor, make an emulsion by thoroughly mixing the solution with the feces until a fecal slurry has been made.
2. Bend the side of the waxed paper cup into a spout, and cover the spout with a piece of cheesecloth. Pour the emulsion through the cheesecloth into a straight-sided shell vial. A tea strainer may be used instead of cheesecloth: Pour the contents of the cup through the strainer into a second waxed paper cup and the contents of that cup into the shell vial. Wash the tea strainer thoroughly in hot, soapy water before using it again.
3. Fill the shell vial to the top, then slightly overfill it so that a meniscus forms above the lip of the vial (see Fig. 17.11). If there is not enough fluid in the cup to fill the shell vial, a small amount of fresh flotation medium may be added. Place a glass coverslip gently on top of the fluid, and allow it to settle on the meniscus.
4. Allow the coverslip to remain undisturbed on top of the vial for 10 to 20 minutes (sugar solution requires longer than sodium nitrate). If the coverslip is removed before this time, all the eggs may not have had time to float to the top. If left for more than 1 hour, some eggs may become waterlogged and begin to sink or become distorted.
5. Remove the coverslip carefully, picking it straight up, and immediately place it on the microscope slide. When placing the coverslip on the slide, be sure to hold the coverslip with one edge tilted slightly up, and allow it to gradually settle levelly on the slide. This reduces the number of air bubbles beneath the coverslip.
6. Examine the area of the slide under the coverslip with the compound microscope (see text), and record any protozoan cysts, eggs, larvae, or gross parasites seen.



Fig. 17.11 Fecalyzer vial filled with flotation medium, showing meniscus.

producing this force. Centrifuges with a fixed-angle head-piece are less suitable for such centrifugal flotation procedures but can be used.

Fecal Sedimentation

Sedimentation procedures concentrate both feces and eggs at the bottom of a liquid medium, usually water (Box 17.5). Sedimentation detects most parasite eggs but is not as good as flotation for providing a clear sample for microscopic examination. Sedimentation is primarily used to detect eggs or cysts that have too high a specific gravity to float or that would be severely distorted by flotation solution.

Sedimentation can be used for roundworm and tapeworm eggs, but there is usually too much fecal debris hiding the eggs to make it worthwhile. Therefore this procedure is not used routinely and has its greatest use in suspected trematode (flake) infections. Flake eggs are somewhat denser and sometimes larger than roundworm eggs. Some fluke eggs float in flotation solutions, and others do not. Some laboratories increase the specific gravity of their flotation solutions to 1.3 to ensure recovery of fluke eggs by the flotation technique. The problem with the use of flotation methods for the recovery of fluke eggs is that the eggs may be damaged by the high concentration of the solution and may become difficult to identify.

Technician's Note

Fecal centrifugation is the method of choice for fecal flotation testing because it has been shown in multiple studies to float a higher concentration of ova, cysts, and larvae than simple fecal flotation.

Technician's Note

Fecal sedimentation is rarely used for routine fecal analysis. It is more commonly used to test for trematode eggs, which are heavier than other parasite eggs and thus do not float as well.



Fig. 17.12 Three commercially available fecal flotation kits: Fecalyzer (*left*), Ovassay (*center*), and Ovatector (*right*). These kits are based on the principles of the simple flotation procedure.

Box 17.4A Fecal Sedimentation and Centrifugation Combination Procedure

1. Using a paper cup and tongue depressor, mix approximately 2 mL of feces with enough water to make a semisolid suspension.
2. Place a wire tea strainer (or piece of cheesecloth) over a second paper cup and empty the fecal suspension into it. Use the tongue depressor to press out most of the liquid; return the solid waste to the first cup and discard. Wash the strainer in hot running water; soak it in water containing dishwashing solution.
3. Pinch the rim of the second paper cup to form a pouring spout, and transfer the contents into a 15-mL centrifuge tube (a test tube). Place the tube into the centrifuge, remembering to counterbalance the tube with an identical tube filled to the same level with water. Be sure that all tubes are marked so they can be identified after centrifugation.
4. Centrifuge for 3 minutes at 400x to 650x g. For many centrifuges, this is about 1500 rpm. Decant the supernatant, which contains fats and dissolved pigments that interfere with the identification of parasite eggs, larvae, or cysts.
5. Add concentrated flotation solution to within $\frac{1}{2}$ to $\frac{3}{4}$ inch of the top of the tube and resuspend the sediment, using a stirring action with a wooden applicator stick. Insert a rubber stopper, and mix by four or more inversions so that the solution is thoroughly mixed with the sediment.

Variation A

Return the tube to the centrifuge, remembering to counterbalance the tube with an identical tube filled to the same level with the same flotation solution. Centrifuge for 5 minutes. Without removing the tube from the centrifuge, pick up the surface film containing eggs, larvae, or cysts by touching the surface gently with a wire loop (bent at a 90-degree angle) (see Fig. 17.13) or a glass rod. Transfer the surface film to a glass microscope slide and add a coverslip. Examine the slide under the compound microscope using the 10x objective (see text).

Variation B

Return the tube to the centrifuge, and fill the centrifuge tube with the flotation solution until a meniscus is formed. Apply a coverslip to the top of the tube. Remember to counterbalance the tube with an identical tube filled to the same level with the same flotation solution and covered with a coverslip. Centrifuge for 5 minutes. After centrifugation, lift the coverslip straight up and place it on the glass slide. This modification works only if a variable-angle (not a fixed-angle) centrifuge is used. Examine the slide under the compound microscope, using the 10x objective (see text).

Box 17.4B Fecal Centrifugation Technique

1. Using a paper cup and tongue depressor, mix approximately 1 oz of feces with enough flotation solution to make a semisolid suspension. (You can use a 12-cc syringe case instead of paper cup and a fecal loop to mix.)
2. Place a wire tea strainer (piece of cheesecloth or 4-inch gauze square) over a second paper cup and empty the fecal suspension into it. Use the tongue depressor to press out most of the liquid; return the solid waste to the first cup and discard. Wash the strainer in hot running water; soak it in water containing dishwashing solution. If using a syringe case, pour directly into centrifuge tube through a funnel with cheesecloth or gauze filter.
3. Pinch the rim of the second paper cup to form a pouring spout, and transfer the contents into a 15-mL centrifuge tube (a test tube). Place the tube into the centrifuge, remembering to counterbalance the tube with an identical tube filled to the same level with water. Be sure that all tubes are marked so they can be identified after centrifugation.

Variation A for Fixed-Head Centrifuge

Place the tube into the centrifuge, remembering to counterbalance the tube with an identical tube filled

to the same level with the same flotation solution. Centrifuge for 5 minutes at about 1500 rpm. Without removing the tube from the centrifuge, pick up the surface film containing eggs, larvae, or cysts by touching the surface gently with a wire loop (bent at a 90-degree angle) (see Fig. 17.13) or a glass rod. Transfer the surface film to a glass microscope slide and add a coverslip. Examine the slide under the compound microscope using the 10x objective (see text).

Variation B for Swinging-Head Centrifuge

Place the tube into the centrifuge, and fill the centrifuge tube with the flotation solution until a meniscus is formed. Apply a coverslip to the top of the tube. Remember to counterbalance the tube with an identical tube filled to the same level with the same flotation solution and covered with a coverslip. Centrifuge for 5 minutes at 1500 rpm. After centrifugation, lift the coverslip straight up and place it on the glass slide. Examine the slide under the compound microscope, using the 10x objective (see text).

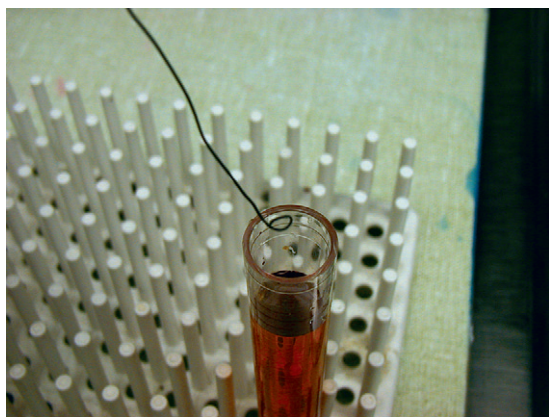


Fig. 17.13 Use of a bacteriologic loop to transfer a drop from the top of a fecal flotation emulsion after a centrifugation procedure. Note that the loop is bent at a 90-degree angle to the wire handle.

Box 17.5 Sedimentation Procedure

1. Using a tongue depressor, mix about 2 g of feces with tap water in a cup or beaker. Strain the mixture through cheesecloth or a tea strainer into a centrifuge tube, as described for centrifugal flotation.
2. Balance the centrifuge tubes and centrifuge the sample at about $400 \times g$ (about 1500 rpm). If a centrifuge is unavailable, allow the mixture to sit undisturbed for 20 to 30 minutes.
3. Pour off the liquid in the top of the tube without disturbing the sediment at the bottom.
4. Using the pipette and bulb, transfer a small amount of the top layer of sediment to a microscope slide. If the drop is too thick, dilute it with a drop of water. Lugol iodine solution (diluted 1:5 in water) may be used for dilution instead of water to aid in identification of protozoan cysts. Apply a coverslip to the drop. Repeat the procedure using a drop from the bottom layer of the sediment.
5. Examine both slides microscopically (see text).

Quantitative Fecal Examination

All the procedures previously described are **qualitative fecal procedures**, which means they reveal the presence or absence of parasite ova or cysts. **Quantitative fecal procedures** indicate the number of eggs or cysts present in each gram of feces. The results of these procedures are a rough,

or approximate, indication of the number of adult parasites present within the host (the severity of the infection). These procedures are not completely accurate because different species of parasites produce different numbers of eggs. Also, the most severe signs of disease are produced by parasites that have not yet started to produce eggs or larvae.

Technician's Note

Qualitative procedures tell you whether parasite ova or cysts are present in a fecal sample, whereas quantitative procedures provide the number of ova or cysts in 1 g of feces.

Several procedures are used to estimate the numbers of parasite eggs or cysts per gram of feces, including the Stoll egg-counting technique, the modified Wisconsin sugar flotation method, and the McMaster technique. These techniques are used most often in research laboratories and are not usually performed in veterinary clinical practice. Of these tests, the **modified Wisconsin technique** and the McMaster Technique are used most often (Boxes 17.6A and 17.6B).

Technician's Note

Quantitative procedures are used more often in research facilities than in the veterinary clinic.

Box 17.6A Modified Wisconsin Sugar Flotation Method

1. Fill a 20-mm × 150-mm test tube with Sheather solution 1 inch below the top of the tube.
2. Using scales, weigh exactly 3 g of the fecal sample and place into a paper cup.
3. Pour the Sheather solution from the test tube into the paper cup containing the feces and mix well.
4. Place a tea strainer in a second paper cup, and pour the Sheather solution and feces mixture through the strainer. Using a tongue depressor, press all the liquid out of the fecal pat and through the tea strainer.
5. Return the Sheather solution and strained feces mixture to the test tube originally containing the Sheather solution and place it in a test tube rack.
6. Add Sheather solution to the test tube until a small meniscus forms. Carefully place a glass coverslip on top of the meniscus.
7. Allow the test tube with its coverslip to stand undisturbed for 4 hours.
8. Remove the coverslip, place it on a glass microscope slide, and examine the entire coverslip on low power (10×), counting parasite eggs, cysts, or oocysts. This count represents the number of eggs, cysts, or oocysts per 3 g of feces.

Examination of Feces for Protozoans

All the procedures for microscopic fecal examination are useful for the detection of cysts of intestinal protozoans. However, some protozoans do not form cysts and are passed in the feces as **trophozoites** (motile forms). Cyst-forming protozoans may also pass trophozoites in the feces in large numbers when the host has diarrhea. Trophozoites lack the rigid wall of cysts, and they collapse and become difficult to recognize in flotation solutions.

To observe live trophozoites, a direct wet mount technique should be prepared as previously described, but physiologic saline must be used to dilute the feces. Trophozoites are recognized by their movement, which varies among the different groups of protozoans. *Balantidium coli*, a parasite of humans, pigs, and dogs, moves in a slow, tumbling manner. *Giardia* species, which are found in several species of animals, swim in a jerky motion. Trichomonads, also found in several different types of hosts, appear to wobble and have a sail-like, undulating membrane that ripples as they swim. Amoebae, found in humans and dogs, move by extending part of their cell body (the pseudopod) and moving the rest of the body after it.

Technician's Note

Motile Giardia trophozoites swim in a jerky motion in a fresh fecal smear.

Box 17.6B McMaster Technique

1. Place 26 mL of flotation solution in a beaker or cup.
2. Measure out 3 g of feces.
3. Add small amounts of feces (if using a graduated beaker, up to the 30-mL mark) until 3 g of feces has been added.
4. Macerate and mix feces in solution to distribute the ova.
5. Stir contents with a pipette; once evenly mixed, pipette off solution to add to McMaster chamber (counting slide).
6. Fill McMaster's chamber (counting slide) with pipetted solution.
7. Place McMaster's chamber on microscope.
8. Count eggs for each type of parasite in both sides of the chamber. Record each parasite type separately.
9. Multiply the total eggs counted by 25 for each parasite type. This equals eggs per gram (EPG).
10. Calculate fecal egg count reduction (FECR) with the following equation (when you have pretreatment and posttreatment counts): $\text{EPG (pretreatment)} - \text{EPG (posttreatment)} = \text{FECR EPG}$, then $\text{FECR EPG/pretreatment EPG} \times 100 = \% \text{ egg reduction post treatment}$.

Many methods have been used to stain and preserve intestinal protozoans. The simplest method to stain cysts is a direct smear stained with an iodine solution (as described under the direct smear procedure). This method does not preserve the sample but highlights any protozoans in the smear, facilitating identification. Several iodine solutions are available for staining. Modified D'Antoni iodine or Lugol iodine is often used in diagnostic laboratories to stain protozoan cysts (Box 17.7).

Technician's Note



Modified D'Antoni's iodine or Lugol iodine can be used to stain protozoan cysts on a direct smear.

Fecal smears containing protozoal trophozoites can be allowed to dry and then can be stained with Giemsa, Wright, or Diff-Quik stain.⁴ Once stained in this manner, the slides may be sent to a diagnostic laboratory for identification of the organism.

Other procedures for the concentration, staining, and preservation of intestinal protozoans include merthiolate-iodine-formaldehyde (MIF) solution, polyvinyl alcohol, and iron hematoxylin. These staining procedures are generally too complex and time-consuming for use in veterinary practice.

Box 17.7 Preparation of Modified D'Antoni's Iodine Solution

1. Before preparing this solution, the technician should remove all jewelry because this iodine solution can permanently stain precious metals.
Distilled water, 100 mL
Potassium iodide, 1 g
Powdered iodine crystals, 1.5 g
2. The potassium iodide solution should be saturated with iodine, with some excess remaining in the bottle. It should be stored in brown, glass-stoppered bottles and kept in the dark. The solution is ready for use immediately and should be decanted into a brown glass dropping bottle. When the solution lightens, it should be discarded and replaced with fresh stock. The stock solution is good as long as an excess of iodine remains in the bottom of the bottle.
3. When using this solution in the laboratory around the compound microscope, the technician should take great care not to spill the solution onto the metal parts of the microscope because it is extremely corrosive.

⁴Diff-Quik, product number B4132-1; Baxter Diagnostics, Scientific Products Division, McGaw Park, IL.

Fecal Culture

Fecal culture is used in diagnostic parasitology to differentiate parasites whose eggs and cysts cannot be distinguished by examination of a fresh fecal sample. For example, the eggs of large strongyles in horses are very similar to those of small strongyles. To distinguish between them, feces containing strongyle eggs are allowed to incubate at room temperature for several days while the larvae hatch from the eggs. The newly hatched larvae can then be identified.

Nematode (Roundworm) Eggs

The procedure for the culture of nematode (roundworm) eggs in feces is simple; however, identifying the larvae once they are recovered is much more tedious (Box 17.8). Diagnosticians who need to culture and identify nematode larvae are referred to state or private diagnostic laboratories.

Technician's Note



The culture and identification of nematode larvae are often referred to state or private diagnostic laboratories.

Coccidial Oocysts

Another type of fecal culture that has some use in veterinary practices is sporulation of coccidial oocysts (Box 17.9). **Sporulation** is a process of development that takes place

Box 17.8 Fecal Culture of Roundworm Eggs

1. Place 20 to 30 g of fresh fecal sample in a jar. Break up the feces with a tongue depressor and moisten slightly with tap water. The mixture should not be so wet as to appear soupy.
2. Place the jar on a shelf, away from direct sunlight, and allow it to incubate at room temperature for 7 days. There should be enough moisture so that droplets of condensed water can be seen on the sides of the glass jar. If moisture does not form, add a few drops of water.
3. Some species of nematode larvae can migrate up the walls of the jar. These may be recovered by removing condensation drops from the glass with an artist's paintbrush and transferring them to a drop of water on a microscope slide. Other species must be recovered with the Baermann technique (see p. 18).
4. Apply a coverslip to the slide (a drop of modified D'Antoni's iodine may be added), and pass it over the open flame of a Bunsen burner once or twice to kill the larvae while they are in an extended position. Place the slide on the microscope slide stage and identify the larvae.

Box 17.9 Fecal Culture of Coccidial Oocysts

1. When coccidial oocysts are found in a fresh fecal sample, place 10 to 20 g of the sample in a beaker or a paper cup and cover with about 60 mL of 2.5% potassium dichromate solution. Mix this solution thoroughly with a tongue depressor.
2. Pour the solution into a Petri dish and let incubate at room temperature for 3 to 5 days. Open the plate daily and swirl the contents gently to allow air to reach the developing oocysts.
3. After incubation, centrifuge the plate's contents as described under the sedimentation procedure (see [Box 17-5](#)).
4. Process the fecal sediment by the centrifugal flotation procedure to recover the oocysts; then examine them microscopically.

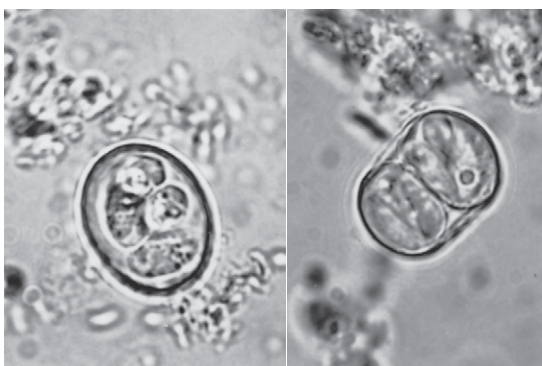


Fig. 17.14 Fully sporulated oocysts of *Eimeria* species (left) and *Cystoisospora* species (right) (1400 $\times$).

within the oocyst. In fresh feces, oocysts of various species of coccidia may appear similar to one another; however, once sporulation occurs, coccidia of the genus *Eimeria* can be easily distinguished from those of the genus *Cystoisospora*. A fully sporulated oocyst of the genus *Eimeria* contains four sporocysts, whereas a fully sporulated oocyst of the genus *Cystoisospora* has two sporocysts ([Fig. 17.14](#)).

Technician's Note

When sporulated *Cystoisospora* species have two sporocysts, each containing four sporozoites while, *Eimeria* species have four sporocysts each containing two sporozoites.

Sample Collection at Necropsy

Necropsy, or postmortem examination, is an important method for diagnosing parasitism of the digestive tract.

Box 17.10 Decanting Method for Sample Collection at Necropsy

1. Using wrapping twine, tie off each portion of the digestive tract (the stomach, duodenum, small intestine, large intestine, and so on). Open each organ, and pour its contents into a bucket marked with the animal's identification and the organ being examined. Scrape the interior lining of the organ with a spatula or the blunt edge of a pair of scissors, and add the scrapings to the bucket.
2. Add an equal volume of water to the contents in each labeled bucket and mix thoroughly with a stirring spoon or paddle.
3. Allow the heavier part of the contents to settle to the bottom of the bucket. This usually takes about 45 minutes. Carefully pour off the liquid on top, leaving the sediment.
4. Add an equal volume of water to the sediment and stir again. Allow this to resettle. Repeat this process until the water over the sediment becomes clear.
5. Pour off the clear water over the sediment, then transfer the sediment to the dissection pan.
6. Using the dissecting microscope, examine a small amount of the sediment at a time. Any parasite found should be gently removed from the sediment with thumb forceps and should be preserved (see text). Each parasite should be identified using a compound microscope.

Lesions of internal organs are often fairly indicative of the type of parasites that produce them. The veterinary technician is responsible for assisting during necropsy procedures and, in particular, helping with the preservation and processing of the samples collected. During necropsy and the processing of samples, all workers should wear gloves.

Technician's Note

Technicians are usually responsible for assisting with necropsy examinations, and all participants should wear gloves.

The contents of the digestive system may contain many types of parasites, some of which may be nematodes (roundworms). Trematodes (flukes) and cestodes (tapeworms) are easily seen and can be individually isolated. The two preferred methods for recovering roundworms are the decanting method ([Box 17.10](#)) and the sieving

Box 17.11 Sieving Method for Sample Collection at Necropsy

1. Using wrapping twine, tie off each portion of the digestive tract (the stomach, duodenum, small intestine, large intestine, and so on). Open each organ, and pour its contents into a bucket marked with the animal's identification and the organ being examined. Scrape the interior lining of the organ with a spatula or the blunt edge of a pair of scissors, and add the scrapings to the bucket.
2. Add an equal volume of water to the contents in each labeled bucket and mix thoroughly with a stirring spoon or paddle.
3. Pour the mixture through a 1-mm mesh (No. 18) sieve and then through a 0.354-mm mesh (No. 45) sieve. Reverse wash the contents of the sieve with water. Sieves are available from Fisher Scientific (Pittsburgh, PA).
4. Using the dissecting microscope, examine a small amount of the sieve's contents at a time. Any parasite found should be gently removed from the contents with thumb forceps and should be preserved (see text). Each parasite should be identified using a compound microscope.

method (Box 17.11). With either method, the contents of the different parts of the digestive tract should be separated into individual containers.

It is not always necessary to examine all sediment or sievings. An estimate of the number of worms may be obtained by counting an **aliquot** (a known percentage of the total volume) of the sediment.

When parasites are recovered from the digestive tract or other parts of the body, it may be necessary to preserve them for identification later. **Nematodes** (roundworms) should be briefly washed in water to remove any attached debris and then placed in hot 70% ethyl alcohol (ethanol). Isopropyl alcohol may be used but is not preferred. The alcohol is allowed to cool, after which the worms are examined. The worms may be stored in the alcohol after adding glycerine to make a 5% concentration. **Cestodes** (tapeworms), including the scolices (heads), should be placed in water at about 37°C (98.6°F) for about 1 hour and then stored in a mixture of 5% glycerine or 70% alcohol or 5% to 10% formalin. **Trematodes** (flukes) may be preserved in the same manner as tapeworms. If tapeworms and flukes are to be stained later, they should be "relaxed" in alternate changes of ice water and tap water for about 3 hours and then lightly pressed between sheets of glass immersed in 10% formalin.

Technician's Note

Parasites may be preserved and stored for future analysis. The preservation technique depends on the type of parasite. Nematodes are preserved differently than cestodes or trematodes.

Sometimes during necropsy of domestic animals, **cysticerci**, or bladder worms, are seen in the abdomen, muscles, or other internal organs. These are the larval stages of certain species of tapeworms and appear as fluid-filled, balloon-like structures that vary from the size of a pea to the size of a basketball, depending on the species of tapeworm. Caution should be used in handling these parasites because the fluid inside could produce allergic reactions.

Also during necropsy of large animals, long filarial parasites of the genus *Setaria* may be observed in the abdominal cavity. These should be recorded and saved as part of the tissues collected and parasites recovered from the animal.

Government or private diagnostic laboratories are useful in assisting with identification when questions arise, but they must be supplied with well-preserved specimens and adequate histories from the animals on which the necropsies were performed.

Many diagnostic laboratories have the capability of identifying both protozoan and metazoan parasites in histopathologic sections. Again, the laboratories must be provided with well-preserved tissue samples and adequate histories from the animals. These procedures are beyond the scope of this textbook; however, the diagnostician must remember that even tiny cross sections or longitudinal sections of parasites in histopathologic sections may be used to diagnose both infections and infestations of all types of parasites.

Shipping Parasitologic Specimens

Any parasitologic specimen shipped to a diagnostic laboratory by the U.S. Postal Service or other private carrier should be in a preservative such as 70% ethyl alcohol or 10% formalin to render it noninfectious. Specimen jars must be sealed well so that they do not leak, and a suitable packing material, such as foam "peanuts," should be added to cushion the contents from any rigorous handling during the shipping process. During the summer months or any hot spell, cool packs should accompany any specimen.

Technician's Note

Parasitologic samples sent through the U.S. Postal Service or other private carriers should be preserved in 70% ethyl alcohol or 10% formalin and properly packaged so the contents do not leak.

Fecal materials should be mixed with 10% formalin at a ratio of 1 volume of feces to 3 volumes of formalin and placed in a screw-cap vial of 20- to 30-mL capacity. The vials should be sealed with tape and labeled with the practitioner's name; the client's name; and the species of animal and its name or number, gender, and age. The relevant clinical history or diagnostic questions should also accompany the specimen. It is always wise to place any pertinent papers detailing the case history in a separate plastic bag in case leakage occurs during the shipping process. Parasite specimens preserved in alcohol or formalin should be shipped in similar vials. The vials should be wrapped in absorbent material, such as soft tissue or paper towels, and placed in a foam mailing container or heavy cardboard mailing tube. To ensure the greatest care during shipping, specimens should be checked in at a postal window in a post office with instructions on the package requesting that postal workers "hand cancel" and "handle with care." For either private or postal carriers, it is important to consult with them regarding proper rules and regulations.

Technician's Note

All fecal samples or parasite samples being sent to reference laboratories should be labeled with the practitioner's name; client's name; and animal name or number, gender, age, and species, with as much history as possible for accurate analysis.

Miscellaneous Procedures for Detection of Digestive Tract Parasites

Cellophane Tape Preparation

Cellophane tape preparation is used to detect the eggs of pinworms (Box 17.12). Female pinworms are nematodes (roundworms) that protrude from the anus and deposit

their eggs on the skin around the anus. Pinworm eggs usually are not seen in routine fecal examinations. Of the major domesticated species, horses are the most commonly infected by pinworms (*Oxyuris equi*). Of animals used in laboratory research, primates, rodents, and rabbits serve as hosts for pinworms. It is important to remember that dogs and cats are never hosts for pinworms. Pinworms are parasites of herbivores (horses and rabbits) and omnivores (rodents, primates, and humans) but never parasites of carnivores (dogs and cats).

Technician's Note

Cellophane tape preparation is used to detect the eggs of pinworms and a number of ectoparasites. Remember that pinworms are parasites of herbivores and omnivores but never carnivores.

Baermann Technique

The Baermann technique is used to recover the larvae of roundworms from feces, soil, or animal tissues (Box 17.13). This method takes advantage of the fact that warm water stimulates nematode larvae in a sample to move about. Once the larvae move out of the sample, they relax in the water and sink to the bottom of the container. A Baermann apparatus may be easily constructed to perform this function (Fig. 17.15). The Baermann apparatus consists of a ring stand and a ring supporting a large glass funnel. The funnel's stem is connected by a piece of rubber tubing to a tapered tube (a cut of Pasteur pipette). The rubber tubing is clamped shut with a pinch clamp. A piece of metal screen is placed in the funnel to serve as a support for the sample. The funnel is then filled with water or physiologic saline at

Box 17.12 Cellophane Tape Presentation for Detection of Pinworms in the Horse

1. Place transparent cellophane tape in a loop, adhesive (sticky) side out, on one end of a tongue depressor.
2. Stand to the side of the horse's hindquarters and raise the tail with one hand while using the other hand to press the tape on the tongue depressor firmly against the skin immediately around the anus.
3. Place a small drop of water on the slide, allowing the water to spread out under the tape.
4. Using a compound microscope, examine the tape for the presence of asymmetric pinworm eggs.

Box 17.13 Baermann Technique

1. Spread out a piece of cheesecloth or a gauze square on the support screen in the Baermann apparatus. Place 5 to 15 g of the fecal, soil, or tissue sample on the cheesecloth. Fold any excess cheesecloth over the top of the sample. Be sure the sample is covered by the warm water or physiologic saline; add more if necessary.
2. Allow the apparatus to remain undisturbed overnight.
3. Hold a glass microscope slide under the cutoff pipette, and open the pinch clamp long enough to allow a large drop of fluid to fall on the slide. Apply a coverslip to the slide and examine it microscopically for the presence of larvae. Repeat by examining several slides before deciding that the sample is negative.

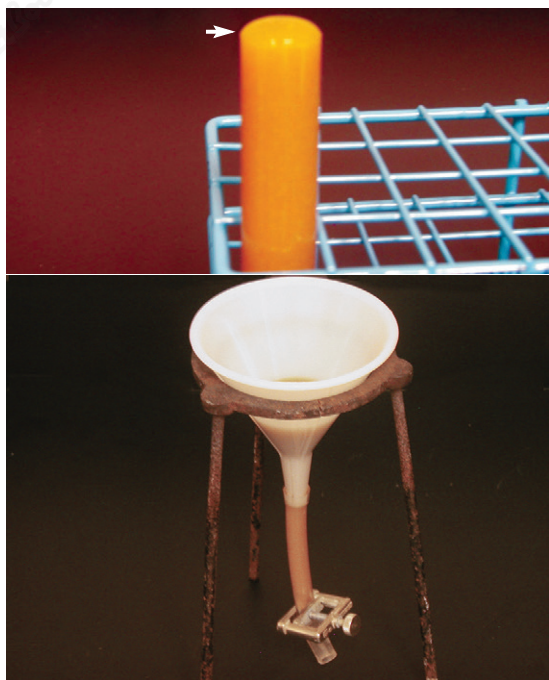


Fig. 17.15 The Baermann apparatus is used to recover the larvae of roundworms from feces, soil, or animal tissues. This apparatus is most useful in recovering the larvae of lungworms.

about 30°C (86°F) to a level of 1 to 3 cm above the sample. Innovative alternative designs of this apparatus can be devised from similar materials, provided the same features are preserved.

Technician's Note



If a Baermann apparatus is needed in the clinic but the proper materials are not immediately available, a 60-mL syringe, gauze, a short length of flexible rubber tubing, and a three-way stopcock can be used as a substitute; however, the proper apparatus is recommended for routine use of the Baermann technique.

Larvae recovered from fresh ruminant and equine feces are almost always lungworms. Larvae of *Strongyloides stercoralis*, the intestinal threadworm, also may be recovered from canine feces. Larvae of *Aelurostrongylus abstrusus* may be found in feline feces. Both larvae and adults of *Ollulanus tricuspis* may be found in feline vomitus.

Blood in the Feces

Some parasitic infections of the digestive tract cause extensive damage to the intestinal lining, resulting in bleeding. This blood may be visible in the fecal sample or may be present in such small quantities that it is detectable only by means of a chemical test. Blood present in such small amounts is termed **occult blood**. Numerous tests are available for the detection of blood in the feces. The simpler tests are based on the detection of enzyme-like activity of the red blood cell component, hemoglobin.⁵

These tests are easily performed by following the directions provided by the manufacturer. Blood is detected through an obvious color change. False-positive results may be obtained in fecal samples from animals on a meat diet, so dogs or cats to be tested should be maintained on a meat-free diet for 24 to 48 hours before testing. The presence of fecal blood may be the result of a condition other than parasitic infection, such as gastrointestinal ulcers, other infectious agents, or neoplasms.

Technician's Note



When testing dogs or cats for occult blood in the stool, the patient should be fed a meat-free diet for 24 to 48 hours before collection of the stool sample.

Gross Examination of Vomitus

Vomitus (the product of vomiting) may be grossly examined for adult parasites. These parasites are usually roundworms, which may be particularly common in the vomitus of puppies or kittens. In these young animals, infections with *Toxocara* species or *Toxascaris leonina* may be extensive. Some of the adult worms are expelled by vomiting.

Microscopic Examination of Vomitus

The microscopic examination of vomitus may reveal the presence of parasites of the stomach of dogs and cats. Parasites of the stomach may cause an inflammation of the stomach lining, producing a condition known as **gastritis**. One of the signs of this inflammation is chronic vomiting. *Physaloptera* species, a nematode that attaches to the lining of the stomach of both dogs and cats, is a voracious blood-feeder. A standard flotation procedure performed on the vomitus (as with feces) may reveal the presence of oval, thick-walled, larvated eggs. *O. tricuspis*, a tiny nematode found in the stomach of cats, produces chronic vomiting. Likewise, a

⁵Hematest reagent tablets, Ames Division, Miles Laboratories, Elkhart, IN.

standard flotation procedure performed on the cat's vomitus (as with feces) may reveal the presence of adult parasites and third-stage larvae of *O. tricuspis*. When confronted with chronic vomiting in a dog or cat, practitioners often overlook this important diagnostic procedure.

Diagnosis of Parasites of the Blood and Blood Vascular System

D. immitis, the canine heartworm, is the most important parasite of the vascular system of domestic animals in North America. For this reason, most of the blood examinations for parasites in veterinary practices are aimed specifically at heartworm identification, although other blood parasites occasionally may be diagnosed in the United States. This section describes general tests that may be used to detect some blood parasites, as well as some specific tests for *D. immitis*.

Technician's Note

Dirofilaria immitis is the most important blood parasite in North America, although other blood parasites may occasionally be diagnosed in the United States.

Collection of Blood Samples

Any collection of blood from an animal should be performed **aseptically**. This includes swabbing the skin over the vein with isopropyl alcohol and using a sterile needle.

Blood may be drawn with a standard needle and syringe or a vacuum collection tube (e.g., Vacutainer, Becton Dickinson, Rutherford, NJ). No anticoagulant is required if the blood will be used immediately for tests, such as the direct smear or filter test, or if it will be allowed to clot so that serum may be obtained. If the tests cannot be performed immediately or if some of the blood must be reserved for further testing, clotting must be prevented by the addition of an anticoagulant.

Vacuum blood collection tubes are sold containing several different anticoagulants, with color-coded stoppers indicating the particular anticoagulant in each tube. Of these, ethylenediaminetetraacetic acid (EDTA), in tubes with lavender stoppers, is among the best for collecting blood for parasite examination because the amount of distortion it produces is minimal. If the blood is allowed to clot to obtain the clear serum, as for immunologic tests for canine heartworm, vacuum tubes with red stoppers, which contain no anticoagulant, should be used.

Technician's Note

When using an anticoagulant sample tube such as EDTA, one should make sure that one collect at least a 1-mL sample of whole blood for the proper mixture of the anticoagulant to prevent unexpected cell distortions that can occur with too much anticoagulant and not enough blood sample.

Blood samples should always be labeled with the client's name, the animal's name or number, and the date of collection.

The microfilariae of *D. immitis* are more common in canine blood at certain times of the day than at other times. These microfilariae are found in greater numbers during the evening hours than during the daylight hours.

Examination of Blood

General observations of blood samples should always be recorded. For example, if the blood appears watery, the animal may be anemic. Clinical pathology tests such as packed-cell volume and white blood cell counts may aid in the diagnosis of parasitism.

Direct Microscopic Examination

The simplest procedure for blood parasite detection is direct microscopic examination of whole blood, known as the **direct smear** technique. This procedure is aimed primarily at detecting the movement of parasites that live outside the red blood cells. In the United States and Canada, direct smear usually is used to demonstrate the microfilariae of the canine heartworm, *D. immitis*; trypanosome protozoans also may be observed. The direct smear is quick and easy to perform, but only a small amount of blood is examined; that is, the sample size is very small. This is a major disadvantage of this technique; unless the parasites are present in very large numbers, they may be easily overlooked.

Technician's Note

The direct blood smear is a good and quick scanning technique; however, it should not be relied on if the sample does not reveal parasites because only a very small sample is being used.

Trypanosomes are found primarily in the tropical regions of the world; occasionally, however, they may be reported in the United States. Trypanosomes are more

easily identified as such on stained blood smears than by direct examination of whole blood.

The microfilariae of primary interest in North America are those found in dogs, *D. immitis* and *A. reconditum*. It is important that veterinary diagnosticians differentiate between these two filarial parasites because the treatment for *D. immitis* can be stressful and expensive for the pet owner, whereas treatment for *A. reconditum* is not necessary.

Direct microscopic examination of whole blood is an unsatisfactory method for differentiating microfilariae. There are better methods for diagnosing these parasites. Nevertheless, the microfilariae of *D. immitis* are more numerous than those of *A. reconditum*. It is possible to observe low levels of microfilariae in the peripheral blood. There are also subtle differences in the behavior of these microfilariae in the blood smear. Microfilariae of *D. immitis* tend to remain in one spot on the slide and coil and gyrate in place. If they do move, the movement is sluggish. Microfilariae of *A. reconditum* (on rare occasions) move rapidly across the microscopic field with a snake-like movement.

Technician's Note

Although the direct blood smear will reveal microfilariae, it is hard to differentiate the genus and species of the microfilariae from the blood smear.

Thin Blood Smear

A **thin blood smear** is prepared in the same manner as a blood smear prepared for a white blood cell differential count (Box 17.14 and Fig. 17.16).

The area of the smear farthest from the original drop of blood should be the thinnest part of the smear. This region

Box 17.14 Thin Blood Smear

1. Place a glass microscope slide (the "surface slide") flat on the bench surface; then place a small drop of the whole-blood sample near the short end of the slide.
2. Place the short end of a second slide (the "spreader slide") near the middle of the bench surface slide, and hold it at a 35- to 45-degree angle. Holding the spreader slide at that angle, slide the short side of that slide backward across the surface slide until it just contacts the drop of blood (see Fig. 17.16). When the drop is contacted, it rapidly spreads along the juncture between the two slides.
3. The spreader slide is then smoothly and rapidly slid forward the length of the surface slide, producing a smear with a feathered edge.
4. Allow the surface slide to air dry and then stain it. Examine the slide with the 10x objective for microfilariae or trypanosomes; the 100x (or oil-immersion) objective may be used for the intracellular parasites.

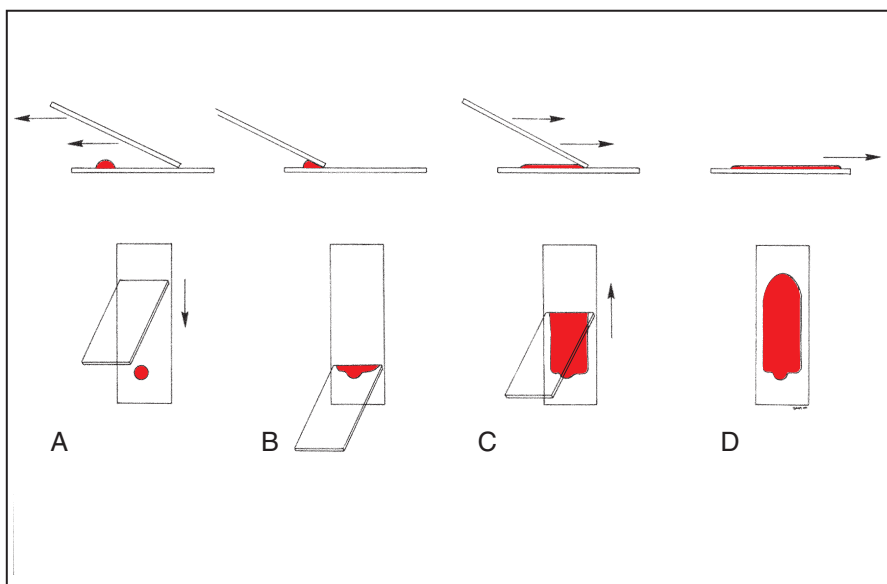


Fig. 17.16 Demonstration of the correct angle and direction of movement of a thin blood smear.

is known as the **feathered edge** of the smear. Because of the large relative size of microfilariae, they are not carried into the feathered edge. The entire slide is fixed and stained with Diff-Quik.

A thin blood smear cannot be used for accurate differentiation of the microfilariae of *D. immitis* from those of *A. reconditum*. Trypanosomes can be seen between the red blood cells in the smear. Protozoans such as *Babesia* and *Theileria* species can be seen within the red blood cells. Rickettsiae such as *Anaplasma* species may be seen on the surface of the red blood cells.

Technician's Note



A thin blood smear will reveal such blood parasites as *Babesia* and *Theileria* within the red blood cells but cannot be used for accurate differentiation of *Dirofilaria immitis* and *Acanthocheilonema reconditum*.

This blood examination technique uses minute amounts of whole blood. As with the direct smear, the thin blood smear uses only a small amount of blood. Again, the sample size is very small. This is a major disadvantage to using this technique; unless the parasites are present in very large numbers, they may easily be overlooked. To ensure that mild infections are not missed, several blood concentration techniques using larger volumes of blood have been developed.

Thick Blood Smear

A thick blood smear allows examination of a slightly larger amount of blood than a thin blood smear (Box 17.15). Microfilariae, protozoans, and rickettsiae may be seen using this method.

Buffy Coat Method

The **buffy coat preparation** method is a concentration technique for the detection of microfilariae in blood samples (Box 17.16). The buffy coat is the layer of white blood cells located between the red blood cells and the clear plasma formed by the centrifugation of whole blood. The specific gravity of microfilariae causes them to gravitate to the upper surface of the buffy coat layer (Figs. 17.17 and 17.18). This test is quick and can be performed in conjunction with a packed-cell volume determination. It is not possible, however, to determine the species of microfilariae.

Modified Knott Technique

The **modified Knott technique** is a fairly rapid method that detects microfilariae and allows for differentiating between the microfilariae of *D. immitis* and those of *A. reconditum* (Box 17.17). This technique concentrates the microfilariae from 1 mL of blood and hemolyzes the red blood cells so that the microfilariae may be observed more clearly.

Box 17.15 Thick Blood Smear

1. Place 3 drops of the blood sample together on a glass slide and with a wooden applicator stick spread them out to an area about 2 cm in diameter.
2. Allow the smear to air dry.
3. Place the glass slide in a slanted position, smear side down, in a glass beaker containing distilled water. Allow the slide to remain in the beaker until the smear loses its red color.
4. Remove and air dry the slide; then immerse it for 10 minutes in methyl alcohol. Stain with Giemsa stain for 30 minutes. Wash the excess stain with tap water.

Box 17.16 Buffy Coat Method

1. Fill a hematocrit tube with the whole-blood sample and seal one end with hematocrit clay.
2. In the hematocrit centrifuge, centrifuge the hematocrit tube for 5 minutes.
3. If desired, read the packed-cell volume to determine whether the animal is anemic. Observe the location of the buffy coat layer between the red cell layer and the plasma (Fig. 17.17).
4. Place the hematocrit tube on the stage of the compound microscope. Using the 4x objective, examine the zone between the buffy coat layer and the plasma for the presence of microfilarial activity. Use the iris diaphragm

to decrease the light because low light intensity and high contrast increase visualization of the motile microfilariae.

or
Using a small file or glass cutter, deeply scratch the hematocrit tube at the level of the buffy coat. Snap the hematocrit tube by applying thumb pressure opposite the scratch. Immediately take the part of the buffy coat and plasma and tap the buffy coat onto the center of a microscope slide, including some plasma with it. Add a drop of physiologic saline and a drop of methylene blue stain and cover with a coverslip. Using the 10x objective, examine the slide for the presence of microfilariae.

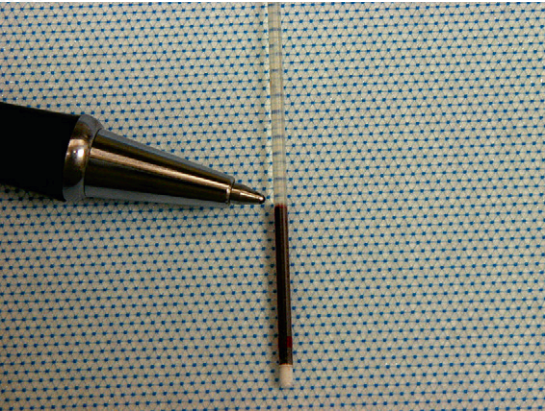


Fig. 17.17 Buffy coat in a hematocrit tube.

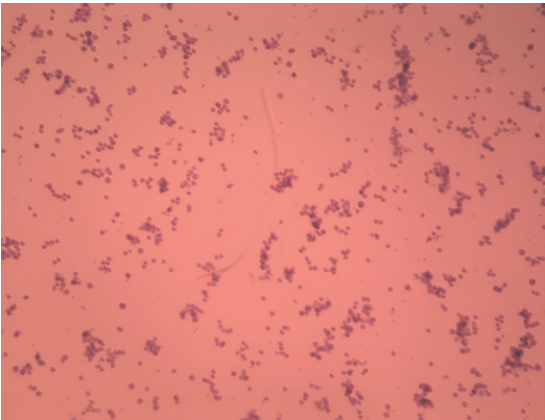


Fig. 17.18 Microfilariae in a buffy coat smear of canine blood (500x).

Technician’s Note



The buffy coat technique can not be used to properly differentiate *D. immitis* from *A. reconditum*. By using an ocular micrometer, the modified Knott technique can be used to properly differentiate *D. immitis* from *A. reconditum*

Using the modified Knott technique, the characteristics in Table 17.1 can be used to distinguish the microfilariae of *D. immitis* from those of *A. reconditum*. Some of these characteristics are unique to the modified Knott procedure and may not be indicative of other tests that depend on observation of morphologic features of the microfilariae. The most accurate features are the total length of the microfilaria, the midbody

Table 17.1 Morphologic Characteristics for Differentiation of Microfilariae of *Dirofilaria immitis* and *Acanthocheilonema reconditum*

Characteristic	<i>Dirofilaria immitis</i>	<i>Acanthocheilonema reconditum</i>
Body shape	Usually straight	Usually curved
Body length	295–325 μm (average, 310 μm)	250–288 μm (average, 280 μm)
Anterior end	Tapered	Blunt (“broom handle”)
Posterior end	Straight	Curved or hooked (artifact of formalin fixation)

Box 17.17 Modified Knott Technique

1. In a centrifuge tube with a conical end, mix 1 mL of the whole-blood sample and 9 mL of 2% formalin (2 mL of 40% formaldehyde per 98 mL of distilled water). Stopper the tube, and rock it back and forth for 1 to 2 minutes until the mixture becomes a clear, red-wine color.
2. Centrifuge the tube at 1500 rpm for 5 minutes.
3. Pour off the liquid supernatant. It is permissible to let the tube stand with the open end down for 45 minutes to 1 hour if time permits. The purpose of this step is to remove as much fluid as possible, leaving sediment only. The formalin should be poured off into a 1-gallon collection container. Once $\frac{3}{4}$ full, a solution made by a number of companies can be added to neutralize or solidify the formalin for discard. Local environmental or waste-disposal facilities should be contacted for the proper disposal for the area or state.
4. Add 1 drop of methylene blue stain to the sediment at the bottom of the tube. Transfer a drop of the mixture to a glass slide and apply a coverslip.
5. Examine the slide for the presence of microfilariae using the 10x objective. When microfilariae are found, use a higher-power objective (40x) to observe the fine differences between them (see Table 17.1).
6. The diagnostician may stop this procedure at one of two stopping points: (a) The diagnostician has identified microfilariae as those of *Dirofilaria immitis* or *Acanthocheilonema reconditum*, or (b) the diagnostician runs out of the sediment/stain mixture.

width, and the shape of the cranial end. Body length and width should be measured using an ocular micrometer or eyepiece scale (see Fig. 17-9). The body length of the microfilaria of *D. immitis* ranges from 295 to 325 μm (average, 310 μm), whereas the body length of the microfilaria of *A. reconditum* ranges from 250 to 288 μm (average, 280 μm). The midbody width of the microfilaria of *D. immitis* ranges from 5 to 7.5 μm , whereas the midbody width of the microfilaria of *A. reconditum* ranges from 4.5 to 5.5 μm . It is important for the differentiation of the morphologic parameters of the parasites on the modified Knott procedure that veterinary clinics own and calibrate an ocular micrometer within at least one compound microscope. The anterior end of the microfilaria of *D. immitis* tapers gradually from its midbody (Fig. 17.19), whereas the microfilaria of *A. reconditum* has a blunt anterior end, much like the end of a wooden broom handle. Likewise, the posterior end of the microfilaria of *D. immitis* is said to be straight, whereas the microfilaria of *A. reconditum* may have a curved or “buttonhook” or “shepherd’s crook” tail. It is important to remember that the bending, or hooking, of the tail of the microfilaria of *A. reconditum* is an artifact of 2% formalin fixation and may not be observed as a consistent diagnostic feature. Likewise, other microfilarial tests (e.g., commercial filter tests) will not produce this hooking characteristic. Veterinary diagnosticians should remember to measure several microfilariae to confirm that the microfilaremia is not a concomitant infection (i.e., both parasites may be present). In some areas of North America (those with high indigenous populations of both mosquitoes and fleas), infection with both filarial parasites is quite possible.

Technician’s Note

The morphologic features of *Dirofilaria immitis* and *Acanthocheilonema reconditum* are used for differentiation.

Immunologic Heartworm Tests

About 25% of dogs with adult heartworm infection in the heart and pulmonary vasculature do not have circulating microfilariae in the peripheral blood. These infections may consist of (1) heartworms that are too young to produce microfilariae, (2) a “unisex” or “single-sex” infection, (3) an infection in which circulating microfilariae are produced by the adult female heartworms but for some reason are removed by the host, or (4) an infection in which the circulating microfilariae have been killed by a drug but the adults have not been affected. This type of infection is referred to as an **occult infection**. The hosts are said to be **amicrofilaremic**, without microfilariae. It is important to remember that cats also can be infected with canine heartworms. Because the heartworms are in cats rather than in their natural host (the dog), the adult heartworms produce either low numbers of microfilariae or none at all.

Technician’s Note

With the monthly heartworm preventatives being used, animals are amicrofilaremic because the preventatives kill the microfilariae.

To detect infections, tests have been developed in which antibodies against antigens of adult *D. immitis* react with chemicals to produce a color change when these antigens are in a blood sample. These tests are available commercially and are easy to perform and fairly rapid (15 to 20 minutes) when the directions are carefully followed and samples are correctly labeled. Older styles of kits detected only canine antibodies in response to heartworm and were unsuitable for use in cats.

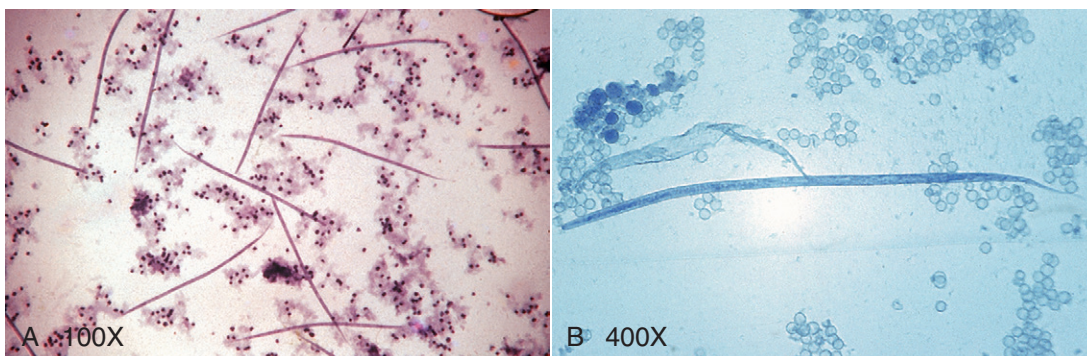


Fig. 17.19 Microfilariae of *Dirofilaria immitis* using the modified Knott test.

Technician's Note

Many heartworm immunologic test kits now are sensitive enough to detect antibodies in cats. However, it is recommended that an antibody test and an antigen test be used for cats because the worm burden is so low.

Other tests for parasites such as *Toxoplasma gondii* can be performed by diagnostic laboratories. The laboratory will provide information on the nature and amount of specimens it requires. Box 17.18 provides a method for collecting serum for these immunologic tests.

Miscellaneous Methods for Microfilarial Identification

Other heartworm diagnostic procedures used in the detection and differentiation of microfilariae include staining with brilliant cresyl blue and acid phosphatase. These procedures are often too cumbersome and time-consuming to be used in a veterinary practice. Many of the reagents used in the processing of these specimens are not found in the practice setting. Diagnostic referral laboratories usually are able to perform both procedures.

Box 17.18 Serum Collection

1. Using a needle and syringe, dispense 10 mL of blood into a blood collection vacuum tube lacking anticoagulant (tube with a red stopper). Slowly dispense the blood from the syringe into the tube to avoid lysis of the red blood cells. Lysis of red blood cells often interferes with the functions of many tests.
2. Keep the blood at room temperature (25°C) for 2 to 3 hours to allow a solid clot to form.
3. Remove the formed blood clot with a wooden applicator stick by gently "rimming" the clot and then sliding it up the side of the tube with the applicator stick. Discard the clot. (Some laboratories request that the clear serum then be transferred to a new tube.)
4. Correctly label each tube of serum with the client's name, animal's name or number, and practitioner's name. Refrigerate the sample until it can be shipped.
5. Ship samples to the laboratory packed in an insulated container with ice or a cool pack. Use the fastest shipper possible for next-day delivery.

Diagnosis of Parasitism of the Respiratory System**Fecal Examination for Respiratory Parasites****Technician's Note**

Because lungworms use the digestive system to pass their eggs or larvae after the animal coughs them up and swallows them, routine fecal flotation techniques and the Baermann technique can be used to find most of these parasite infections.

The life cycles of helminth (nematode and trematode) parasites of the lungs are completed through the passage of their eggs or larvae up the airways to the pharyngeal region, from which they are swallowed and passed to the outside environment in the feces. Because of this dependence on fecal transmission, parasitism of the lungs and airways is often diagnosed by microscopic examination of the feces, as described previously. The Baermann technique can be used to recover the larvae of lungworms from feces. Again, this method takes advantage of the fact that warm water stimulates the larvae in a sample to move about. Once the larvae move out of the sample, they relax in the water and sink to the bottom of the container. The Baermann apparatus should be employed when parasitism with lungworms is suspected (See Fig. 17.15).

Examination of Sputum and Tracheal Washes

The larvae and eggs of respiratory parasites have the same characteristics as those found in the feces. An exception is *Dictyocaulus* species, lungworms of cattle and sheep, which are usually seen in the sputum as eggs containing larvae rather than as free larvae in the feces.

A drop of sputum or nasal discharge on a microscope slide is easily examined. Several slides should be examined. When the sputum is especially viscous, a drop of the material should be placed between two microscope slides and both slides examined microscopically. Larger quantities of fluid obtained from the respiratory tract should be concentrated by centrifugation at 1500 rpm for 5 minutes. A drop of the sediment can then be placed on a slide and examined microscopically.

Dogs may occasionally become infested with the nasal mite, *Pneumonyssoides caninum*, or the tongue worm, *Linguatula serrata*. A cotton swab dipped in mineral oil

Technician's Note

Some endoparasites do not use the digestive tract to complete their life cycle but instead use sputum. Therefore the sputum can be examined for eggs or larvae by either a direct smear or centrifugation performed like a fecal sample.

may be inserted into the nose of a suspect dog and rubbed against the nasal membranes. *Pneumonyssoides* mites have eight legs and are white, hairless, and 1 to 1.5 mm long. The eggs of *L. serrata* measure 90×70 μm and contain a mite-like larval stage. Tiny hooked feet may be observed in the interior of the egg.

Diagnosis of Parasitism of the Urinary System

Roundworms are common parasites of the kidney and urinary bladder. They complete their life cycle by passing eggs out of the host's body in the urine. These nematodes include *Capillaria* species, which inhabit the walls of portions of the urinary system of both dogs and cats; *Diectophyma renale*, the giant kidney worm of dogs; and *Stephanurus dentatus*, the swine kidney worm.

Technician's Note

Some endoparasite eggs can be found in the urine of the animal.

Collection of the Urine Sample

Urine for parasitologic examination may be collected during normal urination. Catheterization and cystocentesis are usually not necessary unless part of the sample will be used for bacteriologic or cytologic examination. A waxed paper cup (3 to 5 mL) with a lid or other clean container may be used for collection. The cup is held in the urine stream and filled. Unless the sample is to be used for other tests, it is not necessary to collect the sample at a certain time during urination. Clients can be instructed to collect a sample at home. Urine samples should be properly labeled with the client's name and the animal's identification and refrigerated until the examination can be conducted.

Box 17.19 Urine Sedimentation

1. Thoroughly mix the urine sample, and put 5 to 10 mL into a centrifuge tube with a conical tip.
2. Centrifuge the sample for 5 minutes at 1500 rpm.
3. Pipette all but about 0.5 mL of the fluid from the centrifuge tube, leaving the sediment at the bottom undisturbed.
4. Mix the remaining fluid and sediment together with the pipette; transfer a drop of the mixture to a microscope slide and apply a coverslip.
5. Thoroughly examine the drop of sediment microscopically using the 10× objective.

Urine Examination for Parasites

The primary method of examining urine for parasites is by microscopic examination of the sediment (Box 17.19). Just as with microscopic examination of feces using the compound microscope, uniform movement and a thorough search of the microscope slide must be performed. Regardless of how the slide is moved, the area under the coverslip must be thoroughly and uniformly searched (see Fig. 17.8). When a parasite egg is observed at low magnification, higher-power objectives may be used to examine it more closely.

Technician's Note

Urine sedimentation is used to find parasite eggs in the urine of an animal.

Diagnosis of Parasitism of the Skin

Skin Scrapings

Skin scraping is one of the most common diagnostic tools used in evaluating animals with dermatologic problems. Equipment required includes an electric clipper with a No. 40 blade, a scalpel or spatula, mineral oil in a small dropper bottle, a microscope slide, a coverslip, and a compound microscope. Typical lesions or sites likely to harbor the particular parasite should be scraped (e.g., margins of the ear for *Sarcoptes scabiei*).

The scraping is performed with a No. 10 scalpel blade used with or without a handle. A stainless steel spatula is preferred by some clinicians. The scalpel blade should be held between the thumb and the second finger, with the first finger used to help prevent cutting the animal (Fig. 17.20).



Fig. 17.20 Safe method of holding a scalpel blade with the thumb and second finger for skin scrapings.

Before the skin is scraped, the blade is dipped in a drop of mineral oil on the slide, or a drop of mineral oil may be placed on the skin.

During the scraping process, the blade must be held perpendicular to the skin. Holding it at another angle may result in the animal being incised. The average area scraped should be 6 to 8 cm².

Technician's Note



Skin scraping is performed with a No. 10 scalpel blade held perpendicular to the skin so that the blade does not incise the animal.

The depth of the scraping varies with the typical location of the parasite in question. When scraping for mites that live in tunnels (e.g., *Sarcoptes* spp.) or hair follicles and sebaceous glands (e.g., *Demodex* spp.), the skin should be scraped until a small amount of capillary blood oozes from the area. Clipping the area with a No. 40 blade before scraping enables better visualization of the lesion and removes excess hair that could impede proper scraping and interfere with collection of epidermal debris. For surface-dwelling mites (e.g., *Chorioptes* spp., *Cheyletiella* spp.), the skin is scraped superficially to collect loose scales and crusts. Clipping before scraping is not always necessary when infestation with surface-dwelling mites is suspected.

Technician's Note



The depth of the skin scrape depends on the type of ectoparasite suspected of causing the skin problem.

All the scraped debris on the forward surface of the blade is then spread in a drop of mineral oil on a glass microscope slide. A glass coverslip is placed on the material, and the slide is ready for microscopic examination using the 4× (scanning) objective. The slide should be examined systematically in rows so that the entire area under the coverslip is evaluated (see Fig. 17.8). Low light intensity and high contrast increase the visualization of mites and eggs. If necessary, the slide may be evaluated using the 10× (low-power) objective.

Demonstration of a characteristic mite or egg is frequently diagnostic for most diseases. In certain circumstances, however, more than identification of the parasite is necessary. For example, determining live: dead ratios and observing immature stages of demodectic mites are important in evaluating a patient with demodicosis. A decrease in the number of live mites and eggs during therapy is a good prognostic sign.

Cellophane Tape Preparation

When attempting to demonstrate the presence of lice or mites that live primarily on the surface of the skin (e.g., *Cheyletiella* spp.), use a cellophane tape preparation instead of a skin scraping. Clear cellophane tape is applied to the skin to pick up epidermal debris. A ribbon of mineral oil is placed on a glass slide, and the adhesive surface of the tape is placed on a glass slide and then placed on the mineral oil. Additional mineral oil and a coverslip may be placed on the tape to prevent it from wrinkling, but this is not necessary. The slide is then examined systematically in rows.

Gross Specimens

Unknown large **ectoparasites** such as fleas, ticks, chigger mites, biting flies, and myiasis-producing maggots are often collected from the surface of the animal's skin. It is important that these arthropods be placed in a sealed container in either 10% formalin or 95% ethyl alcohol for shipment to a diagnostic laboratory. As many intact specimens as possible should be collected and shipped to a diagnostic laboratory capable of **speciating** ecto parasites to their correct scientific name. Again, containers should be properly labeled with the client's name and the animal's identification.

Technician's Note



Unknown large ectoparasites being sent to a diagnostic laboratory should be preserved in either 10% formalin or 95% ethyl alcohol for shipment.

Diagnosis of Parasitism of Miscellaneous Body Systems

Parasites of the Eye

Thelazia species are nematodes that live within the conjunctival sac and on the surface of the eye of several species of domestic animals, including cattle, sheep, goats, horses, dogs, and cats. The adult parasites are milky white and 7 to 17 mm long and reside in the conjunctival sac, just under the eyelids, particularly the third eyelid. Diagnosis is made by anesthetizing the eye with a local ophthalmologic anesthetic and directly examining the eye for parasites. If observed, these nematodes should be removed while the eye is anesthetized.

Technician's Note

Parasites found in the region of the conjunctival sac and eyelids should be removed by the veterinarian while the eye is anesthetized for examination.

Another nematode parasite often associated with the eye is *D. immitis*, the canine heartworm. This parasite is often associated with aberrant locations throughout the body of both dogs and cats. A site that may become infected is the anterior chamber of the eye; this is usually noted with alarm by the pet owner. Treatment is by surgical extraction of the wandering ("lost") parasite by a veterinary ophthalmologist.

Parasites of the Ear

Otodectes cynotis, the ear mite, is a common cause of external ear irritation in both dogs and cats. These white mites are frequently observed during otoscopic examination. *O. cynotis* are approximately the size of a grain of salt; they may be seen on a cotton swab after it has been moistened with mineral oil and used to clean the dark, waxy debris from the ears of infested animals. This material may be transferred to a drop of mineral oil on a microscope slide and spread out with the swab. A coverslip is applied to the debris, and the slide is examined microscopically in a systematic manner (Box 17.20). This mite has suckers on short stalks at the tips of some of its legs (see Box 17.20).

Box 17.20 Ear Smear Procedure

1. Obtain a sample of debris from the affected ear.
2. Place 2 or 3 drops of mineral oil on the slide and an equal amount of ear debris.
3. Mix the ear debris and mineral oil with a wooden applicator to form a homogeneous solution.
4. Remove large pieces of debris.
5. Place a coverslip over the smear.
6. Examine the slide under the compound microscope and record any parasites or parasite eggs found.

Technician's Note

The **ear smear procedure** is used to diagnose parasites of the ear.

Parasites of the Genital Tract

Tritrichomonas foetus is a protozoan parasite of the reproductive tract of cattle. These parasites reside in the prepuce of infected bulls and in the vagina, cervix, and uterus of infected cows. They may also be found within the stomach contents of aborted fetuses. *T. foetus* is pear shaped and 10 to 25 μ m long, with a sail-like, undulating membrane and three rapidly moving, whip-like anterior flagella. In fresh specimens, these protozoans move actively with a jerky motion. Diagnosis is by finding the organisms in washings from the predilection sites or from the stomach of the aborted fetus. Fluid material should be centrifuged at 2000 rpm for 5 minutes. The supernatant is then removed and a drop of sediment transferred to a slide for microscopic examination for the organisms. Several slides should be examined. For more accurate diagnosis, fluid material from the predilection sites can be cultured in a special medium. Laboratories specializing in diagnostic parasitology should be consulted for information on these techniques.

Technician's Note

Fluid samples from the genital parasite's predilection site should be centrifuged to concentrate the parasites, and the sediment should be examined for organisms.

Chapter Seventeen Test

MATCHING—Match the scientific term in the left hand column with the correct phrase or term in the right hand column.

A. Mineral deposits unique to tapeworms	1. Eyepiece scale
B. Stage micrometer	2. Does not require the use of a centrifuge
C. Ocular micrometer	3. Process of development that takes place within a coccidian oocyst
D. Specific gravity	4. Flotation medium that best concentrates cystic stages of <i>Giardia</i>
E. Flotation solutions	5. Used primarily in suspected trematode (flake) infections
F. Sheather solution	6. Calcareous bodies or calcareous corpuscles
G. Sodium nitrate solution	7. Concentrated sugar or various salts added to water to increase its specific gravity and thus make parasite eggs float because they are lighter than the solution
H. Saturated sodium chloride	8. Weight of an object compared with the weight of an equal volume of pure water
I. Zinc sulfate solution	9. Two sporocysts, each with four sporozoites
J. Simple flotation technique	10. Apparatus used to collect larval nematodes from fresh feces; a funnel is an essential part of this apparatus
K. Fecal sedimentation technique	11. Used to stain protozoan cysts such as <i>Giardia</i>
L. Quantitative procedures	12. Four sporocysts, each with two sporozoites
M. Modified D'Antoni's iodine	13. Messy to work with because it is quite sticky; it is a sugar solution
N. Sporulation	14. Instrument used to calibrate a compound microscope
O. Sporulated oocyst of <i>Eimeria</i>	15. "Color change" test kits, many of which use antibodies against adult <i>Dirofilaria immitis</i> antigen
P. Sporulated oocyst of <i>Cystoisospora</i>	16. Term meaning "without microfilariae"
Q. Cellophane tape preparation	17. Collection of eggs of pinworms such as <i>Oxyuris equi</i>
R. Baermann apparatus	18. Most efficient flotation solution, but it forms crystals and distorts eggs
S. Modified Knott procedure	19. Indicate the number of eggs or cysts present in each gram of feces
T. Immunologic heartworm tests	20. Least desirable flotation solution; can corrode the microscope
U. Occult heartworm infection	21. Diagnosed using the ear smear procedure
V. Amicrofilaremic	22. Used to differentiate microfilariae of <i>D. immitis</i> from those of <i>Acanthocheilonema reconditum</i>
W. Microscopic examination of urine sediment	23. Finding organisms in preputial washings of infected bulls
X. Skin scraping	24. Dog with adult heartworms but no demonstration of circulating microfilariae
Y. <i>Tritrichomonas foetus</i>	25. Performed using a No. 10 scalpel blade
Z. <i>Otodectes cynotis</i>	26. Detection of ova of <i>Diocetophyma renale</i> or <i>Stephanurus dentatus</i>

Questions for Thought and Discussion

1. What is the best procedure for identifying the presence of each of the following parasites?
 - *Giardia* assemblages
 - *Aelurostrongylus abstrusus* larvae (feline lungworms)
 - *Fasciola hepatica*
 - *Dirofilaria immitis*
 - *Stephanurus dentatus*
 - *Sarcoptes scabiei* variety *canis*
 - *Acanthocheilonema reconditum*
 - *Tritrichomonas foetus*
 - *Dipylidium caninum*
2. Discuss the importance of accurate identification of the following parasites in a veterinary clinical situation:
 - *Giardia* assemblages
 - *Aelurostrongylus abstrusus* larvae (feline lungworms)
 - *Fasciola hepatica*
 - *Dirofilaria immitis*
 - *Stephanurus dentatus*
 - *Sarcoptes scabiei* variety *canis*
 - *Acanthocheilonema reconditum*
 - *Tritrichomonas foetus*
 - *Dipylidium caninum*

Reference to Common Parasite Ova and Forms Seen in Veterinary Medicine

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- Common Parasites of Dogs and Cats** 302
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A major part of the veterinary technician's job is identifying parasites in feces, blood, skin scrapings, and cellophane tape techniques. This chapter is a quick reference guide for identifying those parasites often seen in feces, in blood, and on the skin of dogs, cats, horses, ruminants, swine, and exotic animals.

Common Parasites of Dogs and Cats

(Figs. 18.1 to 18.29)

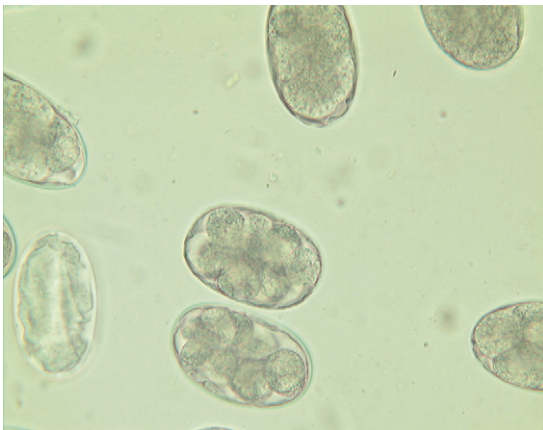


Fig. 18.1 *Ancylostoma caninum* ("hookworm").

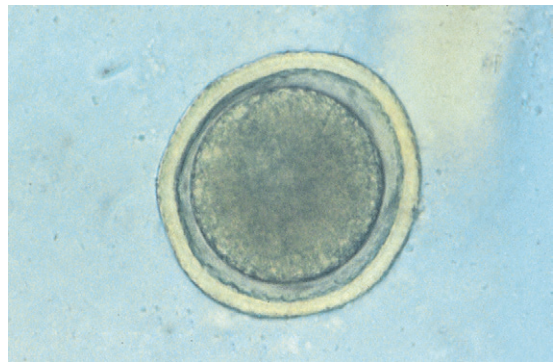


Fig. 18.2 *Toxocara canis* ("roundworm").

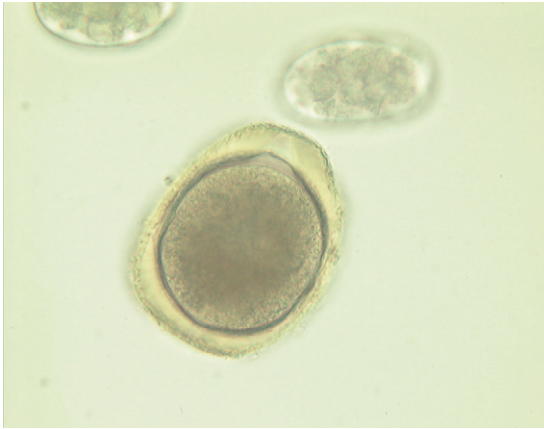


Fig. 18.3 *Toxocara cati* ("roundworm").



Fig. 18.6 *Dipylidium caninum* ("tapeworm").



Fig. 18.4 *Trichuris vulpis* ("whipworm").



Fig. 18.7 *Dipylidium caninum* segments in stool ("cucumber seed tapeworm").

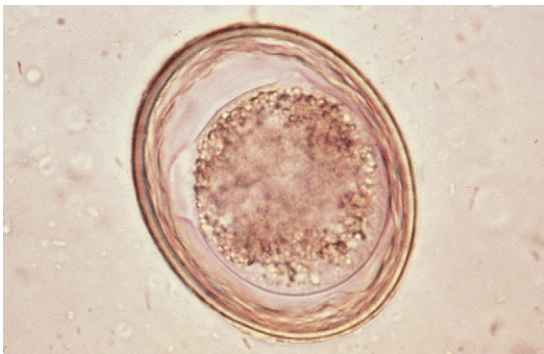


Fig. 18.5 *Toxascaris leonina* ("roundworm").



Fig. 18.8 *Taenia pisiformis* ("tapeworm").

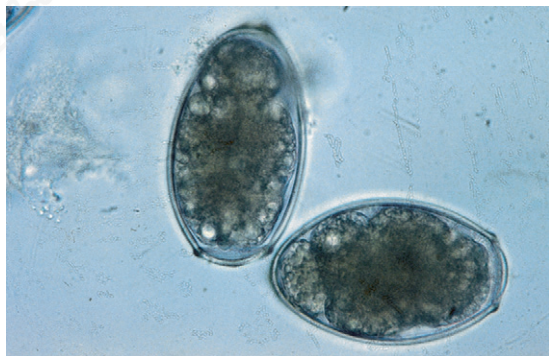


Fig. 18.9 *Paragonimus kellicotti* ("lung fluke").

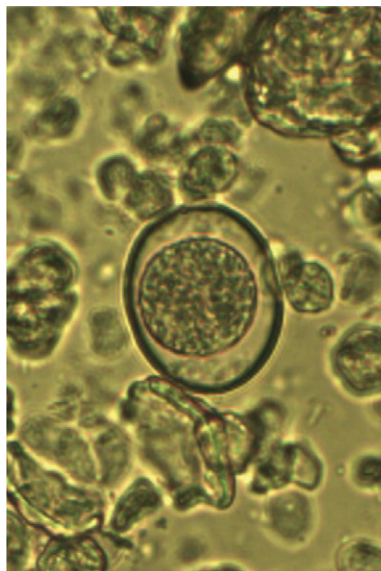


Fig. 18.12 *Cystoisospora canis*, large oocysts ("coccidia").



Fig. 18.10 *Giardia* species trophozoite.



Fig. 18.13 *Aelurostrongylus abstrusus* ("feline lungworm").



Fig. 18.11 *Giardia* species oocyst.

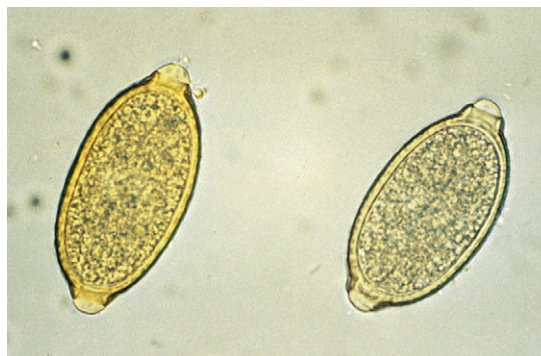


Fig. 18.14 Left, *Trichuris vulpis* (whipworm). Right, *Eucoleus aerophilus* (lungworm).



Fig. 18.15 *Hymenolepis nana*.

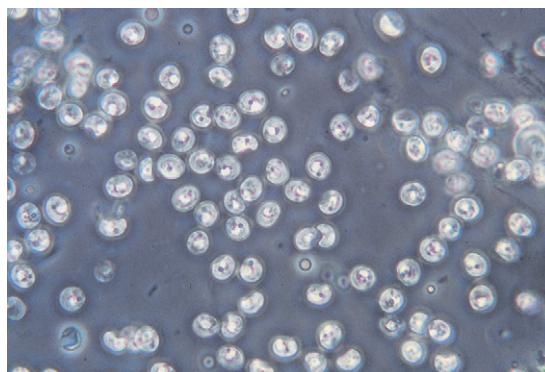


Fig. 18.18 *Cryptosporidium* species ("cryptosporidium" or "cryptosporidiosis").

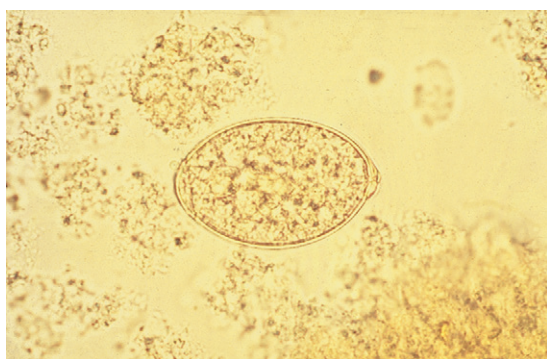


Fig. 18.16 *Spirometra mansonioides* ("zipper tapeworm").



Fig. 18.19 *Toxoplasma gondii* ("toxoplasma or toxoplasmosis") 100x.



Fig. 18.17 *Alaria* species ("intestinal fluke of dogs and cats").

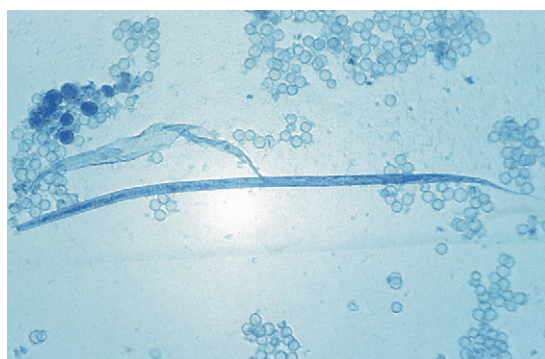


Fig. 18.20 *Dirofilaria immitis* microfilariae ("heartworm").

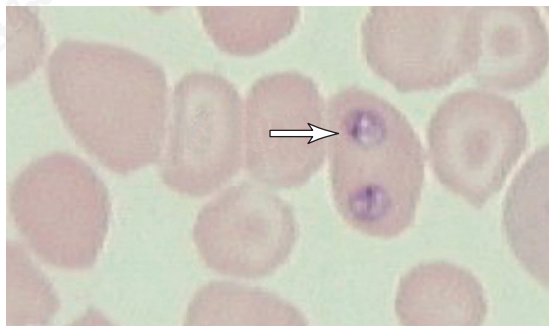


Fig. 18.21 *Babesia canis* ("babesia").

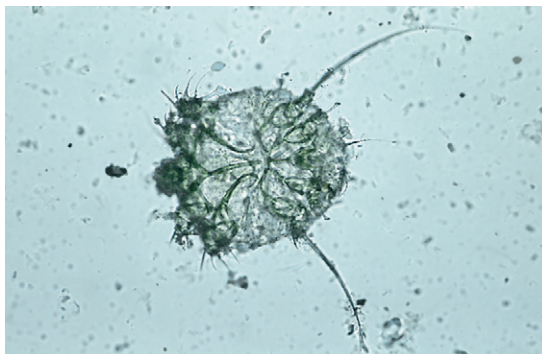


Fig. 18.24 *Sarcoptes scabiei* variety *canis* ("scabies").



Fig. 18.22 *Capillaria plica* ("bladder worm").



Fig. 18.25 *Otodectes cynotis* ("ear mites").



Fig. 18.23 *Cuterebra* species ("warbles or wolves").



Fig. 18.26 *Demodex canis* ("demodectic mange mite").

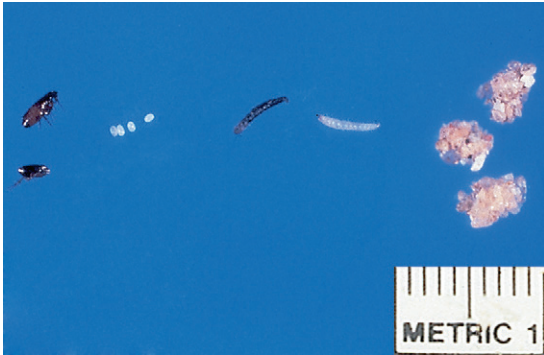


Fig. 18.27 Flea life cycle stages (adults, eggs, larvae, and pupae).

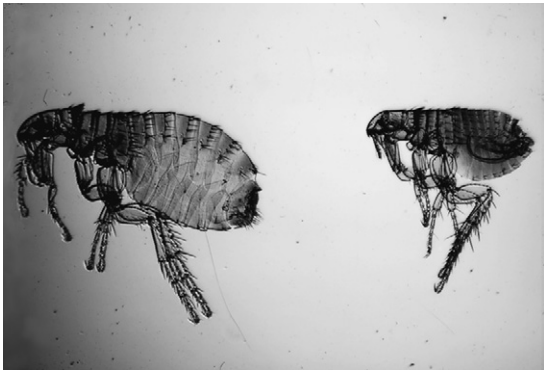


Fig. 18.28 Adult fleas (male and female).



Fig. 18.29 *Linognathus setosus* ("sucking louse of dogs").

Common Parasites of Horses

(Figs. 18.30 to 18.38)

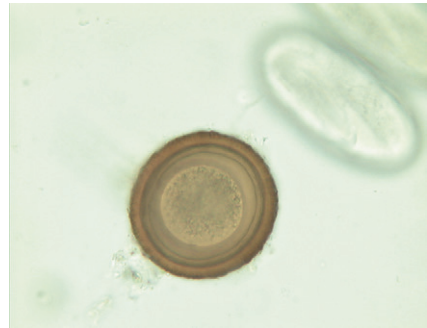


Fig. 18.30 *Parascaris equorum* ("equine roundworm").

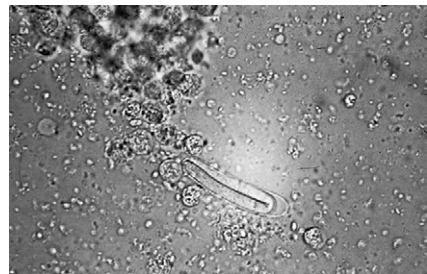


Fig. 18.31 *Habronema* species ("equine stomach worm").



Fig. 18.32 *Strongylus vulgaris* ("equine hookworm").



Fig. 18.33 *Oxyuris equi* ("equine pinworm").

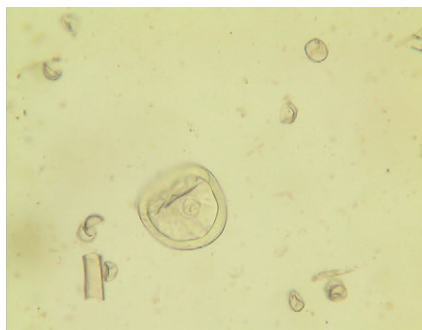


Fig. 18.34 *Anoplocephala perfoliata* ("equine tapeworm").



Fig. 18.35 *Eimeria leuckarti* ("equine coccidia").

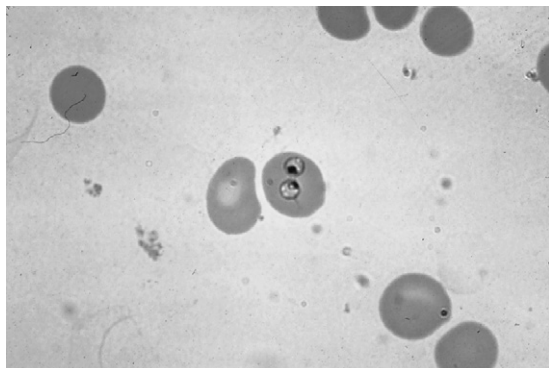


Fig. 18.36 *Babesia caballi* ("equine piroplasm").



Fig. 18.37 *Gastrophilus* species eggs ("horse bot fly eggs").



Fig. 18.38 *Gastrophilus* species larvae ("horse bot fly larvae").

Common Parasites of Ruminants

(Figs. 18.39 to 18.50)



Fig. 18.39 *Trichostrongylus* species ("ruminant hookworm").



Fig. 18.40 *Dictyocaulus viviparus* ("bovine lungworm").



Fig. 18.43 *Muellerius capillaris* ("lungworm of sheep and goats").

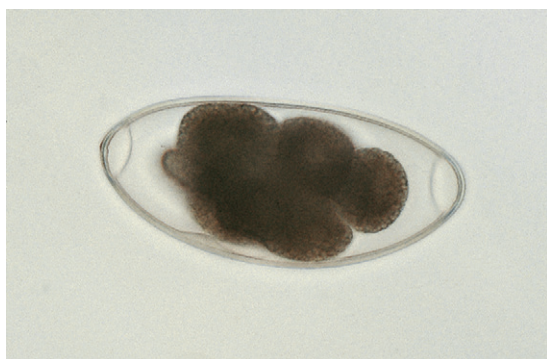


Fig. 18.41 *Nematodirus* species ("ruminant trichostrongyle").

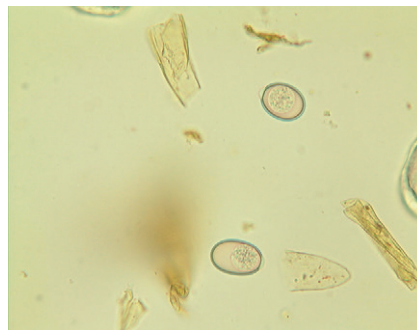


Fig. 18.44 *Eimeria* species ("ruminant coccidia").



Fig. 18.42 *Moniezia* species, square ("ruminant tapeworm").

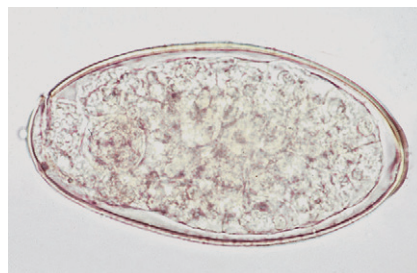


Fig. 18.45 *Fasciola hepatica* ("ruminant liver fluke").

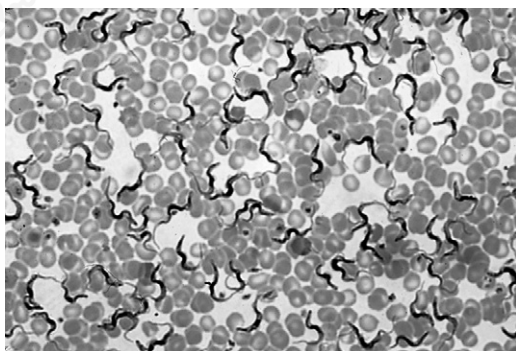


Fig. 18.46 *Trypanosoma* species in bovine blood ("trypanosome").

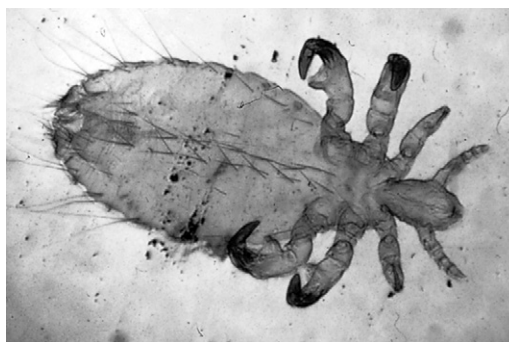


Fig. 18.49 *Solenopotes capillatus* ("sucking louse of sheep").

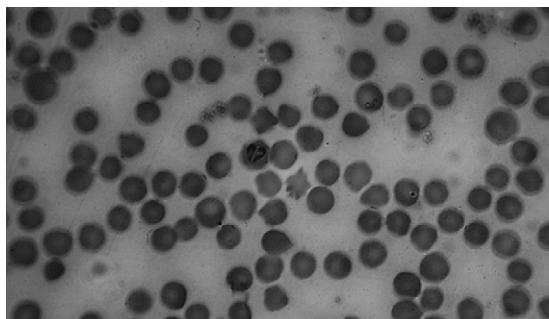


Fig. 18.47 *Babesia bigemina* in bovine red blood cells ("babesia").



Fig. 18.50 *Melophagus ovinus* ("sheep ked").

Common Parasites of Swine

(Figs. 18.51 to 18.57)



Fig. 18.48 *Damalinia bovis* ("biting/chewing louse of cattle").



Fig. 18.51 *Ascarops strongylina* ("swine stomach worm").

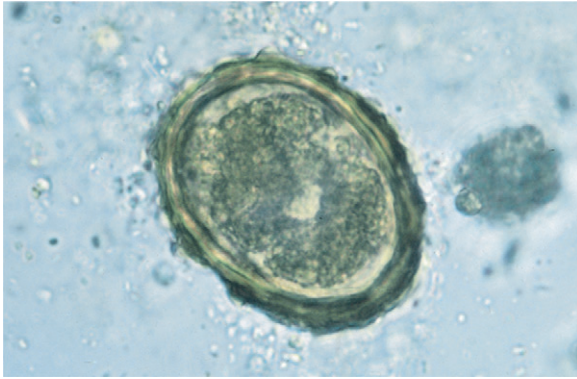


Fig. 18.52 *Ascaris suum* ("swine roundworm").

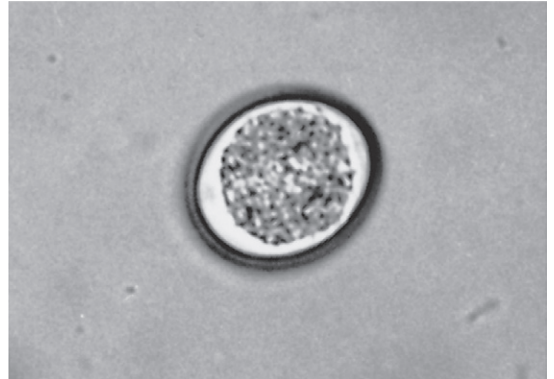


Fig. 18.55 *Cystoisospora suis* ("swine coccidia").



Fig. 18.53 *Metastrongylus apri* ("swine lungworm").

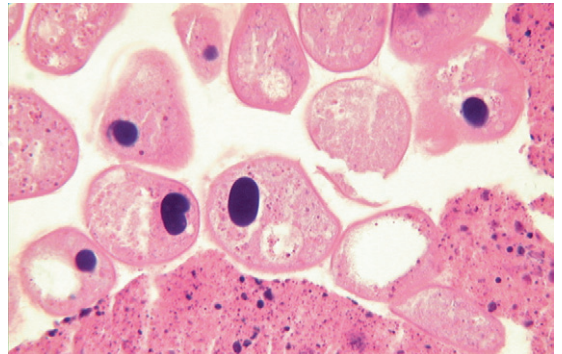


Fig. 18.56 *Balantidium coli* ("balantidium").



Fig. 18.54 *Stephanurus dentatus* ("swine kidney worm").



Fig. 18.57 *Haematopinus suis*, adult ("sucking lice of pigs").

Common Parasites of Exotic Pets and Birds

(Figs. 18.58 to 18.85)

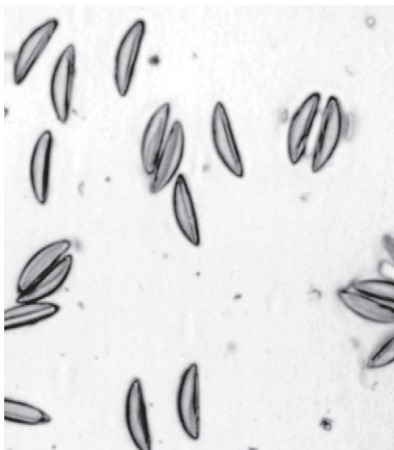


Fig. 18.58 *Syphacia obvelata* ("pinworm of mice").



Fig. 18.59 *Syphacia muris* ("pinworm of mice and rats"—cellophane tape technique).



Fig. 18.60 *Dentostomella translucida* ("pinworm of gerbils").



Fig. 18.61 *Passalurus ambiguus* ("pinworm of rabbits").



Fig. 18.62 *Ascaridia* species ("roundworm of birds").

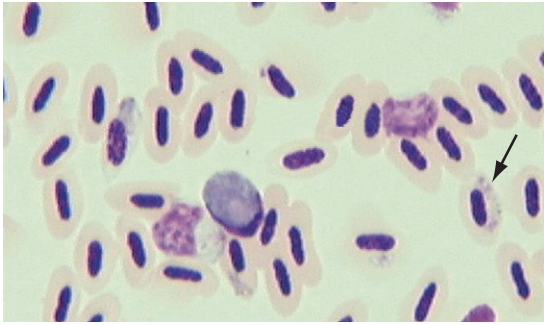


Fig. 18.63 *Trichomonas gallinae* ("trichomona of birds").

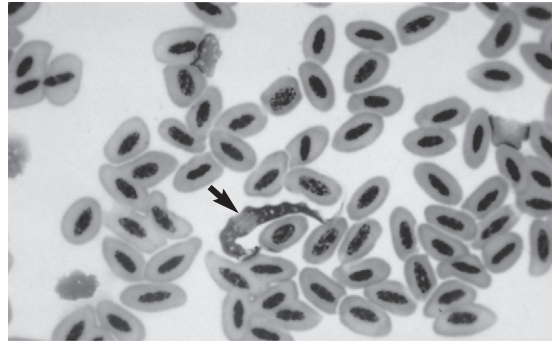


Fig. 18.64 *Trypanosoma* species ("trypanosomes of birds").

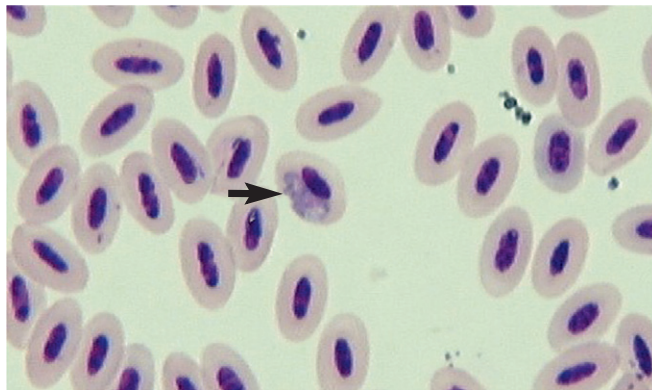


Fig. 18.65 *Haemoproteus* species ("Haemoproteus of birds").

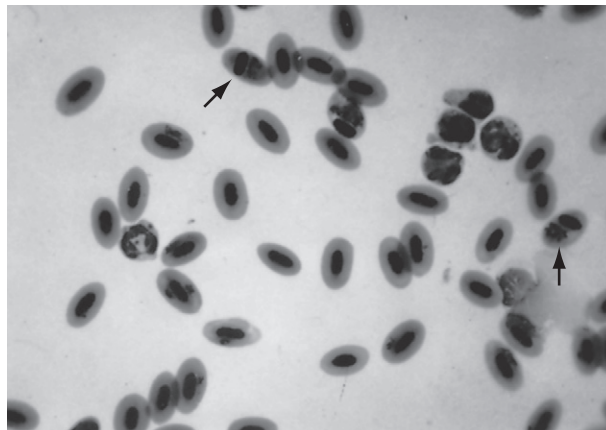


Fig. 18.66 *Plasmodium* species ("avian malaria").



Fig. 18.67 Unsporulated *Eimeria magna* ("coccidia of rabbits").

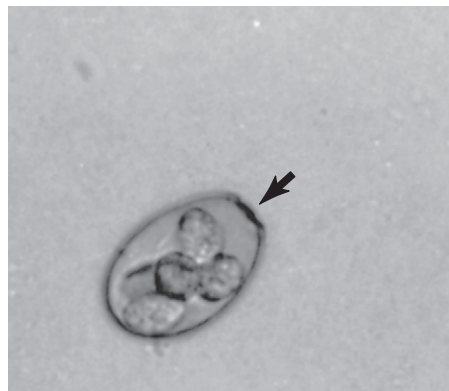


Fig. 18.68 Sporulated *Eimeria magna* ("coccidia of rabbits").



Fig. 18.69 *Goniocotes gallinae* ("fluff louse of poultry").

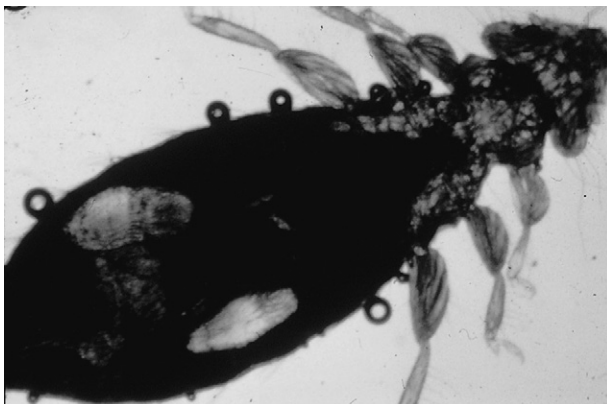


Fig. 18.70 *Menacanthus stramineus* ("avian body louse").



Fig. 18.71 *Gliricola porcelli* ("guinea pig chewing louse").

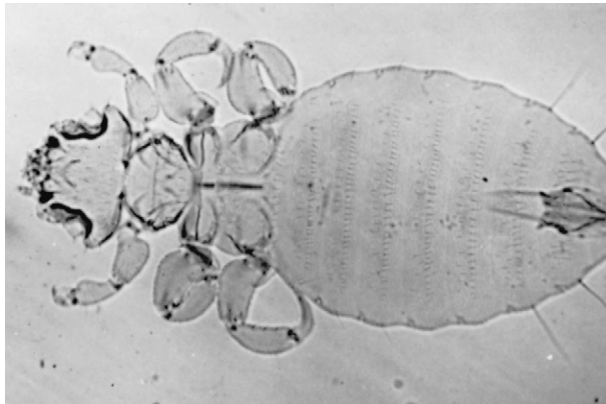


Fig. 18.72 *Gyropus ovalis* ("guinea pig chewing louse").



Fig. 18.73 *Cuterebra* species under skin ("wolves or warbles of rabbits").



Fig. 18.74 *Cuterebra* species larval stages ("wolves or warbles of rabbits").

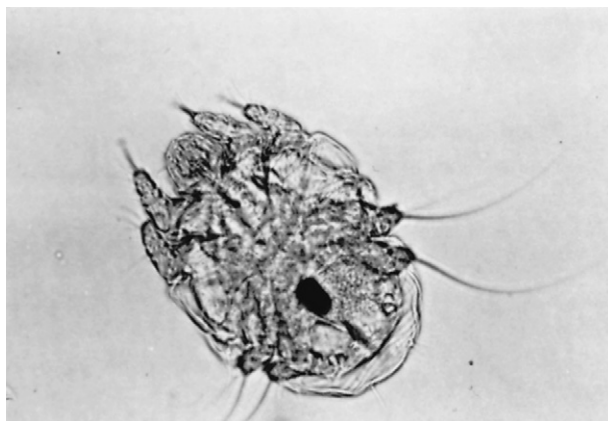


Fig. 18.75 *Psoroptes cuniculi* ("ear canker mite of rabbits").



Fig. 18.76 *Trixacarus caviae* ("sarcoptic mite of guinea pigs").

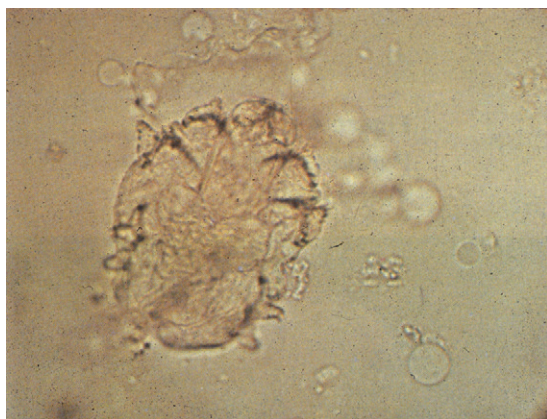


Fig. 18.77 *Cnemidocoptes pilae* ("sarcoptic mite of birds").



Fig. 18.78 *Demodex criceti* ("demodectic mite of hamsters").

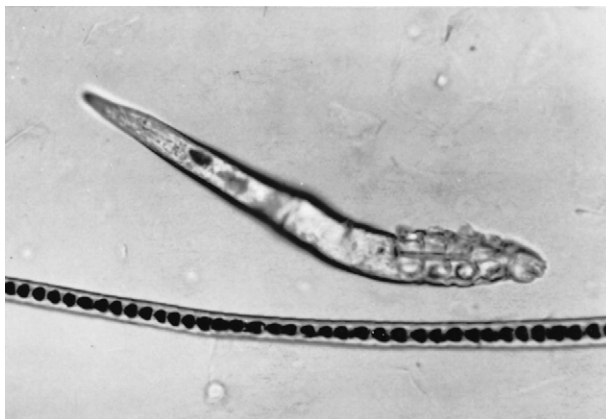


Fig. 18.79 *Demodex aurati* ("demodectic mite of hamsters").



Fig. 18.80 *Ornithonyssus bacoti* ("tropical mite of rats").



Fig. 18.81 *Cheyletiella parasitivorax* ("fur mite of rabbits, dogs, and cats").

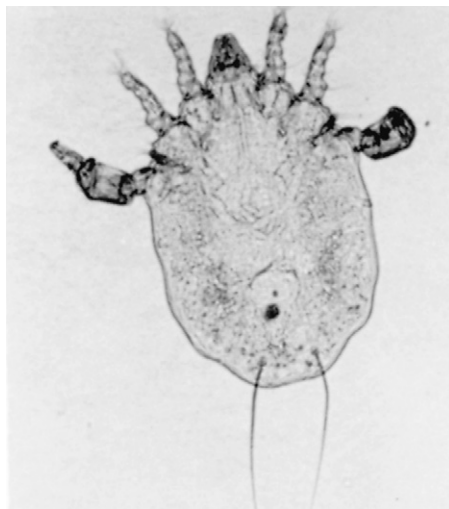


Fig. 18.82 *Myocoptes musculus* ("fur mite of mice").

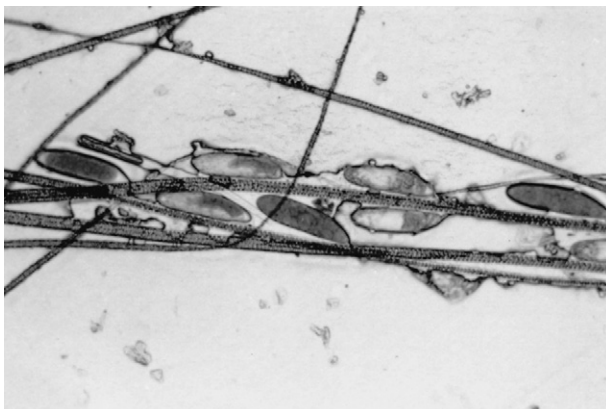


Fig. 18.83 *Myocoptes musculus* nits ("fur mite of mice"; nits).

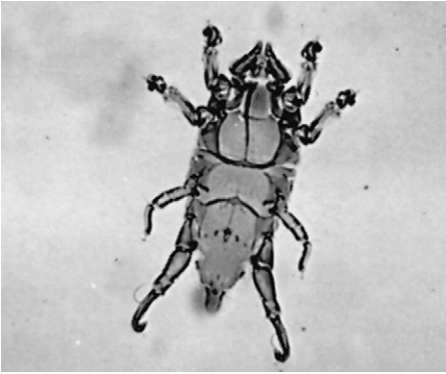


Fig. 18.84 *Chirodiscoides caviae* ("fur mite of guinea pigs").



Fig. 18.85 *Chirodiscoides caviae* (female "fur mite of guinea pigs").

Pseudoparasites

(Figs. 18.86 to 18.92)

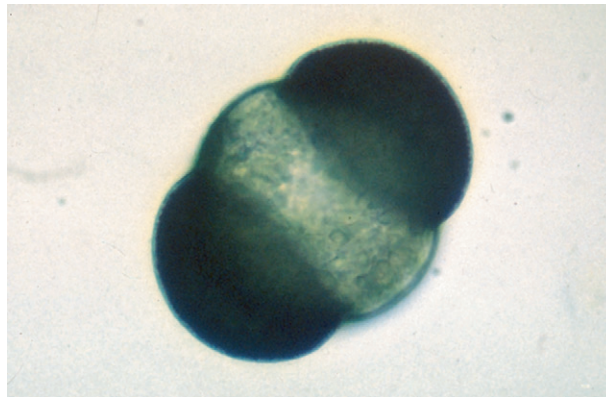


Fig. 18.86 Pine pollen.



Fig. 18.87 *Monocystis* (sporulated) parasite of the earthworm.

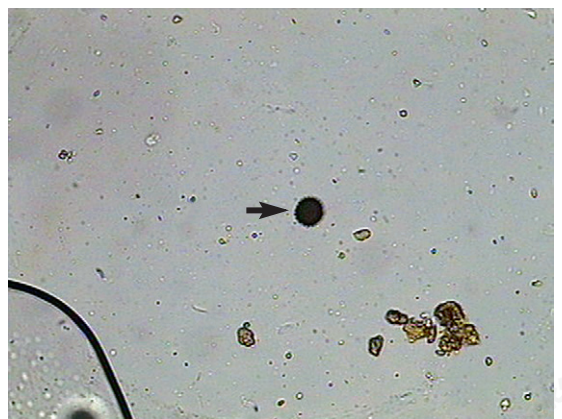


Fig 18.88 Pollen.

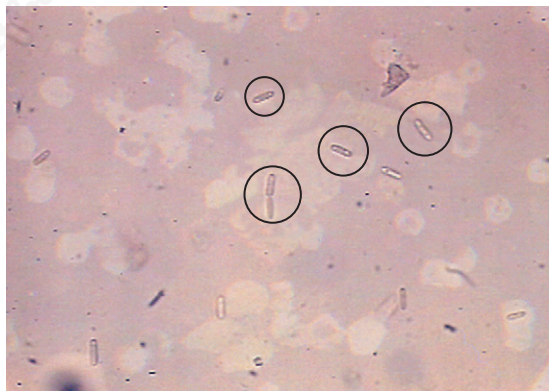


Fig. 18.89 *Saccharomyces guttulatus*, a yeast of the rabbit alimentary tract.



Fig. 18.90 Plant hair. (From Bowman DD: *Georgis' Parasitology for Veterinarians*, 9th ed., St Louis, 2008, Elsevier)

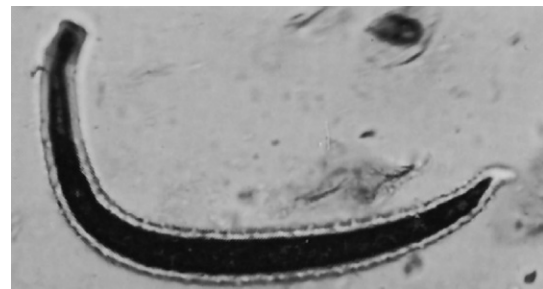


Fig. 18.91 Plant hair. (From Bowman DD: *Georgis' Parasitology for Veterinarians*, 9th ed., St Louis, 2008, Elsevier.)

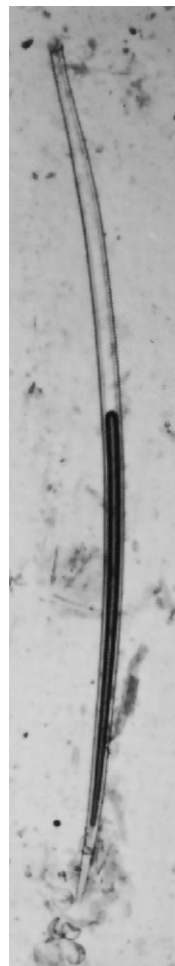


Fig. 18.92 Plant hair. (From Bowman DD: *Georgis' Parasitology for Veterinarians*, 9th ed., St Louis, 2008, Elsevier.)

Epilogue

Becoming Proficient in Veterinary Medicine's Most Important Skill

Charles M. Hendrix, DVM, PhD

One of the requirements for the accreditation of any college of veterinary medicine by the American Veterinary Medical Association (AVMA) is that veterinary students be given instruction in veterinary medical ethics and/or jurisprudence. At Auburn University's College of Veterinary Medicine, the first year ethics course requires the recitation of the AVMA's Veterinarian's Oath by every member of the class. This is a task that may be accomplished at any time throughout the course's duration. Each class member is required to learn and recite the Veterinarian's Oath. This task is accomplished in a rather unique manner, that is, each student will determine the manner in which the assignment is completed. Choices are recitation of the Oath to the entire class, recitation of the Oath to the course instructor, or writing the Oath on a single sheet of paper. The three methods are based on the each student's choice of the manner in which he or she wishes to respond. Methods are based on the different degrees of difficulty the students must endure during the formal recitation process. Point values are as follows: 125 points for solo recitation in front of the entire class; 100 points for the face-to-face recitation with the course instructor; and finally 90 points for the writing the Oath. The difference in point value are loosely based on a single parameter of personality types, "introversion" versus "extroversion." The testing methods are based on the individual student's views on public speaking. With regard to their veterinary futures, every student must come to grips with the art of public speaking: conferring with colleagues on a day-to-day basis, explanation of disease processes to clients, or presentation of detailed veterinary data to live audiences during classes or formal presentations during professional meetings. All veterinarians (and veterinary technicians) must become proficient in their learned communication skills in one form or another. They will remember the tenets of the Veterinarian's Oath or the Veterinary Technician's Oath throughout their veterinary careers. The Oaths for both professions are detailed in the following discussion.

The Veterinarian's Oath: Being admitted to the profession of veterinary medicine, I solemnly swear to use my scientific knowledge and skills for the prevention and relief of animal suffering, the conservation of animal resources, the promotion of public health, and the advancement of medical knowledge.

I will practice my profession conscientiously, with dignity, and in keeping with the principles of veterinary medical ethics. I accept as a lifelong obligation the continual improvement of my professional knowledge and competence.

There is a similar oath that veterinary technicians must take as they enter their chosen profession. This Veterinary Technician's Oath is quite similar to that of practicing veterinarians:

The Veterinary Technician's Oath: I solemnly dedicate myself to aiding animals and society by providing excellent care and services for animals, by alleviating animal suffering, and promoting public health. I accept my obligations to practice my profession conscientiously and with sensitivity, adhering to the profession's Code of Ethics, and furthering my knowledge and competence through a commitment to lifelong learning.

For both of these veterinary/veterinary-related professions, the legal definition of the word *oath* affirms the facts that "a solemn attestation is made regarding the truth of one's words or the sincerity of one's intentions specifically" and "a promise (as to perform official duties faithfully)."

When one examines and compares both the Veterinarian's Oath and the Veterinary Technician's Oath, one finds that both oaths are quite similar in the following tenets: "relief of animal suffering" and "alleviating animal suffering"; "promotion of public health" and "promoting public health"; "practicing [the veterinary] profession with dignity" and "practice [the veterinary] profession

conscientiously and with sensitivity”; “upholding the principles of veterinary medical ethics” and “adhering to the profession’s Code of Ethics”; and “the continual improvement of [one’s] professional knowledge and competence” and “furthering [one’s] knowledge and competence through a commitment to lifelong learning.”

For both, these five tenets are powerful and all-encompassing professionally relative to veterinary medicine. However, one of these tenets stands out and is perhaps most important and most applicable to the role that veterinary medicine plays in human health promotion and disease prevention: “promotion of public health” (Veterinarian’s Oath) and “promoting public health” (Veterinary Technician’s Oath).

These similar goals are in unison with the veterinary technician working in the practice of a licensed veterinary practitioner. The technician must understand that promoting public health is the most important skill that both the veterinarian and the veterinary technician possess. Ultimately, it is both individuals’ job to ensure that clients understand/comprehend the public health significance of the zoonotic potential of the diverse range of parasites of domesticated animals. The array of parasites includes protozoans (unicellular parasites); helminths, including nematodes (roundworms, both adult and larval [immature] stages); cestodes (tapeworms, both adult and larval [metacystode] stages); trematodes, both adult and larval stages; and arthropods (insects, mites, ticks, and pentastome parasites). Each of these major groups of parasites possesses either adult or immature developmental stages that have the potential to infect or infest human beings and produce significant problems in human health. It is extremely important that both the veterinarian and the veterinary technician are able to explain to clients how the many types of parasites may infect/infest human beings and how they produce significant pathology to the human owner or the owner’s family. The veterinarian has an additional charge: to serve as an intermediary professional in advising all human health care professionals on the intricacies of the life cycles of and the pathology produced by parasites and their developmental stages.

Technician’s Note



If a disease or pathogen is zoonotic, regardless of the educational institution of training, regardless of the course discipline, and regardless of the instructor involved with teaching the course, the student must know the who(s), what(s), when(s), where(s), why(s), and how(s) of that disease or pathogen in order to properly explain to the client or to another health care professional *all* of the zoonotic parameters related to the transmission of that disease or pathogen. This is especially true for the zoonotic parasites that might occur in veterinary practice in veterinary parasitology.

Zoonotic Parasites of Veterinary Importance

Protozoan parasites

- *Toxoplasma gondii*—Toxoplasmosis
- *Cryptosporidium parvum*—Cryptosporidiosis

Trematode parasites

- Schistosome cercarial dermatitis—“Swimmer’s itch”

Cestode parasites

- *Taenia saginata* —Beef tapeworm
- *Taenia solium*—Pork tapeworm
- *Echinococcus granulosus*—Unilocular hydatid disease
- *Echinococcus multilocularis*—Multilocular hydatid disease
- *Dipylidium caninum*—Dipylidiasis
- *Spirometra mansonoides*—Both benign and malignant forms
- *Diphyllobothrium latum*—Diphyllobothriasis
- *Hymenolepis nana*—Hymenolepiasis

Nematode parasites

- *Toxocara canis*, *Toxocara cati*—Toxocaral larva migrans, visceral larva migrans, ocular larva migrans
- *Baylisascaris procyonis*—Neural larva migrans, cerebrospinal larva migrans
- *Ancylostoma caninum*, *Ancylostoma braziliense*, *Ancylostoma tubaeforme*, and *Uncinaria stenocephala*—Cutaneous larva migrans, creeping eruption, plumber’s itch
- *Ancylostoma caninum*—Enteric hookworm disease
- *Strongyloides stercoralis*—Strongyloidiasis
- *Trichostrongylus axei*
- *Trichinella spiralis*—Trichinosis
- *Dirofilaria immitis*—Pulmonary dirofilariasis

Arthropod parasites

- *Sarcoptes scabiei* variety *canis*—Canine scabies

Pentastome parasites

- Reptilian pentastomiasis

Note to Instructors and Students

One of the challenges in teaching today is that it is very difficult to make students communicate and explain the basic, important concepts that they have learned. I always tell my students, “The object of this ‘game’ in life is to *make the correct veterinary words come out of ones mouths.*” Nothing else could be more important in the performance one’s duties in any veterinary clinical situation. This most important task takes on significance when one is discussing with clients the zoonotic parasites that play such an important role in health promotion and disease prevention. Basically,

today's veterinary technician must be able to explain the zoonotic significance of parasites to the public at large using the journalistic questions—"What? Who? When? Where? Why? How?"—to convey the gravity of parasitic zoonoses to the public at large. Competency boils down to effectively describing the answers to these questions.

I have not fleshed out the remaining zoonotic parasites—that will be your task and challenge. It is your job to go out into the world and flex your veterinary parasitologic muscles!

What Types of Zoonotic Parasites Are We Dealing With?

Zoonotic parasites are classified as being either **unicellular zoonotic parasites** or **multicellular zoonotic parasites**. For the most part, unicellular parasites and/or their developmental stages are microscopic, that is, observable using a compound microscope. Multicellular parasites are usually identified grossly, that is, with the naked eye. However, their eggs or developmental stages may be microscopic or may be able to be visualized using a compound microscope.

Unicellular Zoonotic Parasites

Protozoan? Is this a unicellular (one-cell) parasite (e.g., *Toxoplasma gondii*, a protozoan parasite frequently found in domestic cats)? The sporulated oocyst of *T. gondii* will hatch, releasing the infective stages of this protozoan parasite, which may infect a developing fetus.

Multicellular Zoonotic Parasites

- **Nematode?** Is this an adult roundworm (e.g., adult nematodes like *Trichinella spiralis*, which may be found in the small intestine of human beings, versus the microscopic stage of *T. spiralis*, which may be found in the musculature of human beings)? (Note: Human beings are capable of serving as both definitive and intermediate hosts for *T. spiralis*.)
- **Cestode?** Is this an adult tapeworm versus a larval tapeworm (metacestode stage)? For example, adult tapeworms like *Taenia solium* are found in the small intestine of human beings, versus the almost-microscopic stages of *T. solium* (now referred to as *Cysticercus cellulosae*), which are found in the muscles of human beings. (Note: Human beings are capable of serving as both definitive hosts [harboring adult *T. solium*] and as intermediate hosts harboring a metacestode stage in the muscles for *C. cellulosae*.)
- **Trematode?** Is this a larval fluke? Human beings seldom harbor adult stages of trematodes (flukes) of domestic or wild animals. However, the larval stages (cercarial stages) of an avian fluke of wild birds may

be found. These larval schistosomes can produce an allergic reaction in the skin of humans upon repeated penetration of larval stages into the skin of a human who has swum in infested waters (*schistosome cercarial dermatitis*, or swimmer's itch).

- **Arthropods?** Is this a mite or a tick? In this instance, both larval and adult stages of *Sarcoptes scabiei* variety *canis* (both larval and adult stages) are found tunneling in the superficial layers of the epidermis in the skin of dogs, especially young puppies. These tunneling mites are capable of penetrating human skin and producing similar tunnels in the epidermis, which results in an intense itching reaction in the infested human host.

Who Can Become Infected/Infested With the Zoonotic Parasite?

- **Adult humans versus children?**
Migrant farmworkers who eat poorly cooked beef containing the infective (larval metacestode stages) cysticerci of *Cysticercus bovis* will develop adult tapeworms, *Taenia saginata*, in their small intestines.
Young children who play in unattended, uncleaned backyards where young puppies infected with *Toxocara canis* are kept and where the puppies are allowed to defecate may ingest the eggs of *T. canis*. If these eggs have been allowed to develop to the egg stage containing the second-stage larvae, the larvae will hatch and continue to migrate in the child's body, producing a condition known as *visceral larva migrans*.
- **Male versus female humans?** Pregnant women who change the litter box of an animal infected with the sexual stages of *Toxoplasma gondii* may ingest the sporulated oocyst of this protozoan parasite. The sporulated oocyst will hatch, releasing the infective stages of this protozoan parasite, which may infect the developing fetus. A final result of this infection in a child developing within the womb may be miscarriage, hydrocephaly, or blindness. As a result, only a nonpregnant individual preferably a male within the household should come in contact with the litter box of a cat possibly infected with *T. gondii*.

When Does the Parasite Infect the Human Host? If Available, Give the Scientific Term for the Infection in a Human Beings

With the larval hookworm (*Ancylostoma* species), the human host may become infected by penetration of the hookworm's infective third-stage larvae. Young children, particularly toddlers, enjoy sitting in a sandbox as they

play. If a cat uses a child's sandbox as a site for defecation, the eggs of *Ancylostoma* spp. will be found in the cat's fresh feces. The sand is an excellent medium into which each egg will pass, where they develop into the larval stage. When the larva hatches from the egg, it will thrive in the moist, sandy environment. Each larva will eventually develop to the infective third-stage larva. If a single larva penetrates the delicate skin of a child, the child will be an unsuitable host for this canine/feline parasite, so the adult hookworm will not develop to the adult stage within the intestine of the child. Instead, the larva will only be able randomly travel through the superficial layers of the child's skin, producing tiny red tunnels in the skin. When this skin condition happens, the term for the skin condition is *cutaneous larva migrans*.

With larval ascarids (intestinal canine roundworm, e.g., *Toxocara canis*), the human host (usually a small child) may become infected by ingestion of the roundworm's infective stage, an egg containing a second-stage larva. Young children, particularly toddlers, enjoy playing in the home's backyard. If a dog defecates, unembryonated eggs of *T. canis* will be found in the dog's fresh feces. The sand is an excellent medium into which each egg will pass, where the eggs will develop into the infective stage, an egg containing a second-stage larva. If one of these eggs containing an infective second-stage larva is ingested by the child, the child will be an unsuitable definitive host. Instead of developing to the adult stage in the child's small intestine, these roundworm larvae will encyst as second-stage larvae in sites outside of the intestine, such as the liver or the lungs. When this migration to sites out of the intestine occurs, the term for this infection in children is *visceral larva migrans*.

Where Does the Human Host Become Infected?

- **In or near the home environment:** "Owning" or "maintaining" raccoons as pets in *any* home environment is *not* a wise decision. Raccoons should *never* be maintained as pets. Nevertheless, raccoons are kept as backyard pets by uninformed individuals. In such cases, these formerly wild animals are maintained in cages with either open wire bottoms or with plywood cage bottoms. Wire cage bottoms allow raccoon feces to fall to the ground below. Plywood cage bottoms allow raccoon feces to collect/remain in the tiny wood crevices of the wooden floor. Raccoons of all ages are capable of harboring the intestinal roundworm *Baylisascaris procyonis* within the small intestine. In this intestinal site within the raccoon, the female ascarids are fertilized by the male ascarids. The female ascarids produce ova that eventually pass

to the outside environment. In wire-bottom cages, the feces fall to the ground beneath the cage. In plywood-bottom cages, the feces fall to the floor of the cage. The ground beneath the cage and the tiny crevices in the wood serve as excellent sites where the eggs can embryonate to the infective stage, an egg containing a second-stage larva. If one of these eggs containing an infective second-stage larva is ingested by the child, the child will serve as an unsuitable definitive host. Instead of developing to the adult stage in the child's small intestine, the roundworm larvae will migrate as second-stage larvae in sites outside of the intestine, within the spinal cord or within the brain, producing significant pathology. When this migration to these neurologic sites occurs, the term for this neurologic infection in children is *neurologic larva migrans*.

- **Away from the home environment (exotic locales) or in the vicinity of the pet's outdoor environment:** Individuals who travel to exotic locales that have beaches where stray dogs are allowed to run up and down the beach may come in contact with infective hookworm larvae. Stray dogs often harbor *Ancylostoma* species within the small intestine. The adult female hookworms produce eggs that pass out in the feces. The sandy environment of the beach allows the larvae to develop and hatch from the eggs and eventually develop to the infective third stage. These larvae are capable of surviving in the moist, sandy environment and develop to infective third-stage larvae. These larvae penetrate the bare feet of the traveler, producing very red, winding, itching tunnels in the soles of the feet, resulting in a condition known as *cutaneous larva migrans*.

Why Should the Client Be Informed Regarding the Infective Life-Cycle Stages of the Parasite?

The client must be educated regarding the multitude of zoonotic parasites in veterinary medicine. In households in which pets are part of the family, children are quite often the unintended host recipients of the effects of infection/infestation by a zoonotic parasite. Any time small children are present during the physical examination of a family pet or the veterinarian or technician has knowledge of a child's presence in the home environment, the zoonotic significance of the parasite must be thoroughly explained to the pet owner.

Veterinary practitioners and their technicians must always explain the intricate details in the life cycle of a

zoonotic parasite. However, during this process, they are prevented from giving specific medical advice to the pet owner. Veterinary practitioners should never attempt to make diagnoses in their clients or in the client's family members. Ideally, the role of the veterinary health professional is to inform the client of the intricacies of the parasite's life cycle, the specific points at which animal-to-human transmission of the pathogen occurs, and the need for the client to seek the advice of or consultation with a medical practitioner (e.g., family practice specialist, dermatologist, or pediatrician). The best example of this would be regarding the existence of the human pinworm, *Enterobius vermicularis*, in a small child. Parents are often led to believe that the home-dwelling pet is the source of pinworm infections in small children. In some cases, even well-educated pediatricians have referred the family pet to a veterinary clinic to have the pet treated for pinworm infection. In this case, nothing could be further from the truth. A practice tip for client education is the simple adage that "pinworms are parasites of herbivores (e.g., *Oxyuris equi*, the equine pinworm in horses) and omnivores (e.g., *Enterobius vermicularis*, the human pinworm in small children) but never carnivores such as the dog or cat." Physicians must be informed of this adage; however, in no instance must human treatment or medical advice be given to a client or the client's family. These instances reveal the importance of effectively

communicating the details of the infective life-cycle stages of any zoonotic parasite.

How Is the Parasite Prevented/Controlled/Treated in Human Beings?

The cycle of any zoonotic infection in humans is broken by the transmission of diverse knowledge of pertinent preventive techniques. If a disease or pathogen is zoonotic, regardless of the course discipline and regardless of the instructor involved with teaching that course, the veterinary student (be they a veterinary or a veterinary technician student) must understand and be able to relate the who(s), what(s), when(s), where(s), why(s), and how(s) of that zoonotic disease or pathogen. For collaborative situations, veterinary technicians must always be able to explain to the client or to another health care professional *all* of the zoonotic parameters related to the transmission of that disease or pathogen to human beings.

In closing, veterinary technicians must remember the importance of client education. This oral skill is perhaps one of the most importance skills that a veterinarian technician possesses, and it is only through practice that the technician develops these skill.

Parasite Reference List by Species and Parasite Type

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Parasites of Rabbits

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Obeliscoides cuniculi, p. 72
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Protozoans

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Nematodes

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Protozoans

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Arthropods

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Parasites of Rats

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Aspiculuris tetraptera, pp. 66–68
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Protozoans

Eimeria nieschultzi, pp. 164–165
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Arthropods

Cuterebra species, p. 201
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Parasites of Mice

Nematodes

Aspiculuris tetraptera, pp. 66–68
Syphacia muris, pp. 66–68
Syphacia obvelata, pp. 66–68

Cestodes

Hymenolepis diminuta, pp. 86–88
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Protozoans

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Myobia musculi, pp. 224–225
Myocoptes musculus, p. 224
Polyplax serrata, p. 185
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Radfordia affinis, p. 224
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Parasites of Hamsters

Nematodes

Syphacia muris, pp. 66–68
Syphacia obvelata, pp. 66–68

Cestodes

Hymenolepis diminuta, pp. 86–88
Hymenolepis nana, pp. 86–88

Protozoans

Giardia species, p. 165
Spironucleus muris, p. 165
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Arthropods

Demodex aurati, pp. 218–219
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Parasites of Gerbils

Nematodes

Dentostomella translucida, pp. 69–70

Cestodes

Hymenolepis diminuta, pp. 86–87
Hymenolepis nana, pp. 86–87

Arthropods

Demodex aurati, p. 218
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Parasites of Fish

Protozoans

Ichthyophthirius multifiliis, p. 167

Parasites of Reptiles

Pentastomes

Armillifer species, p. 239

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Porocephalus species, p. 239

Kiricephalus species, p. 239

Arthropods

Glossina species, p. 191

Appendix

B

VTNE Review Questions in Parasitology

Outline

245 Questions on parasites and vocabulary to prepare for the Veterinary Technician National Exam (VTNE) on parasitology.

Learning Objectives

Prepare for the most commonly asked about parasites on the VTNE in Large and Small Animal Veterinary Medicine.

The VTNE is composed of different subjects. The test is composed of 170 multiple-choice questions answered in a 3-hour period. The breakdown of the test questions is as follows:

Pharmacy and Pharmacology 12%

Surgical Nursing 11%

Dentistry 7%

Laboratory Procedures 12% (this would include parasitology questions)

Animal Care and Nursing 22%

Diagnostic Imaging 7%

Anesthesia 15%

Emergency Medicine/Critical Care 8%

Pain Management/Analgesia 7%

1. *Babesia bigemina* is transmitted to cattle by the tick _____.

- A. *Rhipicephalus annulatus* C. *Ixodes scapularis*
B. *Rhipicephalus sanguineus* D. *Dermacentor andersoni*

2. An obligatory parasite is _____.

- A. A parasite that can live free in the environment and becomes parasitic under the right conditions
B. A parasite that lives in a host
C. A parasite that lives on a host
D. A parasite that requires a host to survive

3. Canine, feline, and ferret ear mites are caused by the mite _____.

- A. *Psoroptes cuniculi* C. *Cheyletiella parasitivorax*
B. *Otodectes cynotis* D. *Demodex canis*

4. Crusting, scaling, and excoriation are common symptoms of a canine scabies infestation. These symptoms commonly or classically occur on the _____.

- A. Toes, tail base, and ventral neck C. Ears, lateral elbows, and ventral abdomen
B. Tail tip, dorsal abdomen, and nose D. Ears, footpads, and tail base

5. Parasitism is _____.

- A. When a parasite lives in or on a host, benefitting both parasite and host
B. When a parasite lives in or on a host and can cause harm to the host
C. When a parasite lives in or on a host and neither one is harmed or benefits
D. When a parasite lives in or on a host and one benefits while the other neither benefits nor is harmed

6. The hexacanth contains _____.
 A. Six hooks C. Four hooks
 B. Five hooks D. Three hooks
7. The two animals *not* infected with any pinworms are _____.
 A. Horses and pigs C. Cows and dogs
 B. Dogs and cats D. Sheep and cats
8. The nematodes are collectively called the _____.
 A. Tapeworms C. Roundworms
 B. Flukes D. Thorny-headed worms
9. The motile life cycle stage of *Giardia* species is the _____.
 A. Oocyst C. Merozoites
 B. Trophozoite D. Tachyzoites
10. The adult flea can survive up to _____ without a blood meal.
 A. 3 days C. 5 days
 B. 4 days D. 7 days
11. One of the most common tests for dermatologic parasites is _____.
 A. Skin cytology C. Ear cytology
 B. Impression smear D. Skin scraping
12. The most important vascular parasite of domestic animals in the United States is _____.
 A. *Trypanosoma cruzi* C. *Acanthocheilonema reconditum*
 B. *Babesia bigemina* D. *Dirofilaria immitis*
13. *Rhipicephalus sanguineus* is known to transmit _____.
 A. *Babesia canis* C. Tularemia
 B. Rocky Mountain spotted fever D. Heartworm disease
14. Flea control for pets includes monthly applications of topical liquids or _____.
 A. Powders C. Orals
 B. Sprays D. Injectables
15. A louse infestation is called _____.
 A. Pediculosis C. Myiasis
 B. Mange D. Acariasis
16. The preferred microscopic test to differentiate *Dirofilaria immitis* is the _____.
 A. Buffy coat test C. Knott's test
 B. Thin blood smear D. Thick blood smear
17. The definitive host of *Taenia pisiformis*, *Taenia Hydatigena*, and *Taenia ovis* is the _____.
 A. Cat C. Cow
 B. Dog D. Pig
18. *Trichinella spiralis* can be transmitted by _____.
 A. Blood transfusion
 B. Transmammary route
 C. Ingestion of undercooked or raw meat, usually pork
 D. Transplacental route
19. The preferred flotation technique to find parasite eggs or oocysts is the _____.
 A. Simple flotation C. Sedimentation
 B. Direct wet mount D. Centrifugal flotation
20. The most important step in completing all laboratory tests is _____.
 A. Recording results C. Freezing fecal samples
 B. Tasting the sample D. Cleaning up after testing
21. The protozoans that cause giardiasis are named by _____.
 A. Genus and species C. Assemblages
 B. Family D. Kingdom

22. The attachment organelles of pseudotapeworms are called _____.
 A. Acetabula C. Rostellum
 B. Bothria D. Coracidium
23. *Cryptosporidium* species are diagnosed with _____.
 A. Fecal sedimentation C. Baermann technique
 B. Fecal direct wet mount D. Fecal centrifugal flotation
24. The mite that causes sarcoptic mange or scabies in canines is _____.
 A. *Sarcoptes scabiei* variety *felis* C. *Sarcoptes scabiei* variety *bovis*
 B. *Sarcoptes scabiei* variety *suis* D. *Sarcoptes scabiei* variety *canis*
25. The *Cysticercus bovis* found in cattle is the metacestode stage of the human tapeworm _____.
 A. *Taenia solium* C. *Taenia pisiformis*
 B. *Taenia saginata* D. *Taenia multiceps*
26. The large animal most rarely infested with *Sarcoptes scabiei* is the _____.
 A. Pig C. Cow
 B. Horse D. Sheep
27. The intermediate host for *Dipylidium caninum* is _____.
 A. The tick C. The house fly
 B. The flea D. The mange mite
28. One of the most economically important flukes is _____.
 A. *Dicrocoelium dendriticum* C. *Fasciola hepatic*
 B. *Fascioloides magna* D. *Paragonimus kellicotti*
29. The eggs of *Ancylostoma caninum* contain a(n) _____.
 A. 2- to 4-cell morula C. 8- to 16-cell morula
 B. 4- to 6-cell morula D. 22- to 32-cell morula
30. *Klossiella equi* is diagnosed using _____.
 A. Fecal centrifugation C. ELISA testing
 B. Blood smear D. Urine testing
31. The definitive host of *Echinococcus multilocularis* is the _____.
 A. Horse C. Dog
 B. Cat D. Sheep
32. Sarcoptic acariasis is commonly called _____.
 A. Ehrlichia disease C. Demodicosis
 B. Scabies D. Walking dandruff
33. *Stephanurus dentatus* is the _____.
 A. Swine kidney worm C. Swine heartworm
 B. Swine roundworm D. Swine lungworm
34. The sexually transmitted protozoan is _____.
 A. *Giardia* species C. *Trypanosoma* species
 B. *Babesia* species D. *Tritrichomonas* fetus
35. *Moniezia* species eggs have a characteristic _____.
 A. Round shape C. Elliptical shape
 B. Ovoid shape D. Square shape
36. One common symptom of a *Babesia canis* infection is _____.
 A. Vomiting C. Hemophilia
 B. Diarrhea D. Fever
37. An egg packet of *Dipylidium caninum* contains _____.
 A. 5 hexacanth embryos C. 10–20 hexacanth embryos
 B. 10 hexacanth embryos D. 20–30 hexacanth embryos
38. *Babesia* species appear _____ within red blood cells.
 A. Cucumber shaped C. Ovoid shaped
 B. Pear shaped D. Pie shaped

39. One stomach worm of horses is _____.
 A. *Oxyuris equi* C. *Dictyocaulus arnfieldi*
 B. *Trichostrongylus axei* D. *Ascarops strongylina*
40. *Paramphistomum* species and *Colytrophoran* species are commonly called the _____.
 A. Carnivore flukes C. Intestinal flukes
 B. Rumen flukes D. Lung flukes
41. The genus and species for the hookworm is _____.
 A. *Ancylostoma caninum* C. *Oxyuris equi*
 B. *Toxocara canis* D. *Strongyloides papillosus*
42. Although large animals can be infested with *Sarcoptes scabiei*, the _____ is the most common large animal affected.
 A. Pig C. Cow
 B. Horse D. Sheep
43. Hookworms can infect a host _____.
 A. By ingestion of a lobster C. By direct contact between hosts
 B. Through the skin D. By the bite of a tick
44. The simple flotation technique requires the use of _____.
 A. A centrifuge C. Water
 B. A fecal container D. 10 g of feces
45. Simple flotation or centrifugal flotation techniques can be used on vomitus to find parasite eggs from the _____.
 A. Small intestine C. Large intestine
 B. Stomach D. Entire gastrointestinal system
46. Mites in the Sarcoptidae family of sarcoptiform mites live _____.
 A. On the surface of the skin only C. On the hair shafts only
 B. In the epidermis D. On the toenails only
47. *Cysticercus tenuicollis* found in cattle, sheep, and goats is the metacestode stage of the canine tapeworm _____.
 A. *Taenia solium* C. *Taenia hydatigena*
 B. *Taenia saginata* D. *Taenia multiceps*
48. The most common reason for the need of immunologic testing for *Dirofilaria immitis* in dogs is _____.
 A. Monthly heartworm preventatives
 B. Heartworms are too young to produce microfilaria
 C. Single-sex infections
 D. Host clears microfilaria spontaneously
49. Ticks can survive up to _____ year(s) without a blood meal.
 A. 3 C. 1
 B. 2 D. 0.5
50. The broad fish tapeworm is the common name for _____.
 A. *Cysticercus bovis* C. *Dipyllobothrium latum*
 B. *Echinococcus granulosus* D. *Spirometra mansonioides*
51. The intermediate hosts for *Taenia pisiformis* are _____.
 A. Cats and dogs C. Rabbits and hares
 B. Cattle and goats D. Pigs and horses
52. Although mosquitoes are known for spreading disease, the disease best known in veterinary medicine is _____.
 A. Chagas disease C. Lyme disease
 B. Heartworm disease D. Rocky Mountain spotted fever
53. The sucking lice do not parasitize birds or _____.
 A. Dogs C. Sheep
 B. Cats D. Pigs
54. *Babesia canis* is transmitted by its intermediate host, the _____.
 A. Flea C. Fly
 B. Tick D. Louse

55. *Demodex* species are considered _____.
 A. Reportable C. Species specific
 B. Highly contagious D. Zoonotic
56. Pulmonary dirofilariasis in humans is transmitted by the _____.
 A. Mosquito C. Tick
 B. Flea D. Mite
57. An endoparasite lives _____.
 A. In a host C. In the environment
 B. In the water D. On a host
58. The most *inaccurate* fecal technique is the _____ technique.
 A. Centrifugal flotation C. Simple flotation
 B. Direct wet mount D. Sedimentation
59. The canine whipworm is _____.
 A. *Trichuris suis* C. *Eucoleus aerophilus*
 B. *Trichuris ovis* D. *Trichuris vulpis*
60. The protozoan commonly called *coccidia* is _____.
 A. *Giardia* species C. *Toxoplasma* species
 B. *Cystoisospora* species D. *Cryptosporidium* species
61. The tapeworm segments that contain the hexacanth embryos are _____.
 A. Mature proglottids C. Gravid proglottids
 B. Immature proglottids D. Zipper proglottids
62. The preferred flotation solutions are Sheather's solution and _____.
 A. Sodium nitrate solution C. Magnesium sulfate solution
 B. Saturated sodium chloride solution D. Zinc sulfate solution
63. The common name for *Spirometra* species of pseudo-tapeworms is the _____.
 A. Cucumber seed tapeworm C. Canine taeniid
 B. Zipper tapeworm D. Double-pored tapeworm
64. *Paranoplocephala mamillana* is the equine _____.
 A. Dwarf tapeworm C. Flea tapeworm
 B. Cucumber seed tapeworm D. Double-pored tapeworm
65. The salmon-poisoning fluke is _____.
 A. *Platynosomum fastosum* C. *Fasciola hepatica*
 B. *Paragonimus kellicotti* D. *Nanophyetus salmincola*
66. The most common nematodes found in the fecal flotations of ruminants are _____.
 A. Threadworms C. Trichostrongyles
 B. Whipworms D. Lungworms
67. Cats can be infested with scabies by *Sarcoptes scabiei* variety *felis* and _____.
 A. *Notoedres muris* C. *Notoedres cati*
 B. *Otodectes cynotis* D. *Psoroptes cuniculi*
68. *Cochliomyia hominivorax* is commonly called the _____.
 A. Nail worm C. Screwworm
 B. Stomach worm D. Esophageal worm
69. The only life cycle stage of *Trombicula* species that parasitizes animals and humans is the _____.
 A. Nymphal stage C. Larval stage
 B. Pupal stage D. Adult stage
70. The intermediate hosts for *Echinococcus multilocularis* are _____.
 A. Sheep and cattle C. Pigs and goats
 B. Rabbits and squirrels D. Mice, rats, and voles

71. One way to differentiate *Dirofilaria immitis* from *Acanthocheilonema reconditum* is the _____.
 A. Length of the tail C. Width of the body
 B. Length of the head D. Shape of the tail
72. Anopluran lice can be identified by the widest part of the head being _____ than the widest part of the thorax.
 A. Longer C. Wider
 B. Shorter D. Narrower
73. The _____ trematodes are usually ectoparasites of fish, amphibians, and reptiles.
 A. Monogenetic B. Digenetic
 C. Trigenetic D. Quadrigenic
74. *Gasterophilus* species adults are commonly called _____.
 A. House flies C. Horn flies
 B. Stable flies D. Bot flies
75. The ideal specific gravity for flotation solutions is _____.
 A. 1.2–1.25 C. 1.3–1.35
 B. 1.25–1.3 D. 1.1–1.2
76. The sheep ked is transmitted by _____.
 A. Flying from host to host C. Brushing against infected grass
 B. Direct contact D. Being dropped by birds
77. The prepatent period for canine heartworm disease is _____.
 A. 3–4 months C. 6–8 months
 B. 4–5 months D. 1 year
78. *Toxascaris leonina* eggs are round to ovoid with a _____ and a hyaline central portion.
 A. Smooth outer shell C. Rough, pitted outer shell
 B. 6-cell morula D. Hexacanth embryo
79. The brown dog tick is scientifically known as _____.
 A. *Dermacentor variabilis* C. *Rhipicephalus sanguineus*
 B. *Amblyomma americanum* D. *Rhipicephalus annulatus*
80. A facultative parasite is _____.
 A. A parasite that can live free in the environment and becomes parasitic under the right conditions
 B. A parasite that lives in a host
 C. A parasite that lives on a host
 D. A parasite that requires a host to survive
81. *Taenia ovis* is commonly called _____.
 A. The mutton tapeworm of dogs C. The multilocular tapeworm of dogs
 B. The coenrus tapeworm of dogs D. The zipper tapeworm of dogs
82. The intermediate host for *Moniezia benedini*, the ruminant tapeworm, is _____.
 A. The flea C. The grain beetle
 B. The tick D. The louse
83. *Psoroptes* species in large animals are _____.
 A. Transmitted by flies C. Transmitted by ticks
 B. Transmitted between species D. Species specific
84. The simple flotation technique relies on the weight of the parasite eggs or oocysts and the _____ of the solution.
 A. Refractile percent C. Specific gravity
 B. Total protein D. 10 g of feces
85. The largest coccidian oocyst is produced by _____.
 A. *Giardia* species C. *Toxoplasma gondii*
 B. *Eimeria leuckarti* D. *Cystoisospora canis*
86. *Demodex* species can be identified as long or short _____.
 A. Cigars C. Grains of rice
 B. Cigarettes D. Spaghetti

87. *Cystoisospora canis* is typically seen in _____.
 A. Adult cats C. Puppies
 B. Adult dogs D. Kittens
88. A hexacanth embryo contains _____.
 A. Two hooks C. Six hooks
 B. Four hooks D. Eight hooks
89. *Toxascaris leonina* infects _____.
 A. Horses and pigs C. Cows and sheep
 B. Dogs and cats D. Guinea pigs and hamsters
90. The _____ technique can be used to identify pinworms if eggs are not found in flotation techniques.
 A. Cellophane tape C. Baermann
 B. Fecal cytology D. Sedimentation
91. Tapeworm eggs are also called _____.
 A. Football shaped C. Egg packets
 B. Hexacanth embryos D. Oocysts
92. *Otobius megnini*, a soft body tick, is commonly called the _____.
 A. American dog tick C. Brown dog tick
 B. Lone star tick D. Spinose ear tick
93. The Baermann technique is used to recover _____ from soil, feces, or animal tissues.
 A. Whipworm larvae C. Roundworm larvae
 B. Hookworm larvae D. *Giardia* trophozoites
94. The eggs of lice are called _____.
 A. Oocysts C. Nits
 B. Nymphs D. Larvae
95. Adult *Toxocara canis* can be described as _____.
 A. Rice grains C. Spaghetti
 B. Cucumber seeds D. Elbow macaroni
96. Identification of *Psoroptes cuniculi* is made with a superficial skin scrape or _____.
 A. Ear cytology C. Blood smear
 B. Cellophane tape technique D. Impression smear
97. *Parascaris equorum* is _____.
 A. The equine whipworm C. The equine hookworm
 B. The equine pinworm D. The equine roundworm
98. The whipworm of cattle, sheep, and goats is _____.
 A. *Trichuris ovis* C. *Trichuris suis*
 B. *Trichuris vulpis* D. *Trichuris campanula*
99. Identifying *Otodectes cynotis* in dogs, cats, and ferrets may be done with an otoscope or _____.
 A. Cellophane tape technique C. Fecal cytology
 B. Ophthalmoscope D. Ear cytology
100. Summer sores in horses are caused by _____.
 A. *Draschia megastoma* C. *Parascaris equorum*
 B. *Setaria equina* D. *Oxyuris equi*
101. The "holdfast organ" of the trematode is called the _____.
 A. Miracidium C. Acetabulum
 B. Cirrus pouch D. Redia
102. Argasid ticks are _____.
 A. Ornate ticks C. Soft body ticks
 B. Hard body ticks D. Inornate ticks
103. Proglottids of true tapeworms can be said to resemble _____.
 A. Spaghetti C. Footballs
 B. Orange seeds D. Grains of rice

104. The condition caused by fly larvae developing in the tissues or organs of an animal or human is called _____.
 A. Acariasis C. Pediculosis
 B. Folliculitis D. Myiasis
105. *Paragonimus kellicotti* is commonly called _____.
 A. Lung fluke of dogs and cats C. Liver fluke of ruminants
 B. Lung fluke of hamsters and gerbils D. Blood fluke of ruminants
106. The cucumber seed tapeworm is a common name for _____.
 A. *Dipylidium caninum* C. *Echinococcus granulosus*
 B. *Taenia pisiformis* D. *Taenia multiceps*
107. The majority of important tick species to veterinary medicine are the _____.
 A. Soft body ticks C. Southern ticks
 B. Ornate ticks D. Hard body ticks
108. Ticks that display distinctive white patterns on the scutum are _____.
 A. Soft body ticks C. Hard body ticks
 B. Ornate ticks D. Inornate ticks
109. The intermediate hosts for *Echinococcus granulosus* are _____.
 A. Sheep and cattle C. Pigs and goats
 B. Rabbits and squirrels D. Mice, rats, and voles
110. *Heterobilharzia americana* is transmitted to canines by _____.
 A. Ingestion of eggs C. Ingestion of snails
 B. Ingestion of frogs D. Through the skin
111. The larval chigger stays attached to an animal host for _____.
 A. 1 hour C. 1 day
 B. 2 hours D. Several hours
112. The most diverse and complicated phylum of kingdom Protista is _____.
 A. Mastigophora C. Ciliophora
 B. Sarcomastigophora D. Apicomplexa
113. A complete flea control program includes products used on _____.
 A. The yard C. The pet
 B. The house D. All of the above
114. The Reduviid bugs spread _____.
 A. Giardiasis C. Lyme disease
 B. Chagas disease D. Anaplasmosis
115. Digenetic trematode eggs are _____.
 A. Bipolar plugged C. Morulated
 B. Bilaterally operculated D. Operculated on one pole
116. The animal species most commonly and seriously infested with *Demodex* species is the _____.
 A. Feline C. Lagomorph
 B. Equine D. Canine
117. The fringed tapeworm of goats and sheep is _____.
 A. *Moniezia benedini* C. *Thysanosoma actinoides*
 B. *Taenia pisiformis* D. *Anoplocephala perfoliata*
118. The primary vector of Rocky Mountain spotted fever is _____.
 A. *Dermacentor occidentalis* C. *Rhipicephalus annulatus*
 B. *Dermacentor andersoni* D. *Ixodes scapularis*
119. One important characteristic of sarcoptiform mites is that they _____.
 A. Have a round, oval shape C. Have a cigar shape
 B. All burrow under the skin D. All live on the surface of the skin

120. The tick identified by a white spot on its scutum that looks like a star is _____.
 A. *Rhipicephalus sanguineus* C. *Amblyomma americanum*
 B. *Dermacentor andersoni* D. *Rhipicephalus annulatus*
121. One ectoparasite in the Dipteran order does not have wings. That ectoparasite is _____.
 A. *Melophagus ovinus* C. *Glossina* species
 B. *Haematobia irritans* D. *Stomoxys irritans*
122. Anopluran lice are commonly called _____.
 A. Sucking lice C. Climbing lice
 B. Burrowing lice D. Chewing/biting lice
123. *Culicoides* species or "no-see-ums" cause Queensland itch or sweat itch, more commonly called _____.
 A. Summer sores C. Summer dermatitis
 B. Bot itch D. Swimmer's itch
124. Flea infestations are identified by finding live fleas and/or _____.
 A. Eggs in feces C. Larval stage on the animal
 B. Pupal stage on the animal D. Flea dirt
125. Neural larval migrans is caused by _____.
 A. *Baylisascaris procyonis* C. *Ancylostoma caninum*
 B. *Toxocara canis* D. *Dipylidium caninum*
126. The equine pinworm is _____.
 A. *Parascaris equorum* C. *Oxyuris equi*
 B. *Strongyloides westeri* D. *Trichostrongylus axei*
127. The centrifugal flotation technique requires 400X–650X g or _____.
 A. 1500 rpm C. 4500 rpm
 B. 3000 rpm D. 6000 rpm
128. One reason crustaceans are important to veterinary medicine is that they _____.
 A. Are raised for food
 B. Are kept as pets
 C. May cause disease to animals as intermediate hosts when ingested
 D. None of the above
129. *Sarcocystis neurona* causes the disease _____.
 A. Equine babesiosis C. Equine protozoal myeloencephalitis
 B. Bovine fetal abortion D. West Nile virus
130. An ectoparasite lives _____.
 A. In a host C. On a host
 B. In the environment D. In the water
131. The best diagnostic protocol for identifying *Giardia* species is fecal centrifugal flotation in conjunction with _____.
 A. Fecal sedimentation C. ELISA test
 B. Baermann technique D. Fecal cytology
132. Parasitism occurs when a parasite _____.
 A. Lives in or on a host, benefiting both parasite and host
 B. Lives in or on a host and can cause harm to the host
 C. Lives in or on a host and neither one is harmed or benefits
 D. Lives in or on a host and one benefits while the other does not benefit or is not harmed
133. A cetyloda is a(n) _____.
 A. True tapeworm C. Intestinal fluke
 B. Blood fluke D. Pseudotapeworm
134. The best current treatment for feline heartworm disease is _____.
 A. Melarsomine dihydrochloride C. Caparsolate sodium
 B. Supportive care D. Doxycycline

135. *Cystoisospora* species are transmitted _____.
 A. By ingestion of eggs C. By ingestion of oocysts
 B. By ingestion of a flea C. Through the skin
136. The definitive host of *Taenia taeniaeformis* is the _____.
 A. Cat C. Cow
 B. Dog D. Horse
137. Mallophagan lice can be identified by the widest part of the head being _____ than the widest part of the thorax.
 A. Longer C. Wider
 B. Shorter D. Narrower
138. The genus and species of the liver fluke is _____.
 A. *Dicrocoelium dendriticum* C. *Paragonimus kellicotti*
 B. *Fasciola hepatica* D. *Nanophyetus salmincola*
139. The _____ technique can be used to find surface parasites of the skin.
 A. Baermann C. Impression smear
 B. Cellophane tape D. Ear smear
140. Common indications of an ear mite infestation in dogs, cats, and ferrets are _____ and _____.
 A. Scratching nose/shaking head C. Scratching ears/shaking head
 B. Running in circles/scooting D. Shaking body/scooting
141. Mallophagan lice are commonly called _____.
 A. Sucking lice C. Climbing lice
 B. Burrowing lice D. Chewing/biting lice
142. Flea eggs hatch within _____ weeks after being laid.
 A. 2 C. 4
 B. 3 D. 5
143. The egg of *Trichuris vulpis* looks like a _____.
 A. Baseball C. Football
 B. Tennis ball D. Lemon
144. The rodent tapeworm that can parasitize humans is _____.
 A. *Hymenolepis diminuta* C. *Moniezia expansa*
 B. *Dipylidium caninum* D. *Hymenolepis nana*
145. The intermediate hosts of *Taenia taeniaeformis* are _____.
 A. Rabbits and squirrels C. Chipmunks and crayfish
 B. Birds and lizards D. Rats and mice
146. Eucestoda are the _____.
 A. Lung flukes C. Liver flukes
 B. True tapeworms D. Pseudotapeworms
147. The acetabula of a true tapeworm are _____.
 A. Four suckers used for attachment C. The integument
 B. The heads D. The backward-facing hooks
148. The definitive host for *Baylisascaris procyonis* is the _____.
 A. Opossum C. Deer
 B. Rat D. Raccoon
149. The best fecal technique for viewing motile trophozoites of protozoans is the _____.
 A. Centrifugal flotation technique C. Direct wet mount technique
 B. Sedimentation technique D. Simple flotation technique
150. Larval ticks have _____ legs.
 A. 6 C. 10
 B. 8 D. 4

151. Ruminant trichostrongyle eggs have a _____.
 A. Morula of six or more cells
 B. One- to three-cell morula
 C. Two- to four-cell morula
 D. Five-cell morula
152. *Chorioptes equi* causes a horse to stamp, bite, and kick, especially _____.
 A. At night
 B. During the day
 C. In the pasture
 D. All the time
153. *Otodectes cynotis* are found using the _____ technique.
 A. Cellophane tape
 B. Baermann
 C. Ear smear
 D. Fecal smear
154. *Dicrocoelium dendriticum*, the lancet fluke, is unusual because it uses two _____.
 A. Intermediate hosts from only dry environments
 B. Intermediate hosts from only aquatic environments
 C. Mammalian intermediate hosts
 D. Vegetative intermediate hosts
155. The skin scraping is performed with a stainless-steel spatula or a _____.
 A. No. 10 scalpel blade
 B. No. 11 scalpel blade
 C. No. 15 scalpel blade
 D. No. 25 scalpel blade
156. The definitive host of *Echinococcus granulosus* is the _____.
 A. Equine
 B. Canine
 C. Feline
 D. Ovine
157. The coccidia of swine is _____.
 A. *Cystoisospora suis*
 B. *Giardia* species
 C. *Eimeria zuernii*
 D. *Cystoisospora ohioensis*
158. The screwworm, *Cochliomyia hominivorax*, is a reportable parasite to state and federal agencies. It is the _____ larval stage that veterinary professionals must be able to identify.
 A. First
 B. Second
 C. Third
 D. Fourth
159. The preferred solution for the fecal sedimentation technique is _____.
 A. Zinc sulfate solution
 B. Sodium nitrate solution
 C. Sheather's solution
 D. Water
160. The tick most commonly associated with Lyme disease is _____.
 A. *Ixodes scapularis*
 B. *Dermacentor variabilis*
 C. *Rhipicephalus sanguineus*
 D. *Amblyomma americanum*
161. The best diagnostic test for trematode eggs is _____.
 A. Fecal centrifugation
 B. Direct blood smear
 C. Fecal sedimentation
 D. Biopsy
162. Complete flea control involves killing adults and _____.
 A. Killing pupae
 B. Killing larvae
 C. Killing eggs
 D. Regulating insect growth
163. The _____ trematodes are usually endoparasites of domestic and wild animals.
 A. Monogenetic
 B. Digenetic
 C. Trigenetic
 D. Quadrigenic
164. *Cysticercus cellulose*, found in pigs, is the metacystode stage of the human tapeworm _____.
 A. *Taenia solium*
 B. *Taenia saginata*
 C. *Taenia pisiformis*
 D. *Taenia multiceps*
165. Fecal sedimentation is used to find eggs or oocysts that are _____.
 A. Too long for the flotation techniques
 B. Too heavy for the flotation techniques
 C. Too small for the flotation techniques
 D. Too old for the flotation techniques
166. The primary flea control method to prevent infestation from starting is used on the _____.
 A. Yard
 B. House
 C. Pet
 D. Bedding

167. *Spirometra* species and *Diphyllobothrium latum* eggs differ from true tapeworm eggs by _____.
 A. Having 12 hooked hexacanth embryos
 B. Having 10 hooked hexacanth embryos
 C. Having 8 hooked hexacanth embryos
 D. Looking like fluke eggs
168. Canine heartworm disease is identified with _____.
 A. ELISA tests and microfilaria tests
 B. Exam and symptoms
 C. Microfilaria tests alone
 D. X-rays alone
169. The centrifugation technique can be used to identify the eggs of lungworms in feces and _____.
 A. Urine
 B. Sputum/tracheal wash
 C. Blood
 D. Nasal discharge
170. *Dirofilaria immitis* is the _____.
 A. Whipworm
 B. Hookworm
 C. Roundworm
 D. Heartworm
171. *Fasciola hepatica* causes _____.
 A. "Liver rot"
 B. "Kidney rot"
 C. "Lung rot"
 D. "Brain rot"
172. Proper flea control includes products used on _____.
 A. The garden only
 B. The house
 C. The bedding only
 D. All of the above
173. The adult *Anoplocephala perfoliata* tapeworm is identified by its prominent _____.
 A. Size
 B. Lappets
 C. Pyriform apparatus
 D. Tegument
174. *Enterobius vermicularis*, the human pinworm, can infect _____.
 A. Humans only
 B. Humans and dogs
 C. Humans and cats
 D. Humans and any animal
175. *Oesophagostomum dentatum* adults are found in the pig's _____.
 A. Heart
 B. Lungs
 C. Esophagus
 D. Large intestine
176. The nematode that may be found free in the abdomen of ruminants during abdominal surgery is _____.
 A. *Setaria cervi*
 B. *Trichostrongylus* species
 C. *Trichuris ovis*
 D. *Thelazia rhodesii*
177. The preferred diagnostic test for *Paragonimus kellicotti* eggs is _____.
 A. Fecal flotation
 B. Fecal centrifugation
 C. Fecal sedimentation
 D. Fecal direct wet mount
178. When fleas are found on a dog or cat, the veterinary professional should also think of a _____.
 A. Roundworm infection
 B. Tapeworm infection
 C. Whipworm infection
 D. Heartworm infection
179. A tapeworm that lacks a rostellum is said to be _____.
 A. An unarmed tapeworm
 B. A Cotyloda
 C. An armed tapeworm
 D. A mature tapeworm
180. The first intermediate host for *Paragonimus kellicotti* is a(n) _____.
 A. Tadpole
 B. Operculated snail
 C. Frog
 D. Salamander
181. The roundworm of pigs is _____.
 A. *Oesophagostomum dentatum*
 B. *Ascaris suum*
 C. *Strongyloides ransomi*
 D. *Trichuris suis*
182. *Cystoisospora* species is identified by _____.
 A. Fecal sedimentation
 B. ELISA testing
 C. Visual inspection of feces
 D. Fecal centrifugal flotation

183. The least effective test for finding *Dirofilaria immitis* is the _____.
 A. ELISA test C. Buffy coat test
 B. Knott's test D. Direct smear
184. Eggs of *Paragonimus kellicotti* are _____.
 A. Yellowish brown C. Reddish brown
 B. Dark brown D. Unoperculated
185. *Toxocara canis* and *Toxocara cati* have eggs described as having a deeply pigmented center, spherical, unembryonated, and a _____.
 A. Six-cell morula C. Smooth outer shell
 B. Hexacanth embryo D. Rough, pitted outer shell
186. *Sarcoptes scabiei* variety *canis* is transmitted by _____.
 A. Airborne transmission C. Intermediate host
 B. Direct contact D. Contaminated water
187. *Giardia* trophozoites have a distinctive pair of adhesive discs that appear to look like _____.
 A. Eyes C. A mouth
 B. A proboscis D. Four flagella
188. The canine piroplasm is _____.
 A. *Cystoisospora canis* C. *Babesia canis*
 B. *Giardia* Assemblage A D. *Hepatozoon canis*
189. *Cheyletiella parasitivorax* is commonly called _____.
 A. Demodectic mange C. Walking dandruff
 B. Sarcoptic mange D. Ear mites
190. *Babesia canis* can be identified by its _____ shape in blood smears.
 A. Rectangular C. Pear
 B. Ovoid D. Apricot
191. The leech of medical importance is _____.
 A. *Linguatula serrata* C. *Haemaphysalis leporispalustris*
 B. *Hirudo medicinalis* D. *Argas persicus*
192. The most common flea seen in small animal medicine is _____.
 A. *Ctenocephalides felis* C. *Cediopsylla simplex*
 B. *Ctenocephalides canis* D. *Echidnophaga gallinacea*
193. When processing a fecal sample, the first and most important thing to do is _____.
 A. Perform the sedimentation technique C. Make sure the sample is properly labeled
 B. Perform a Baermann technique D. Record the results
194. The most commonly encountered life cycle stage of the flea in the veterinary office is _____.
 A. Adult stage C. Larval stage
 B. Egg stage D. Pupal stage
195. The eggs of *Trichuris vulpis* have a thick, yellow-brown color with _____.
 A. Asymmetric plugs C. An operculum
 B. Bipolar plugs D. A hexacanth embryo
196. Which of the following is *not* a hallmark symptom of canine heartworm disease?
 A. Exercise intolerance C. Abdominal ascites
 B. Right-side heart enlargement D. Uncontrolled bleeding
197. The pupal stage is the _____ of the flea.
 A. Larval stage C. Young adult stage
 B. Cocoon stage D. Most sensitive stage to insecticide
198. Fleas are said by clients to fly because they _____.
 A. Have wings C. Jump with powerful back legs
 B. Have strong front legs D. Are thrown by other parasites

199. *Giardia* oocysts have a refractile wall, are oval, and have _____.
 A. One nucleus C. Four nuclei
 B. Two nuclei D. Eight nuclei
200. The only definitive host that can produce oocysts of *Toxoplasma gondii* is the _____.
 A. Canine C. Equine
 B. Feline D. Bovine
201. The *Demodex* species of mites are in the group of _____.
 A. Sarcoptiform mites C. Argasid mites
 B. Nonsarcoptiform mites D. *Psoroptidae*
202. The nymphal and adult ticks have _____ legs.
 A. 6 C. 10
 B. 8 D. 4
203. *Demodex* species are considered _____.
 A. Reportable C. Zoonotic
 B. Normal body flora D. Highly contagious
204. Protozoans that move with flagella belong in subphylum _____.
 A. *Mastigophora* C. *Sarcodina*
 B. *Ciliophora* D. *Apicomplexa*
205. *Diocotophyma renale* and *Stephanurus dentatus* can be found using _____.
 A. Fecal sedimentation C. Urine sediment
 B. Fecal flotation D. Skin scraping
206. Gross examination of fecal samples includes _____.
 A. Examination of slides C. Smelling sample
 B. Tasting sample D. Visual examination for parasites
207. The most important parasites that belongs to order *Siphonaptera* are _____.
 A. Ticks C. Lice
 B. Fleas D. Mites
208. *Psoroptes* species in large animals are highly contagious and need to be _____.
 A. Handled carefully C. Reported to state and federal agencies
 B. Treated with soap and water D. Left alone
209. Trichinosis is a disease of humans acquired from _____.
 A. Cattle C. Cats
 B. Dogs D. Pigs
210. A mite infestation is called _____.
 A. Acariasis C. Myiasis
 B. Pediculosis D. Dermatitis
211. Although *Eimeria leuckarti* can be identified with fecal flotation techniques, it can also be identified using _____.
 A. Fecal sedimentation C. Fecal direct wet mount
 B. Baermann technique D. Fecal cytology
212. *Phlebotomus* species sand flies can transmit the zoonotic disease known as _____.
 A. Chagas disease C. Summer dermatitis
 B. Lyme disease D. Leishmaniasis
213. *Ixodes scapularis* is commonly called the _____.
 A. American dog tick C. Brown dog tick
 B. Deer tick D. Texas cattle fever tick
214. Lice are transmitted by _____.
 A. The fly intermediate host C. The mosquito intermediate host
 B. The tick intermediate host D. Direct contact

215. Members of the *Psoroptidae* family of sarcoptiform mites _____.
 A. Burrow into the epidermis
 B. Live on the hair shafts
 C. Live on the surface of the skin only
 D. Live on the toenails only
216. *Demodex* species cause demodicosis when they _____.
 A. Proliferate
 B. Are transmitted by fleas
 C. Are transmitted by ticks
 D. Are in their adult form
217. *Sarcocystis neurona* is transmitted by the ingestion of infective feces from a(n) _____.
 A. Raccoon
 B. Deer
 C. Groundhog
 D. Opossum
218. The protozoans that move with pseudopodia belong in the phylum Sarcomastigophora, superclass _____.
 A. Mastigophora
 B. Sarcodina
 C. Ciliophora
 D. Apicomplexa
219. The flea life cycle stage that feeds on "flea dirt" is the _____.
 A. Egg stage
 B. Larval stage
 C. Pupal stage
 D. Adult stage
220. The equine coccidian is _____.
 A. *Eimeria bovis*
 B. *Eimeria zuernii*
 C. *Eimeria leuckarti*
 D. *Klossiella equi*
221. The *Demodex* species is identified by the _____.
 A. Cellophane tape technique
 B. Skin scraping technique
 C. Sedimentation technique
 D. Flotation technique
222. *Dirofilaria immitis* must be differentiated from _____ in any microscopic examination of blood.
 A. *Trypanosoma cruzi*
 B. *Acanthocheilonema reconditum*
 C. *Babesia canis*
 D. *Cytauxzoon felis*
223. A periodic parasite is a parasite that _____.
 A. Uses a host for feeding only
 B. Uses a host for transport
 C. Uses a host for shelter
 D. Lives free in the environment
224. The life cycle stage of *Giardia* species that can withstand environmental elements is the _____.
 A. Oocyst
 B. Trophozoite
 C. Merozoite
 D. Tachyzoite
225. The American dog tick is scientifically known as _____.
 A. *Dermacentor occidentalis*
 B. *Rhipicephalus sanguineus*
 C. *Ixodes scapularis*
 D. *Dermacentor variabilis*
226. The fly that lays eggs on horses' legs is _____.
 A. *Oestrus ovis*
 B. *Gasterophilus* species
 C. *Cochliomyia hominivorax*
 D. *Stomoxys irritans*
227. Visceral larval migrans is caused by _____.
 A. *Trichuris vulpis*
 B. *Taenia solium*
 C. *Taenia saginata*
 D. *Toxocara canis/cati*
228. The diagnostic test of choice for mite infestation is _____.
 A. Fecal flotation
 B. Cellophane tape technique
 C. Blood smear
 D. Skin scrape
229. The fly species that causes wolves or warbles is _____.
 A. *Cuterebra* species
 B. *Cochliomyia hominivorax*
 C. *Stomoxys irritans*
 D. *Musca domestica*
230. The coccidia of ruminants is caused by _____.
 A. *Cystoisospora* species
 B. *Eimeria* species
 C. *Giardia assemblages*
 D. *Cryptosporidium* species

231. The most commonly diagnosed parasites in puppies and kittens are roundworms and _____.
 A. Coccidia
 B. Hookworms
 C. *Toxoplasma gondii*
 D. Whipworms
232. Although the Baermann technique is used to identify roundworm larvae, it can also be used to identify _____ larvae.
 A. 100
 B. Whipworm
 C. *Toxoplasma*
 D. Lungworm
233. When labeling large animal fecal samples, the label should contain _____.
 A. Person who obtained the sample
 B. Farm or location of the animal
 C. Animal's color
 D. Animal's age
234. Adult fleas are _____.
 A. Ventrodorsally flattened
 B. Winged
 C. Species specific
 D. Bilaterally flattened
235. Enteric larval migrans is caused by _____.
 A. *Trichuris vulpis*
 B. *Ancylostoma caninum*
 C. *Dipylidium caninum*
 D. *Toxascaris leonina*
236. The protozoan that is a significant pathogen in humans, particularly pregnant women, is _____.
 A. *Giardia* species
 B. *Toxoplasma gondii*
 C. *Cystoisospora* species
 D. *Babesia canis*
237. Fleas in the pupal stage hatch when the ---- are right.
 A. House temperatures
 B. Outdoor signs
 C. Environmental signs
 D. Skin temperatures
238. The characteristic lesion of *Notoedres cati* is a _____ on the ears, neck, or face of the cat and occasionally the rabbit.
 A. Black discharge
 B. Green discharge
 C. Brown crusting
 D. Yellowish crusting
239. The flea life cycle stage most difficult to interrupt for treatment is the _____.
 A. Egg stage
 B. Larval stage
 C. Pupal stage
 D. Adult stage
240. Cutaneous larval migrans is caused by _____.
 A. *Trichuris vulpis*
 B. *Dipylidium caninum*
 C. *Ancylostoma caninum*
 D. *Toxocara cati*
241. The protozoan commonly called *coccidia* is from the phylum _____.
 A. Sarcomastigophora
 B. Ciliophora
 C. Mastigophora
 D. Apicomplexa
242. The rabbit ear mite is _____.
 A. *Chorioptes equi*
 B. *Psoroptes cuniculi*
 C. *Otodectes cynotis*
 D. *Chorioptes caprae*
243. The intermediate host for *Toxoplasma gondii* is or are _____.
 A. Many warm-blooded animals
 B. Humans only
 C. Dogs and humans
 D. Invertebrates
244. *Babesia canis* is identified by finding the parasite _____.
 A. Within red blood cells
 B. Within white blood cells
 C. Freely between cells in the blood
 D. In feces
245. The smallest fluke of domesticated animals is _____.
 A. *Paragonimus kellicotti*
 B. *Fascioloides magna*
 C. *Nanophyetus salmincola*
 D. *Heterobilharzia americana*

Answers for VTNE Practice Questions

1. A	33. A	65. D	97. D	129. C	161. C
2. D	34. D	66. C	98. A	130. C	162. D
3. B	35. D	67. C	99. D	131. C	163. B
4. C	36. D	68. C	100. A	132. B	164. A
5. D	37. D	69. C	101. C	133. D	165. B
6. B	38. B	70. D	102. C	134. B	166. A
7. B	39. B	71. D	103. D	135. C	167. D
8. C	40. B	72. D	104. D	136. A	168. A
9. B	41. A	73. A	105. A	137. C	169. B
10. D	42. A	74. D	106. A	138. B	170. D
11. D	43. B	75. A	107. D	139. B	171. A
12. D	44. B	76. B	108. B	140. C	172. B
13. A	45. B	77. C	109. A	141. D	173. B
14. C	46. B	78. A	110. D	142. A	174. A
15. A	47. C	79. C	111. D	143. C	175. D
16. C	48. A	80. A	112. D	144. D	176. A
17. B	49. A	81. A	113. D	145. D	177. C
18. C	50. C	82. C	114. B	146. B	178. B
19. D	51. C	83. D	115. D	147. A	179. C
20. A	52. B	84. C	116. D	148. D	180. B
21. C	53. B	85. B	117. C	149. C	181. B
22. B	54. B	86. A	118. B	150. A	182. D
23. D	55. C	87. C	119. A	151. A	183. D
24. D	56. A	88. C	120. C	152. A	184. A
25. B	57. A	89. B	121. A	153. C	185. D
26. B	58. B	90. A	122. A	154. A	186. B
27. B	59. D	91. B	123. C	155. A	187. A
28. C	60. B	92. D	124. D	156. C	188. C
29. C	61. C	93. C	125. A	157. A	189. C
30. D	62. D	94. C	126. C	158. C	190. C
31. B	63. B	95. C	127. A	159. D	191. B
32. B	64. A	96. A	128. C	160. A	192. A

193. C	212. D	231. A
194. A	213. B	232. D
195. B	214. D	233. B
196. D	215. C	234. D
197. B	216. A	235. B
198. C	217. D	236. B
199. C	218. B	237. C
200. B	219. B	238. D
201. B	220. C	239. C
202. B	221. B	240. C
203. B	222. B	241. D
204. A	223. A	242. B
205. C	224. A	243. A
206. D	225. D	244. C
207. B	226. B	245. C
208. C	227. D	
209. D	228. D	
210. A	229. A	
211. A	230. B	

Antiparasitic Drugs by Host Species

The following is a list of the most common antiparasitic drugs used in veterinary medicine. Some will be used for multiple parasite families and will only list the parasites that are affected in each family. Therefore one antiparasitic drug may be seen in different families. Those whose brand

name includes two or more drugs will be listed as brand name (combo) for combination drugs. All brand names are trademarked. Parasites affected are as noted in *Plumb's Veterinary Drug Handbook*.

Drug Name	Brand Name™	Host Species	Parasites Affected
Canines and Felines			
Nematodes			
Emodepside	Profender (combo)	Feline	<i>Ancylostoma tubaeforme</i> , <i>Toxocara cati</i> lungworms, <i>Troglostrongylus brevior</i> , <i>Aelurostrongylus abstrusus</i>
Eprinomectin	Centragard(R), combo	Cats	<i>Dirofilaria immitis</i> , <i>Toxocara cati</i> , <i>Ancylostoma tubaeforme</i> and <i>Ancylostoma braziliense</i>
Febantel	Drontal Plus, Vercom	Canine and Feline	<i>Ancylostoma caninum</i> , <i>Ancylostoma tubaeforme</i> , <i>Angiostrongylus vasorm</i> , <i>Toxocara canis</i> , <i>Toxocara cati</i> , <i>Trichuris vulpis</i> , <i>Uncinaria stenocephala</i> (Papich, 5e)
Fenbendazole	Panacur, Safe-Guard	Canine and Feline (off-label in feline)	<i>Ancylostoma caninum</i> , <i>Filaroides hirthi</i> , <i>Toxascaris leonina</i> , <i>Toxocara canis</i> , <i>Toxocara cati</i> , <i>Trichuris vulpis</i> , <i>Uncinaria stenocephala</i> , <i>Eucoleus aerophilus</i>
Ivermectin	Heartgard, Tri-Heart, Iverhart or Iverhart Plus or Iverhart Max Heartgard Plus (combo), Tri-Heart Plus (combo), etc. Heartgard for cats	Canine and Feline	<i>Dirofilaria immitis</i> in dogs, <i>Dirofilaria immitis</i> , <i>Ancylostoma tubaeforme</i> , and <i>Ancylostoma braziliense</i> in cats <i>Angiostrongylus vasorum</i> , <i>Eucoleus aerophilus</i>
Mebendazole		Canine and Feline (not commonly used)	<i>Toxocara canis</i> , <i>Toxocara cati</i> , <i>Toxascaris leonina</i> , <i>Ancylostoma caninum</i> , <i>Uncinaria stenocephala</i> , <i>Trichuris vulpis</i>

Drug Name	Brand Name™	Host Species	Parasites Affected
Melarsomine	Immiticide, Dironan	Canine	<i>Dirofilaria immitis</i> adults
Milbemycin	Interceptor, Sentinel (combo), Sentinel Spectrum (combo), Trifexis (combo), etc.	Canine and Feline	<i>Dirofilaria immitis</i> (canines and felines) <i>Ancylostoma caninum</i> , <i>Toxocara canis</i> , <i>Toxascaris leonina</i> , <i>Trichuris vulpis</i> in dogs, <i>Toxocara cati</i> and <i>Ancylostoma tubaeforme</i> in cats Plumb: <i>Angiostrongylus vasorum</i>
Moxidectin	Pro-Heart, Coraxis, Bravecto Plus (combo), Simpiraca Trio (combo), Advantage Multi (combo)	Canine and Feline	<i>Dirofilaria immitis</i> , <i>Ancylostoma caninum</i> , <i>Uncinaria stenocephala</i> , <i>Toxocara canis</i> , <i>Toxocara cati</i> , <i>Toxascaris leonina</i> , <i>Ancylostoma tubaeforme</i> , <i>Tricuris vulpis</i> , per Advantage Multi for Dogs, <i>Angiostrongylus vasorum</i>
Pyrantel	Virbantel, Drontal (combo), Drontal Plus (combo) Nemex, Tri-Heart Plus (combo), Heartgard Plus (combo), etc.	Canine and Feline (Drontal is labeled for cats)	<i>Toxocara canis</i> , <i>Toxocara cati</i> , <i>Toxascaris leonina</i> , <i>Ancylostoma caninum</i> , <i>Uncinaria stenocephala</i> , <i>Ancylostoma tubaeforme</i> , <i>Ancylostoma braziliense</i> , <i>Physaloptera</i> species
Selamectin	Revolution, Revolution Plus (combo)	Canine and Feline	<i>Dirofilaria immitis</i> (dogs and cats), <i>Ancylostoma tubaeforme</i> , <i>Toxocara cati</i> in cats
Cestodes			
Epsiprantel	Cestex	Canine and Feline	<i>Dipylidium caninum</i> and <i>Taenia pisiformis</i> in dogs, <i>Dipylidium caninum</i> and <i>Taenia taeniaeformis</i> in cats
Fenbendazole	Panacur, Safe-Guard	Canine	<i>Taenia pisiformis</i>
Praziquantel	Droncit, Drontal (combo), Drontal Plus (combo)	Canine and Feline	<i>Dipylidium caninum</i> , <i>Taenia pisiformis</i> , <i>Echinococcus granulosus</i> , and <i>Echinococcus Multilocularis</i> in dogs; <i>Dipylidium caninum</i> and <i>Taenia taeniaeformis</i> in cats
Mebendazole	Telmintic	Canine	<i>Taenia pisiformis</i>
Trematodes			
Fenbendazole Other drugs may be used off-label	Panacur, Safe-Guard	Canine	<i>Heterobilharzia americana</i> , <i>Paragonimus kellicoti</i>
Protozoans			
Atovaquone	Mepron	Canine and Feline	<i>Babesia gibsoni</i> in dogs, <i>Cytauxzoon felis</i> in cats
Azithromycin (Ab) (in combination with atovaquone)	Zithromax	Canine and Feline	<i>Babesia gibsoni</i> in dogs, <i>Cytauxzoon felis</i> in cats
Diminazene	Berenil	Canine and Feline	<i>Babesia</i> species and trypanosomiasis in dogs, <i>Babesia</i> species and <i>Cytauxzoon felis</i> in cats
Fenbendazole	Panacur, Safe-Guard	Canine and Feline	<i>Giardia</i> spp
Imidocarb dipropionate	Imizol	Canine and Feline	<i>Babesia canis</i> and <i>Hepatozoon americanum</i> (not the encysted stage) in dogs, <i>Cytauxzoon felis</i> in cats
Metronidazole	Flagyl	Canine and Feline	<i>Giardia Assemblages C, D, and F</i> , <i>Trichomonas</i> species and <i>Balantidium coli</i>

Drug Name	Brand Name™	Host Species	Parasites Affected
Nitazoxanide	Navigator	Feline	<i>Cryptosporidium</i> species, <i>Isospora</i> (<i>Cystoisospora</i>) species, and <i>Entamoeba</i> species <i>Giardia</i> spp
Paromomycin	Humatin	Canine and Feline	<i>Cryptosporidium</i> species, <i>Leishmania</i> species, <i>Entamoeba histo</i>
Ponazuril	Marquis	Canine and Feline	<i>Cystoisospora</i> species in dogs and cats; may be useful against <i>Toxoplasma gondii</i> and <i>Neospora caninum</i> ; <i>Coccidia</i> species, <i>Eimeria</i> species, <i>Hepatozoon americanum</i>
Pyrimethamine	Daraprim, ReBalance (combo)	Canine and Feline	<i>Hepatozoon americanum</i> and <i>Neospora caninum</i> in dogs, <i>Toxoplasma gondii</i> in cats
Toltrazuril	Baycox	Canine and Feline	<i>Cystoisospora</i> species <i>Coccidia</i> spp., and <i>Eimeria</i> spp
Ectoparasites			
Afoxolaner	Nexgard	Canine	<i>Ctenocephalides felis</i> , <i>Dermacentor variabilis</i> , <i>Amblyomma americanum</i> , <i>Ixodes scapularis</i> , <i>Rhipicephalus sanguineus</i> , <i>Demodex canis</i> , <i>Sarcoptes scabiei</i> variety <i>canis</i> , Cutaneous myiasis, <i>Otodectes cynotis</i> and <i>Ctenocephalides canis</i>
Deltamethrin	Scalibor, Activyl Protector Band, Salvo™ Flea & Tick Collar for Dogs	Canine	<i>Amblyomma americanum</i> , <i>Ctenocephalides felis</i> , <i>Dermacentor variabilis</i> , <i>Ixodes pacificus</i> , <i>Ixodes scapularis</i> , mosquitoes, and <i>Rhipicephalus sanguineus</i>
Dinotefuran with pyriproxyfen	Vectra	Canine and Feline	<i>Ctenocephalides felis</i>
Dinotefuran, pyriproxyfen, and permethrin	Vectra 3D	Canine	<i>Ctenocephalides felis</i> , <i>Amblyomma americanum</i> , <i>Amblyomma maculatum</i> , biting flies, <i>Cheyletiella</i> species, <i>Dermacentor variabilis</i> , <i>Ixodes pacificus</i> , <i>Ixodes scapularis</i> , <i>Linognathus setosus</i> , mosquitoes, <i>Phlebotomas papatasi</i> , <i>Rhipicephalus sanguineus</i> , and <i>Trichodectes canis</i>
Fipronil	Frontline, EasySpot	Canine and Feline	<i>Amblyomma americanum</i> , <i>Ctenocephalides felis</i> , <i>Dermacentor variabilis</i> , <i>Felicola subrostratus</i> (in cats)
Fipronil and (S)-methoprene	Frontline Plus, EctoAdvance Plus	Canine and Feline	<i>Amblyomma americanum</i> , <i>Ctenocephalides felis</i> , <i>Dermacentor variabilis</i> , <i>Ixodes scapularis</i> , <i>Rhipicephalus sanguineus</i> in dogs and cats; <i>Sarcoptes scabiei</i> variety <i>canis</i> , <i>Trichodectes canis</i> in dogs
Fipronil, permethrin, (S)-methoprene, and pyriproxyfen	Frontline Gold, Frontline Shield	Canine and Feline	<i>Amblyomma americanum</i> , <i>Ctenocephalides felis</i> , <i>Dermacentor variabilis</i> , <i>Ixodes scapularis</i> , and <i>Rhipicephalus sanguineus</i> in dogs and cats; <i>Felicola subrostratus</i> in cats; <i>Sarcoptes scabiei</i> variety <i>canis</i> and <i>Trichodectes canis</i> in dogs
Fluralaner	Bravecto Chewable for Dogs, Bravecto Topical, Bravecto Multi (combo)	Canine and Feline	<i>Ctenocephalides felis</i> , <i>Ixodes scapularis</i> , <i>Dermacentor variabilis</i> , <i>Rhipicephalus sanguineus</i> , <i>Amblyomma americanum</i> , <i>Demodex canis</i> <i>Sarcoptes scabiei</i> , <i>Otodectes cynotis</i>

Drug Name	Brand Name™	Host Species	Parasites Affected
Imidacloprid	Advantage, Defense Care	Canine and Feline	<i>Ctenocephalides felis</i>
Imidacloprid and pyriproxyfen	Advantage II	Canine and Feline	<i>Ctenocephalides felis</i> in dogs and cats; <i>Trichodectes canis</i> in dogs
Combination of Imidacloprid, pyriproxyfen and permethrin	K9 Advantix II(R)	Canine	<i>Ctenocephalides felis</i> , <i>Ixodes scapularis</i> , <i>Dermacentor variabilis</i> , <i>Rhipicephalus sanguineus</i> , <i>Amblyomma americanum</i>
Imidacloprid and moxidectin	Advantage Multi	Canine and Feline	<i>Ctenocephalides felis</i> , <i>Otodectes cynotis</i> in cats; <i>Ctenocephalides felis</i> , <i>Sarcoptes scabiei</i> variety <i>canis</i> in dogs
Imidacloprid and flumethrin	Seresto Collar	Canine and Feline	<i>Ctenocephalides felis</i> , <i>Amblyomma americanum</i> , <i>Dermacentor variabilis</i> , <i>Ixodes scapularis</i> , and <i>Rhipicephalus sanguineus</i> in dogs and cats; <i>Ixodes pacificus</i> , <i>Sarcoptes scabiei</i> variety <i>canis</i> , <i>Trichodectes canis</i> in dogs
Indoxacarb	Activyl Topical	Canine and Feline	<i>Ctenocephalides felis</i>
Indoxacarb and permethrin	Activyl Tick Plus	Canine	<i>Ctenocephalides felis</i> , <i>Amblyomma americanum</i> , <i>Dermacentor variabilis</i> , <i>Ixodes scapularis</i> , and <i>Rhipicephalus sanguineus</i>
Lotilaner	Credelio	Canine and Feline	<i>Ctenocephalides felis</i> , <i>Dermacentor variabilis</i> , <i>Ixodes scapularis</i> , <i>Amblyomma americanum</i> , <i>Rhipicephalus sanguineus</i>
Lufenuron	Program, Sentinel, and Sentinel Spectrum	Canine	<i>Ctenocephalides felis</i> growth regulation
Lufenuron	Injectable	Feline	<i>Ctenocephalides felis</i>
Nitenpyram	Capstar	Canine and Feline	<i>Ctenocephalides felis</i> , <i>Cutaneous myiasis</i>
Pyrethrins	Many OTC products. Note that permethrin is toxic to cats.	Canine and Feline	Fleas and ticks
Sarolaner	Simparica, Simparica TRIO for dogs; Revolution Plus for cats	Canine and Feline	<i>Ctenocephalides felis</i> , <i>Amblyomma caninum</i> , <i>Amblyomma maculatum</i> , <i>Dermacentor variabilis</i> , <i>Ixodes scapularis</i> , <i>Rhipicephalus sanguineus</i> Dogs: <i>Demodex</i> species, <i>Sarcoptes mange</i> , <i>Otodectes cynotis</i> Cats: <i>Otodemodex</i>
Selamectin	Revolution for dogs and cats; Revolution Plus for cats; Paradyme	Canine and Feline	<i>Ctenocephalides felis</i> , <i>Otodectes cynotis</i> , <i>Sarcoptes scabiei</i> , and <i>Dermacentor variabilis</i>
Spinetoram	Cheristin	Feline	<i>Ctenocephalides felis</i>
Spinosad	Comfortis and Trifexis for dogs	Canine and Feline	<i>Ctenocephalides felis</i> , <i>Cutaneous myiasis</i>

Drug Name	Brand Name™	Host Species	Parasites Affected
Ruminants			
Nematodes			
Albendazole	Albenza and Valbazen	Bovine and Ovine	<i>Fasciola hepatica</i> in goats, <i>Ostertagia ostertagi</i> , <i>Haemonchus</i> species, <i>Trichostrongylus</i> species, <i>Nematodirus</i> species, <i>Cooperia</i> species, <i>Bunostomum phlebotomum</i> , <i>Oesophagostomum</i> species, and <i>Dictyocaulus viviparus</i> in bovines; <i>Ostertagia circumcincta</i> , <i>Marshallagia marshalli</i> , <i>Haemonchus contortus</i> , <i>Trichostrongylus</i> species, <i>Nematodirus</i> species, <i>Cooperia</i> species, <i>Oesophagostomum</i> species, <i>Chabertia ovina</i> , and <i>Dictyocaulus filaria</i> in ovines
Doramectin	Dectomax	Bovine	<i>Ostertagia ostertagi</i> , <i>Ostertagia lyrata</i> , <i>Haemonchus placei</i> , <i>Trichostrongylus axei</i> , <i>Trichostrongylus colubriformis</i> , <i>Trichostrongylus longispicularis</i> , <i>Cooperia oncophora</i> , <i>Cooperia pectinata</i> , <i>Cooperia punctata</i> , <i>Cooperia surnabada</i> , <i>Bunostomum phlebotomum</i> , <i>Strongyloides papillosus</i> , <i>Oesophagostomum radiatum</i> , <i>Trichuris</i> species, <i>Dictyocaulus viviparus</i> , and <i>Thelazia</i> species
Eprinomectin	Eprinex, LongRange, and Eprizero	Bovine and Caprine	<i>Haemonchus placei</i> , <i>Ostertagia ostertagi</i> , <i>Trichostrongylus axei</i> , <i>Trichostrongylus colubriformis</i> , <i>Trichostrongylus longispicularis</i> , <i>Cooperia oncophora</i> , <i>Cooperia punctata</i> , <i>Cooperia surnabada</i> , <i>Nematodirus helvetianus</i> , <i>Oesophagostomum radiatum</i> , <i>Bunostomum phlebotomum</i> , <i>Strongyloides papillosus</i> , <i>Trichuris</i> species, and <i>Dictyocaulus viviparus</i> in bovines; <i>Dictyocaulus filaria</i> , <i>Haemonchus contortus</i> , <i>Teladorsagia circumcincta</i> (pinnata/trifurcata), <i>Trichostrongylus axei</i> , <i>T. colubriformis</i> , <i>Cooperia curticei</i> , <i>Nematodirus battus</i> , and <i>Oesophagostomum venulosum</i> in goats.
Fenbendazole	Panacur and Safe-Guard	Bovine and Caprine	<i>Haemonchus contortus</i> , <i>Ostertagia ostertagi</i> , <i>Trichostrongylus axei</i> , <i>Bunostomum phlebotomum</i> , <i>Nematodirus helvetianus</i> , <i>Cooperia</i> species <i>Trichostrongylus colubriformis</i> , <i>Oesophagostomum radiatum</i> , and <i>Dictyocaulus viviparus</i> in bovines; <i>Haemonchus contortus</i> and <i>Teladorsagia circumcincta</i> in nonlactating caprines <i>Haemonchus contortus</i> , <i>H. Placei</i> , <i>Ostertagia ostertagi</i> , in bovines
Ivermectin	Ivomec	Bovine and Ovine	<i>Haemonchus contortus</i> , <i>Ostertagia circumcincta</i> , <i>Trichostrongylus axei</i> , <i>T. colubriformis</i> , <i>Cooperia curticei</i> , <i>Nematodirus spathiger</i> , <i>N. battus</i> , <i>Haemonchus placei</i> , <i>Cooperia oncophora</i> , <i>Strongyloides papillosus</i> , <i>Oesophagostomum venulosum</i> , <i>Trichuris ovis</i> , <i>Chabertia ovina</i> , <i>Oesophagostomum columbianum</i> , <i>Dictyocaulus filaria</i> , and all larval stages of <i>Oestrus ovis</i> .

Drug Name	Brand Name™	Host Species	Parasites Affected
Levamisole	LevaMed and Tramisol	Bovine, Ovine, and Caprine	<i>Haemonchus</i> species, <i>Trichostrongylus</i> species, <i>Teladorsagia</i> species, <i>Ostertagia</i> species, <i>Cooperia</i> species, <i>Nematodirus</i> species, <i>Bunostomum</i> species, <i>Oesophagostomum</i> species, <i>Chabertia</i> species, and <i>Dictyocaulus</i> species
Morantel	Rumatel	Bovine and Caprine	<i>Haemonchus</i> species, <i>Ostertagia</i> species, <i>Trichostrongylus</i> species, <i>Nematodirus</i> species, <i>Cooperia</i> species, and <i>Oesophagostomum</i> species in bovines; <i>Haemonchus contortus</i> , <i>Teladorsagia circumcincta</i> , and <i>Trichostrongylus axei</i> in caprines
Moxidectin	Cyductin	Bovine and Ovine	<i>Ostertagia ostertagi</i> , <i>Haemonchus placei</i> , <i>Trichostrongylus axei</i> , <i>Trichostrongylus colubriformis</i> , <i>Cooperia oncophora</i> , <i>Cooperia pectinata</i> , <i>Cooperia punctata</i> , <i>Cooperia spatulata</i> , <i>Cooperia surnabada</i> , <i>Bunostomum phlebotomum</i> , <i>Oesophagostomum radiatum</i> , <i>Nematodirus helvetianus</i> , <i>Trichuris</i> species, <i>Dictyocaulus viviparus</i> in bovines; <i>Haemonchus contortus</i> , <i>Teladorsagia circumcincta</i> , <i>Teladorsagia trifurcata</i> , <i>Trichostrongylus colubriformis</i> , <i>Trichostrongylus axei</i> , <i>Trichostrongylus vitrinus</i> , <i>Cooperia curticei</i> , <i>Cooperia oncophora</i> , <i>Oesophagostomum columbianum</i> , <i>Oesophagostomum venulosum</i> , <i>Nematodirus battus</i> , <i>Nematodirus filicollis</i> , and <i>Nematodirus spathiger</i> in ovines
Oxfendazole	Synanthic	Bovine	<i>Dictyocaulus viviparus</i> (adult, L4), <i>Haemonchus contortus</i> (adult), <i>Haemonchus placei</i> (Adult), <i>Trichostrongylus axei</i> (adult), <i>Ostertagia ostertagi</i> (adult, L4, inhibited L4), <i>Oesophagostomum radiatum</i> (adult), <i>Bunostomum phlebotomum</i> (adult), <i>Cooperia punctata</i> (adult, L4); <i>Cooperia oncophora</i> (adult, L4), <i>Cooperia surnabada</i> (adult, L4)
Cestodes			
Albendazole	Albenza and Valbazen	Bovine and Ovine	<i>Moniezia</i> species in bovines <i>Moniezia expansa</i> and <i>Thysanosoma actinoides</i> in bovines
Fenbendazole	Panacur and Safe-Guard	Bovine	<i>Moniezia</i> species in beef cattle only
Oxfendazole	Synanthic	Bovine	<i>Moniezia benedeni</i> (adult)
Trematodes			
Albendazole	Albenza and Valbazen	Bovine, Ovine, and Caprine	<i>Fasciola hepatica</i> in bovines; <i>Fasciola hepatica</i> and <i>Fascioloides magna</i> in ovines; <i>Fasciola hepatica</i> in nonlactating caprines
Clorsulon/ ivermectin	Ivomec Plus	Bovine	<i>Fasciola hepatica</i>

Drug Name	Brand Name™	Host Species	Parasites Affected
Protozoans			
Amprolium	Corid	Bovine	<i>Eimeria bovis</i> and <i>zurnii</i>
Decoquinate	Deccox	Bovine, Ovine, and Caprine	<i>Eimeria</i> species
Ectoparasites			
Doramectin	Dectomax	Bovine	Parasitic stages of grubs, <i>Hypoderma bovis</i> , <i>Hypoderma lineatum</i> , <i>Haematopinus eurysternus</i> , <i>Linognathus vituli</i> , <i>Solenopotes capillatus</i> , <i>Psoroptes bovis</i> , and <i>Sarcoptes scabiei</i> ; pour on formulations: <i>Haematobia irritans</i> , <i>Chorioptes bovis</i> , and <i>Bovicola (Damalinia) bovis</i>
Eprinomectin	Eprinex, LongRange, and Eprizero	Bovine	<i>Hypoderma lineatum</i> , <i>Hypoderma bovis</i> , <i>Damalinia bovis</i> , <i>Linognathus vituli</i> , <i>Haematopinus eurysternus</i> , <i>Solenopotes capillatus</i> , <i>Chorioptes bovis</i> , <i>Sarcoptes scabiei</i> , <i>Haematobia irritans</i>
Ivermectin	Ivomec	Bovine	<i>Hypoderma bovis</i> , <i>H. lineatum</i> , <i>Sarcoptes scabiei</i> var. <i>bovis</i> , <i>Linognathus vituli</i> , <i>Haematopinus eurysternus</i> , <i>Damalinia bovis</i> , <i>Solenopotes capillatus</i> , and <i>Haematobia irritans</i>
Moxidectin	Cyductin	Bovine	<i>Hypoderma bovis</i> , <i>Hypoderma lineatum</i> , <i>Chorioptes bovis</i> , <i>Psoroptes ovis</i> , <i>Linognathus vituli</i> , <i>Haematopinus eurysternus</i> , <i>Solenopotes capillatus</i> , <i>Bovicola (Damalinia) bovis</i> , and <i>Haematobia irritans</i>
Permethrin	Many OTC products	Bovine, Ovine, and Caprine	Flies, lice, mites, mosquitoes, ticks and keds
Pyrethrins	Many OTC products	Bovine, Ovine, and Caprine	Fleas, lice, ticks, and <i>Cheyletiella</i> species
Equine			
Nematodes			
Fenbendazole	Panacur and Safe-Guard	Equine	<i>Strongylus edentatus</i> , <i>Strongylus equinus</i> , <i>Strongylus vulgaris</i> , <i>Triodontophorus</i> species, <i>Cyathostomum</i> species, <i>Cylicocyclus</i> species, <i>Cylicostephanus</i> species, <i>Cylicodontophorus</i> species, <i>Parascaris equorum</i> , and <i>Oxyuris equi</i>

Drug Name	Brand Name™	Host Species	Parasites Affected
Ivermectin	Duramectin, Equimax (combo), Bimectin, Bimectin Plus (combo) Ivermax, IverCare, Promectin E Zimecterin, Zimecterin Gold (combo)	Equine	<i>Strongylus vulgaris</i> , <i>Strongylus edentatus</i> , <i>Strongylus equinus</i> , <i>Triodontophorus</i> species, small <i>Strongyles</i> , <i>Oxyuris equi</i> , <i>Parascaris equorum</i> , <i>Trichostrongylus axei</i> , <i>Strongyloides westeri</i> , <i>Onchocerca</i> species, <i>Dictyocaulus arnfieldi</i> , oral and gastric bots, <i>Habronema</i> species, and <i>Draschia</i> species
Moxidectin	Quest and Quest Plus	Equine	<i>Strongylus vulgaris</i> , <i>Strongylus edentatus</i> , <i>Triodontophorus brevicauda</i> , <i>Triodontophorus serratus</i> , <i>Cyathostomum</i> species, <i>Cylicocyclus</i> species, <i>Cyliocostephanus</i> species, <i>Coronocylus</i> species, <i>Gyalocephalus capitatus</i> , <i>Petrovinema poculatus</i> , <i>Parascaris equorum</i> , <i>Oxyuris equi</i> , <i>Trichostrongylus axei</i> , <i>Habronema muscae</i> , <i>Gasterophilus intestinalis</i> , <i>Trichostrongylus axei</i> , and <i>Gasterophilus nasalis</i>
Oxibendazole	Anthelcide EQ	Equine	<i>Parascaris equorum</i> , <i>Strongylus edentatus</i> , <i>Strongylus equinus</i> , <i>Strongylus vulgaris</i> , small <i>Strongyles</i> , <i>Strongyloides westeri</i> , and <i>Oxyuris equi</i>
Pyrantel	Strongid	Equine	<i>Strongylus equinus</i> , <i>Strongylus vulgaris</i> , and <i>Parascaris equorum</i> ; variably effective against <i>strongylus edantatus</i> , <i>Oxyuris equi</i> , and small strongyles
Cestodes			
Praziquantel	Equimax (combo), Bimectin Plus (combo), Quest Plus (combo), Zimecterin Gold (combo)	Equine	<i>Anoplocephala perfoliata</i>
Trematodes			
None FDA approved			
Protozoans			
Diclazuril	Protazil	Equine	<i>Sarcocystis neurona</i>
Imidocarb	Imizol	Equine	<i>Babesia caballi</i> , <i>Theileria equi</i>
Ponazuril	Marquis	Equine	<i>Sarcocystis neurona</i>
Pyrimethamine and sulfadiazine	Daraprim, ReBalance (combo)	Equine	<i>Sarcocystis neurona</i>
Toltrazuril	Baycox	Equine	<i>Sarcocystis neurona</i>
Ectoparasites			
Permethrin	Many OTC Products	Equine	Flies, lice, mites, mosquitoes, ticks, and keds
Pyrethrins	Many OTC products	Equine	Fleas, lice, ticks, and <i>Cheyletiella</i> species

Drug Name	Brand Name™	Host Species	Parasites Affected
Porcine			
Nematodes			
Doramectin	Dectomax	Porcine	<i>Ascaris suum</i> , <i>Oesophagostomum dentatum</i> , <i>Oesophagostomum quadrispinolatum</i> , <i>Strongyloides ransomi</i> , <i>Hyostrogylus rubidus</i> , <i>Metastrongylus</i> species, <i>Stephanurus dentatus</i>
Fenbendazole	Panacur, Safe-Guard	Porcine	<i>Ascaris suum</i> , <i>Metastrongylus apri</i> , <i>Metastrongylus pudendotectus</i> , <i>Oesophagostomum dentatum</i> , <i>Oesophagostomum quadrispinolatum</i> , <i>Hyostrogylus rubidus</i> , <i>Trichuris suis</i> , and <i>Stephanurus dentatus</i>
Ivermectin	Vetrimec, Agri-mectin, Bimectin, Ivermax, Noromectin, Vetrimectin	Porcine	<i>Ascaris suum</i> , <i>Hyostrogylus rubidus</i> , <i>Oesophagostomum</i> species, <i>Strongyloides ransomi</i> , <i>Metastrongylus</i> species
Levamisole	LevaMed and Tramisol	Porcine	<i>Ascaris suum</i> , <i>Oesophagostomum</i> species, <i>Strongyloides</i> species, and <i>Metastrongylus</i> species
Pyrantel Tartrate	Banminth 48, Strongid 48	Porcine	<i>Ascaris suum</i> , <i>Oesophagostomum</i> species, and <i>Hyostrogylus rubidus</i>
Cestodes			
None listed			
Trematodes			
None listed			
Protozoans			
Toltrazuril	Baycox, Forceris (combo with iron)	Porcine	<i>Cystisopora suis</i>
Ectoparasites			
Doramectin	Dectomax	Porcine	<i>Sarcoptes scabiei</i> and <i>Haematopinus suis</i>
Ivermectin	Vetrimec, Agri-mectin, Bimectin, Ivermax, Noromectin, and Vetrimectin	Porcine	Lice: <i>Haematopinus suis</i> Mange Mites: <i>Sarcoptes scabiei</i> variety <i>canis</i>
Permethrin	Many products	Porcine	Flies, lice, ticks, mites, mosquitoes, ticks, and keds
Pyrethrin	Many products	Porcine	Fleas, lice, and ticks
<i>Ab</i>, Antibiotic; <i>GI</i>, gastrointestinal; <i>OTC</i>, over-the-counter. Exotic animals are typically dewormed with a number of those listed for other animals, but these are used off-label. There may be products listed for some host species that are used on other host species under which they are not listed because they are used off-label in those species. Where shown as “none listed,” there were no products approved by the U.S. Food and Drug Administration (FDA), but other listed products for other species may be currently used by veterinarians off-label or extralabel.			

Zoonotic and Discourse—Speaking or Writing Authoritatively About Parasitic Zoonoses

Introduction

One of the challenges in teaching today is that it is very difficult to make students communicate and explain the basic, important concepts that they have learned. I always tell me students, “The object of this ‘game’ in life is to make the correct veterinary words come out of ones mouths.” Nothing else could be more important in the performance of one’s duties in any veterinary clinical situation. This most important task takes on significance when one is discussing with clients the zoonotic parasites that play such an important role in health promotion and disease prevention. Basically, today’s veterinary technician must be able to explain the zoonotic significance of parasites to the public at large using the journalistic questions - “What? Who? When? Where? Why? How?” - to convey the gravity of parasitic zoonoses to the public at large. Competency boils down to effectively describing the answers to these questions.

For practice I have taken the following zoonotic conditions and their associated parasites and detailed them as if I were speaking to uninformed clients. I have used the parameters of What? Who? When? Where? Why and How? This is the manner in which all zoonotic parasites should be explained to veterinary clients.

- *Cutaneous larva migrans* and hookworms (*Ancylostoma*, *Uncinaria* species)
- Aberrant migration (wandering) of infective third stage larvae of *Dirofilaria immitis*
- Congenital toxoplasmosis and *Toxoplasma gondii*
- Scabies and *Sarcoptes scabiei*
- Dipylidiasis and *Dipylidium caninum*

Cutaneous larva migraines and hookworms (Ancylostoma, Uncinaria species)

Cutaneous larva migrans resulting from migration of third-stage larvae of *Ancylostoma caninum*, *Ancylostoma braziliense*, *Ancylostoma tubaeforme*, and *Uncinaria stenocephala* may be observed by the client. This human skin condition manifests itself as an extremely pruritic, reddened winding tract in the palms of the hand or soles of the feet of an infected human, many times a small child.

What? What type of parasite produces this zoonotic condition? *A. caninum*, *A. braziliense*, *A. tubaeforme*, and *U. stenocephala* belong to the phylum Nematoda or “roundworms”; however, these small intestinal parasites are grouped together as “hookworms.” These species are called *hookworms* because the anterior end of these adult intestinal parasites is slightly bent dorsally, producing an overall hook-like shape in the adult worms. In the dog or cat’s small intestine, adult hookworms are “vampire-like” in their feeding activities. Adult hookworms attach to the lining or mucosa of the small intestine to obtain their blood meal. Anticoagulant-like compounds are produced in mouth of the adult hookworms. These compounds prevent the cat or dog host’s blood from clotting as the worms feed. Hookworms are also known to change their feeding sites, and as a result of the anticoagulant, the former attachment sites will continue to bleed after worm reattachment to a new site. Blood loss can be very dramatic.

Larval hookworms are associated with a zoonotic skin condition in human beings. The scientific term for this skin condition is *cutaneous larva migrans*. The common names or colloquial terms for this condition in humans include

creeping eruption, dermal larval migrans, ground itch, plumber's itch, and sandworms. Other terms may vary in other different geographic areas around the world.

Who? Who is most likely to become infected with this zoonotic condition known as *cutaneous larva migrans* (CLM)? Anyone who comes in close body contact of their bare skin with infective third-stage larvae of hookworms (the most common larval species to produce CLM is the larva of *A. braziliense*) may become infected. These larvae are usually found in moist, sandy soil. These larval hookworms are capable of penetrating human skin and migrating short distances in the top superficial layers of the skin. The tracts produced by these migrating larvae are winding and tortuous tunnels. These tracts can be seen in people of all ages and in occupations where people contact moist, damp, sandy soil.

When? When does this zoonotic condition occur? CLM occurs when dogs and cats are infected with adult hookworms in the small intestine. Male and female hookworms breed, and the females produce eggs that pass to the outside environment within the host's feces. If the feces are not removed from the outdoor environment, the eggs will embryonate, hatch, and release first-stage larval hookworms. These first-stage larvae eventually develop into third-stage infective larvae that are capable of penetrating the skin of the canine or feline host to continue the infection. However, if these third-stage larvae penetrate the skin of a human being, such as a small child, the larvae will migrate within the superficial layers of the skin (the epidermis), producing inflamed, reddened tunnels or tracts within the skin. The time of year associated with CLM is the warm summer months when the weather is more suitable and individuals are outdoors without their shoes on.

Where? In which location(s) is this zoonotic condition most likely to occur? Within the human host, the places on the human body that are usually involved with this zoonotic infection are the soles of the feet. However, any area of bare skin, such as the buttocks, the back, or the palms of the hands, that comes in contact with infective third-stage larvae in moist, sandy soil is subject to penetration of hookworm larvae. There are also three physical locations associated with CLM in human beings. These are (1) sandboxes; (2) beaches where untreated dogs are allowed to run freely up and down the beach, defecating as they roam; and (3) occupational areas such as garden beds and moist areas in crawl spaces under any building, usually someone's home. Young children and adults who go barefooted in areas frequented by untreated pets or in sandboxes where children play and travelers to beaches where untreated dogs roam will often demonstrate lesions on the soles of the feet. Plumbers, electrical workers, and technicians who crawl into spaces under a house where pets may take refuge and defecate will demonstrate cutaneous

lesions around the lower arms and elbows, hence the name *plumber's itch*.

Why? Why is this zoonotic condition important? Hookworm dermatitis is characterized by blisters, red bumps, and winding red tracts that appear a few days after larval penetration. The migration of these larvae in the skin causes intense itching (pruritus) in the human incidental host. Migrating larvae eventually die and never reach the human's small intestine. This zoonotic condition becomes very important to individuals who have spent lots of money on an exotic beach vacation only to come down with this extremely uncomfortable skin condition during an expensive trip.

How? How is this zoonotic condition diagnosed in infected individuals? CLM is diagnosed by a history of a human host coming in contact with infective larvae in moist soil. The itching only lasts for a few days to a couple of weeks. Veterinarians and veterinary technicians are capable of observing such skin lesions on their clients but must not make a diagnosis in any human subject. Referral to a qualified dermatologist or family practitioner is the best solution. Veterinary professionals working in a veterinary clinic may discuss life cycles and pathology in domestic animals, but answering human disease-related questions would be forbidden. Veterinarians and their technicians provide the best service as public health resource specialists.

Aberrant migration of Larval *Dirofilaria immitis*

Zoonotic infection with *Dirofilaria immitis* is a result of aberrant migration (wandering) of infective third-stage larvae of *D. immitis* (canine/feline heartworm) in a human incidental (not normal) host. Heartworms are normally found in the right ventricle and pulmonary arteries of dogs and cats. In this zoonotic condition, the infected individual demonstrates an isolated mass (usually an opacity or "cloudiness" or density within the human lung field). This lesion is usually found during routine radiographic examination. After surgery and biopsy of the infected tissue, histopathologic examination often reveals a dead/dying/live specimen of an aberrant (wandering) larval stage of *D. immitis*.

What? What type of parasite produces this zoonotic condition? *D. immitis*, the canine heartworm, belongs to the phylum Nematoda, or "roundworms." Heartworms belong to a family of parasites called *filarial parasites*. Adult heartworms are usually found within the blood vasculature of the canine definitive host. Heartworms can also be found in cats; however, the dog is considered to be the true definitive host for these parasites. Heartworms produce

offspring called *microfilariae* that are found circulating in the peripheral blood of the canine definitive host. As an aside, cats rarely demonstrate *microfilariae* circulating in their peripheral blood. Because the dog demonstrates circulating *microfilariae* in its blood, the dog is said to be *microfilaremic*. As filarial parasites, heartworms require a blood-feeding intermediate host to transmit heartworm infection. The female mosquito serves as a means of transmitting heartworm from an infected host to an uninfected host. *Microfilariae* are ingested by the blood-feeding female mosquito, and the *microfilariae* develop to the infective third larval stage, ultimately residing within the female mosquito's mouthparts. When this infected female mosquito feeds on an uninfected host, the infective larvae emerge from the mosquito's mouthparts and then migrate over a 6-month period to finally reach and mature in the right ventricle and pulmonary arteries of the newly infected canine host.

Who? Who is most likely to become infected with this zoonotic condition? Most mosquitoes are found in outdoor areas close to still (not rushing) bodies of water. Still waters are often associated with the life cycle of most mosquitoes. Usually, human beings become infected by being outdoors—where large numbers of female mosquitoes live and thrive. Zoonotic infection in humans occurs when an infected mosquito feeds on a human incidental host. Instead of migrating to the right ventricle and pulmonary artery of the dog, the larvae stray off-course and end up “lost” within lung tissue. These isolated larvae do not grow to the adult stage but instead produce a soft tissue nodule within the lung tissue. As a result of this being the case of a lost immature larval stage, the human does not demonstrate circulating *microfilariae* in the peripheral blood.

When? When does this zoonotic condition occur? Incidental parasitism of a human host usually occurs in individuals who either work or relax in outdoor environments infested with large numbers of mosquitoes. It is also important to understand that it may only take one infected female mosquito to infect a dog or human. Human infection occurs when an infected mosquito feeds on a human host. This feeding process may take place at any time during the day or night. Different species of mosquitoes feed at different times during the 24-hour day. Some species feed during the night. Some species of mosquitoes prefer to feed at dawn and at dusk. During periods of sunrise and sunset, the numbers of *microfilariae* circulating in the dog's blood are at moderate levels—not too high and not too low. Ingesting too many *microfilariae* during a blood meal may ultimately kill the mosquito. Ingesting too few *microfilariae* during a blood meal may ultimately not be enough *microfilarial* numbers to complete transmission in the dog. Moderate levels of *microfilariae* (like those at dawn and dusk) may prove to be the best levels for transmission of the parasite from host to host.

Where? In which location(s) is this zoonotic condition most likely to occur? Transmission may occur in any locality that will promote the development of mosquitoes throughout the world—primarily in tropical and subtropical areas. The key to the locale is the presence of blood-feeding female mosquitoes. As a result of the mobility of individuals of the twenty-first-century society and their pets (through living in or short-term visits to these mosquito-infested areas), practically any dog or human may be liable to becoming infected; for pets, infection can be prevented by the use of a heartworm preventative.

Why? Why is this zoonotic condition important? Zoonotic infection in humans is quite rare. It occurs when an infected mosquito feeds on the human incidental host. Instead of maturing to the adult stage in the human heart, the larvae stray off course and finally end up in the lung tissue. These larvae will not mature to the adult stage in the human lung but instead induce the formation of a nodule in the lung. This nodule may be seen during routine human thoracic radiography and may be suspected to be a cancerous nodule.

How? How is this zoonotic condition diagnosed in infected individuals? The only way to confirm the nature of the nodule in the infected individual is for the patient to undergo a surgical procedure to remove the suspect nodule and submit it for biopsy to determine the nature of the lesion. When the nodule undergoes fixation in formalin and is processed for histopathologic examination, a human pathologist will make the appropriate diagnosis. Usually what is found on microscopic examination is the presence of a dead, necrotic nematode surrounded by the body's histopathologic response to the presence of the now-dead, formerly wandering immature heartworm larva.

Congenital toxoplasmosis *Toxoplasma gondii*

Toxoplasma gondii is a protozoan intestinal parasite that is found in domestic cats having access to outdoor environments. This is an important problem because the parasite might produce a clinical parasitic disease within an indoor house cat that may in turn produce a clinical disease called *congenital toxoplasmosis* in pregnant women. This zoonosis may infect the developing fetus of the pregnant woman, producing debilitating congenital anomalies in the newborn child.

What? What type of parasite produces this zoonotic condition? *T. gondii* is a protozoan parasite that is a member of the kingdom Protista, phylum Apicomplexa. This zoonotic parasite is an intestinal parasite of cats; that is, the cat is the only animal that is the true definitive host for this

protozoan and produces developmental stages that may cause harm to the fetus of a pregnant mother. The domestic cat sheds infective (fully sporulated) oocysts in its feces. When ingested by a pregnant woman, these oocysts can produce significant birth/developmental defects in a developing fetus and may result in a wide range of problems, from abortions to significant congenital anomalies.

Who? Who is most likely to become infected with this zoonotic condition? With respect to zoonotic potential, this is an extremely important parasite. This protozoan infects indoor/outdoor cats that have access to small rodents, especially ones that are found outdoors. The cat ingests tissues (such as raw meat) of the rodent and eventually, infective stages (oocysts) will be produced and ultimately are found in the cat's feces. If the sporocysts from the oocysts are ingested, the pregnant woman and her developing fetus may become infected. When *T. gondii* infects the woman's developing fetus, serious congenital anomalies, miscarriage, and even death of the fetus may occur.

When? When does this zoonotic condition occur? The domestic cat is the only animal that sheds infective (fully sporulated) oocysts in its feces. During the life cycle, infective sporulated oocysts may be found in fresh cat feces. Of particular importance is that if the family's cat is an indoor/outdoor cat, that cat has the opportunity to be outdoors and prey upon such small animals as rodents. The tissues of the rodents may contain developmental stages called *bradyzoites* in the muscles. This sets the pathogenic life cycle of *T. gondii* into motion. If the cat eats the infected rodent, infective oocysts will ultimately be found in the cat's feces. These oocysts contain stages that are dangerous to the fetus of a pregnant woman. These stages may migrate across the woman's placenta to the developing fetus and produce significant congenital anomalies and even death.

Where? In which location(s) is this zoonotic condition most likely to occur? This condition occurs wherever infected rodents and cats are found—thus, worldwide. Pregnant women must avoid contact with a cat's litter box throughout the duration of their pregnancy. The woman must always avoid contact with the fully sporulated oocyst within the cat's feces. Litter boxes should never be placed in or near a kitchen or dining area. Because feral cats often defecate in flower beds and gardens, gloves must be worn by the woman whenever she gardens. Likewise, children's sandboxes must be avoided and, better yet, covered to prevent access by cats. Handwashing must occur after household gardening or any type of outdoor exposure to suspect soil. Humans must never eat undercooked meat because slow-growing cells may also be found in animal tissues.

Why? Why is this zoonotic condition important? *T. gondii* is one of the most serious zoonotic parasites encountered in veterinary practice—the opportunity to inform the public must never be overlooked. Humans become infected in two ways: (1) congenital toxoplasmosis and (2) acquired

toxoplasmosis. In congenital toxoplasmosis, a woman becomes infected during her pregnancy by ingesting sporozoites from infective oocysts found within the feces of cats—especially cats with access to the outdoor environment or feral cats. If a pregnant woman ingests sporulated oocysts, the parasite tachyzoites may infect rapidly growing cells in the developing fetus. If this infection occurs during late pregnancy, the central nervous system may become infected, resulting in neurologic abnormalities in the child. With acquired toxoplasmosis, a human (other than a pregnant woman) ingests tachyzoites (rapidly growing stages) or bradyzoites (slowly growing stages). *T. gondii* may cause significant problems in people with AIDS. Infection with bradyzoites is less serious and is characterized by fever and slight swelling of the lymph nodes.

How? How is this zoonotic condition diagnosed in infected individuals? If sporulated oocysts are found in the feces of a cat belonging to a pregnant woman, the woman must be advised to discuss the situation with her obstetrician. The sensational press often “exploits” *T. gondii* in its headlines to alarm the general public. This parasite is frequently the subject of telephone calls from uninformed individuals who want to gain information. Uninformed clients may ask veterinarians to find homes for their cats or even euthanize them. Veterinarians and veterinary technicians must alleviate any concerns the client may have regarding infection with toxoplasmosis and make appropriate referrals for information. Veterinarians should step into disease-prevention and health-promotion roles with gynecologists and obstetricians. It is important to remember that almost any warm-blooded animal can become infected with toxoplasmosis. Suspected cases of congenital toxoplasmosis in human beings must always be managed under the expertise of a neonatologist, pediatrician, gynecologist, obstetrician, or family practitioner. Veterinarians must serve only in the capacity of resource specialists.

Scabies due to *Sarcoptes scabiei* variety *canis*

Scabies, which results from the burrowing/tunneling of canine scabies mites (*Sarcoptes scabiei* variety *canis*) in the skin of human beings, is observed most often in children. This skin condition manifests itself as isolated tiny red papules on the skin's surface that are highly pruritic.

What? What type of parasite produces this zoonotic condition? Scabies mites (*S. scabiei* variety *canis*) are members of the phylum Arthropoda, subphylum Chelicerata. Arthropods have jointed appendages (legs) as adult parasites. These are classified as chelicerates because in the

mature stages, they possess cutting/lacerating mouthparts that aid them in burrowing into the skin of dogs. If humans come into close body contact with a dog infested with these burrowing mites, the human may become infested with these microscopic mites for a short period of time. These tiny mites are found on the skin surface of the dog. The adult male and female mites mate on the skin surface, but after fertilization, the female mite tunnels into the superficial layers of the epidermis, laying eggs as she tunnels. Six-legged larvae hatch from these eggs and in turn, they tunnel back up to the skin surface. Six-legged larvae molt into eight-legged nymphs, which molt to adult male and female mites. These mites are sexually active. The adult male and female mites become sexually active in about 2 weeks; they mate, and the life cycle begins again.

Who? Who is most likely to become infected with this zoonotic condition? Infestation with canine scabies as a result of *S. scabiei* variety *canis* may be observed in humans having close skin-to-skin contact with an infested puppy. Children are frequently incidental hosts, acquiring the mite during sessions of hugging or cuddling the infested puppy. The canine scabies mites transfer from the puppy's skin to that of the young child, and the tunneling mites begin their infestation of the human.

When? When does this zoonotic condition occur? Children are frequently incidental hosts of this mite, acquiring it during sessions of hugging or cuddling the infested puppy. This infestation by mites is called **acariasis** in human beings.

Where? In which location(s) is this zoonotic condition most likely to occur? The most common locations are the areas of the body where the pet owner/child has cuddled the infested pet. Many times, the pets are strays or have been adopted from infested animal shelters. Mites move from the infested puppy to the uninfested human being. Like infestation in the dog, infestation of the human occurs in the superficial layers of the skin. The tunneling female mites lay eggs as they tunnel into the skin. The eggs hatch, and the newly hatched offspring tunnel out of the mother mite's tunnel to reach the skin surface. As mentioned, this infestation by mites is referred to as *acariasis*. To the mites, warm, naked skin is ideal for infestation. Lesions in the human are characterized by papules (red bumps) or vesicles (tiny blisters). These are characteristic lesions in an infested human, appearing on the trunk of the body, arms, legs, abdomen, and rarely on the face or genitalia. These lesions are highly pruritic because of the tunneling activity of the mites.

Why? Why is this zoonotic condition important? It is important for the client to understand that this is a zoonotic skin condition often associated with stray dogs or with dogs living in or from animal shelters. These mites are frequently associated with unclean environments. Mites are clearly capable of transferring from one infested host to a noninfested host.

How? How is this zoonotic condition diagnosed in infected individuals? These mites can be diagnosed by the signal of a history of a household member in close contact with an infested, highly pruritic dog or small puppy. Diagnosis of this mite in a veterinary diagnostic situation should result in the veterinarian giving words of caution concerning the dog's presence in a household where small children are present. Dogs should be treated with an appropriate acaricide bath/dip. Pet owners should be warned that this mite is highly transmissible from one dog in the household to others and that strict caution must be observed regarding contact with infested, highly pruritic dogs. Pet owners must ensure that children are seen by a family practitioner, pediatrician, or dermatologist.

Dipylidiasis due to *Dipylidium caninum*

Cucumber seed/double-pored tapeworm infection is observed in small children and results from *Dipylidium caninum*. Parents of small children often report the presence of tiny tapeworm segments in the feces of an infected child.

What? What type of parasite produces this zoonotic condition? *D. caninum* (also known as the *cucumber seed tapeworm* or *double-pored tapeworm*) is an armed true tapeworm of dogs and cats that produces this condition. This cestode, a true tapeworm, is commonly found in the small intestine of the family pet, especially if that pet has become infested with fleas. It can be classified as a zoonotic parasite that may be found in small children. Children infected with this tapeworm may demonstrate single or multiple proglottids in chains or individual proglottids in their stools. When they are first passed in the stool, each gravid proglottid will be capable of crawling about and waving at the observer. Each recently passed gravid proglottid will resemble a freshly prepared grain of rice or a cucumber seed (hence the common name *cucumber seed tapeworm*). When fresh, the gravid proglottid is longer than wide and possesses a lateral pore on each long side of the proglottid (hence the common name *double-pored tapeworm*). Each freshly passed, mature proglottid is filled with hundreds to thousands of egg packets. Each egg packet will contain from 20 to 30 individual tapeworm eggs. If fresh proglottids are allowed to dry in the home environment, they resemble uncooked grains of rice. These dried proglottids are often found within the bedding of the pet or within the indoor environment, often where the pet sleeps. If the eggs are eaten by a cat or dog flea, each egg will develop into a larval stage within the body of the mature flea. This larval stage is called a *cysticercoid*. Each *cysticercoid* will develop into an adult tapeworm if ingested by a child.

Each ingested cysticercoid will attach to the wall in the small intestine; the tapeworm then grows, and individual proglottids will be found in the child's stool.

Who? Who is most likely to become infected with this zoonotic condition? Children are most often infected with the double-pored tapeworm. Children become infected with these tapeworms by being around flea-infested pets containing these larval tapeworms (cysticercoids). Most infested children are younger than 8 years old.

When? When does this zoonotic condition occur? Because this parasite is transmitted by ingesting fleas, the child will usually be the only family member infected. When children become infected, they should be taken to the family practitioner or pediatrician. When this parasite is found within one cat or dog in a household with many pets, all pets in the household must be treated for adult tapeworms and for flea infestation. If children are infected, they must be seen by a human physician or family practitioner.

Where? In which location(s) is this zoonotic condition most likely to occur? The home environment (both indoor and outdoor) must be subjected to rigorous flea-control programs. This parasite is most likely to occur in a household with small children and many pets—cats, dogs, and more cats and dogs!

Why? Why is this zoonotic condition important? This is a very important parasite for veterinarians for economic reasons—it involves selling anthelmintic medication for all pets and instituting rigorous flea-control programs for the pets and the household. Because this is a zoonotic parasite, all animals must be treated for *D. caninum* tapeworm and for fleas.

How? How is this zoonotic condition diagnosed in infected individuals? Usually this parasite is diagnosed by observation of tapeworm proglottids in the child's feces. Rigorous cestidal treatment and household treatment must be instituted for effective control of this tapeworm. This is the veterinarian's primary role—to control fleas in the indoor/outdoor environment and to provide anthelmintics to treat adult tapeworms.

Glossary

A

- Aberrant parasite** Parasite that has wandered from its usual site of infection into an organ or location in which it does not ordinarily live; also called *erratic parasite*.
- Acanthella** Larval acanthocephalan within the intermediate host, where the acanthella develops into a juvenile acanthocephalan, the *cystacanth*.
- Acanthocephalan** A thorny-headed worm.
- Acanthor** Larval acanthocephalan parasite within an egg.
- Acariasis** Any infestation or infection by either mites or ticks.
- Acaricides** Chemical compounds developed to kill mites and ticks.
- Acarines** Mites and ticks.
- Accession number** A log-in number to identify a submitted biologic sample for a patient (either small or large animal). The assigned accession number identifies all parameters related to the case, especially the results of diagnostic procedures.
- Acetabulum** One of four suckers on the anterior end of a true tapeworm (*eucestode*).
- Acquired toxoplasmosis** Infection with *Toxoplasma gondii* by ingestion of sporulated oocysts or ingestion of bradyzoites from infected meat.
- Adult fluke** The sexually mature stage of a trematode. Flukes have a set of completely functioning male and female reproductive organs, making them hermaphrodites.

- Aliquot** Percentage of a solution or sample.
- Alopecia** Hair loss.
- Amastigote** Resting cyst stage of some protozoans.
- Amicrofilaremic** Referring to the absence of immature filarial parasites.
- Amphistome** Type of digenetic fluke with an oral sucker on one end and a ventral sucker on the other end.
- Annelids** Earthworms.
- Anoplurans** Members of the class Insecta, order Anoplura. This order includes the sucking lice.
- Anthelmintics** Chemical compounds developed to kill roundworms, tapeworms, flukes, and thorny-headed worms; also called *anthelminthics*.
- Antiprotozoals** Chemical compounds developed to kill protozoan organisms.
- Apicomplexan** Banana-, comma-, or boomerang shaped protozoans found in epithelial cells of the intestine, in blood cells, and in cells of the reticuloendothelial and nervous systems. Apicomplexans have complex life cycles that are intimately integrated into the physiology of the host's body. Their locomotory (movement) organelles are internal and are not grossly visible, as with other types of protozoans.
- Argasid** A family of ticks with soft bodies.
- Armed tapeworm** True tapeworm that possesses a rostellum on its anterior end.
- Arthropodology** The study of arthropods.

- Arthropods** The creatures possessing a chitinous exoskeleton and jointed legs.
- Ascariasis** Infection with ascarids, either larval or adult.
- Ascaroid** One of four egg types produced by nematodes (see Fig. 3.9 for characteristic look).
- Aseptically** Referring to the use of sterile technique.
- Axostyle** A filamentous or hyaline rod-like structure passing through the center of some flagellate protozoans that has a skeletal function.

B

- Baermann technique** Type of diagnostic technique in which nematode larvae are collected using gravity (sedimentation).
- Benzimidazoles** A family of anthelmintics that include fenbendazole, oxfendazole, and albendazole.
- Body cavity** Hollow area of the body that contains the major organs of an organism.
- Borreliosis** Lyme disease.
- Bothria** Two slit-like holdfast organs on the anterior end of a pseudotapeworm.
- Bradyzoites** Slowly multiplying stages of toxoplasmosis within the muscle of an intermediate host.
- Buccal cavity** Large opening that connects to the mouth of a nematode; connects the mouth to the esophagus.
- Bursal rays** Finger-like projections that make up the copulatory bursa of a male nematode.

C

Calcareous corpuscles Microscopic calcium deposits unique to the tissues of cestodes (tapeworms); also called *calcareous bodies*.

Cantharidin Toxic or blistering compound found in a certain group of beetles; often referred to as *Spanish fly* but has no aphrodisiac effect.

Capitulum Mouthparts of an acarine (mite or tick).

Catarrhal Characterized by inflammation of the mucous membranes.

Cercaria Asexual stage within the life cycle of a digenetic trematode. The cercarial stage emerges from the snail, the first intermediate host. Each cercarial stage produces one metacercarial stage, found in the second intermediate host or on vegetation. Sometimes the cercaria can penetrate the definitive host directly.

Cervical alae Lateral expansion of the cuticle in the anterior end of nematodes.

Cestodes Tapeworms.

Chelicerae Two cutting or lacerating organs of the capitulum.

Chelicerata Subphylum of the arthropods that includes the mites, ticks, spiders, and scorpions that possess chelicerae mouthparts.

Chelicerates Arthropods with hold-fast and lacerating mouth parts designed for sucking fluid, either blood or lymph.

Chitin Hard but elastic body covering that envelops the entire body of an arthropod.

Cilia Tiny hairs that cover the body surface of one type of protozoan, the ciliates, which move by beating these hairs.

Ciliates Protozoans that possess cilia.

Ciliophorans Members of the kingdom Protista, phylum Ciliophora. These are the ciliates.

Cloaca Opening of the intestine of the male nematode to the outside.

Coelom The true body cavity.

Coenurus Type of metacystode (larval tapeworm) stage characterized by

a large, fluid-filled bladder with a number of invaginated (inside-out) scolices attached to the wall of the bladder.

Coleopterans Members of the phylum Arthropoda, subphylum Mandibulata, class Insecta, order Coleoptera. These are the beetles.

Commensalism Type of symbiotic relationship in which one symbiont benefits while the other neither benefits nor is harmed.

Common name Nonscientific name for a living organism in different regions of the world; may refer to different organisms in different places.

Complex metamorphosis One of two types of metamorphosis by insects; the four developmental stages are egg, larva (maggot), pupa, and adult. Each stage is morphologically and structurally different from the other stages.

Congenital toxoplasmosis Infection of *Toxoplasma gondii* acquired by the fetus during pregnancy.

Copepod An aquatic crustacean.

Copulatory bursa Flattened, lateral expansion of a nematode's cuticle in the posterior region of certain male nematodes; serves to hold on to or grasp the female nematode during the mating process; composed of finger-like projections called *bursal rays*.

Coracidium Ciliated hexacanth embryo unique to the pseudotapeworms (cotylodans); when ingested by the first intermediate host (an aquatic crustacean), forms a proceroid within the intermediate host.

Cotylodan Pseudotapeworm, or false tapeworm.

Crustaceans Members of the subphylum Mandibulata, class Crustacea. The members include the aquatic arthropods: crabs, lobsters, crayfish, and copepods.

Cutaneous larva migrans Migration of larval stages of a nematode through the skin of humans, most often seen with *Ancylostoma braziliense*.

Cyst stage Nonmotile, resistant stage of a protozoan parasite.

Cystacanth Juvenile acanthocephalan that possesses an inverted proboscis.

Cysticercoid Type of metacystode (larval tapeworm) stage characterized by a small, fluid-filled bladder containing a single, noninvaginated scolex; usually microscopic.

Cysticercus Type of metacystode (larval tapeworm) stage characterized by a large, fluid-filled bladder containing a single invaginated (inside-out) scolex.

D

Definitive host Host that harbors the adult, sexual, or mature stage of the parasite.

Demodicosis Infection with the demodectic (*Demodex*) species of mites.

Dermatitis Inflammation of the skin.

Dictyopterans Members of the class Insecta, order Dictyoptera (also known as *Orthoptera*). These include the cockroaches and the grasshoppers.

Digenetic fluke Within the life cycle of a trematode, there are two intermediate hosts—a first (usually a snail) and a second intermediate host. There will be a few exceptions where the digenetic fluke only has one intermediate host, such as the schistosomes.

Dioecious Having separate sexes, both male and female; the nematodes and the arthropods are dioecious.

Diptera Two-winged flies.

Dipterans Referring to two-winged flies.

Dipylidium egg Tapeworm egg type containing a packet of multiple hexacanth within one egg.

Direct life cycle Life cycle that does not involve an intermediate host.

E

Ectoparasite Parasite that lives on the body of the host.

Ectoparasitism Parasitism by an external parasite; an ectoparasite produces an *infestation* on the host.

ELISA test Enzyme-linked immunosorbent assay, an immunodiagnostic technique that detects the presence of antigen.

Embryophore Tapeworm hexacanth embryo with striated eggshell.

Empodia Claw-like features on the end of the second pair of legs of *Myobia musculi* and *Radfordia affinis*.

Encysted Encapsulated in suspended animation.

Endoparasite Parasite that lives *within* the body of the host; an endoparasite produces an *infection* within that host.

Endoparasitism Parasitism by an internal parasite; an endoparasite produces an infection within the host.

Endosome A tiny pinpoint center within the nucleus of the amoeba.

Entomologist One who specializes in the study of insects.

Erratic parasite See *Aberrant parasite*.

Eucestode True tapeworm.

Euryxenous parasite Parasite with a very broad host range.

Excoriation Self-induced skin trauma.

F

Face fly A periodic parasite (genus *Musca*, species *autumnalis*) that feeds on mucus, tears, and saliva.

Facultative myiasis Condition resulting from fly larvae, normally free living, that become parasitic and use a host for their development.

Facultative parasite Organism that is usually free living (nonparasitic) in nature and develops a parasitic existence in certain hosts.

Feathered edge Thinnest part of a blood smear at the edges.

Festoons Indentations or folds along the margin of an external body part.

Fistula Pore or hole within tissue.

Flagellum Long whip-like or lash-like appendage that is used by a group of protozoans (the flagellates) as a means of moving about in a fluid medium.

Flea dirt Partially digested blood defecated by fleas; also called *flea feces* and *flea frass*.

Flotation solutions Liquids used to float parasite ova, cysts, and larvae for identification.

Fly strike Lesion(s) produced in the tissues of vertebrate hosts by maggots or fly larvae.

Free living Life cycle stage that does not require a host to survive.

G

Gadding Action of a vertebrate host marked by running away from irritating flies.

Gastritis Inflammation of the stomach.

Genus name The group a particular type of animal, parasite, or plant belongs to.

Gravid proglottids Oldest segments of a tapeworm or pseudotapeworm farthest from the scolex or bothria that contain spent or degenerated reproductive organs and viable eggs.

H

Hard ticks Members of the *Ixodid* type of ticks.

Helminths Parasitic worms.

Hemipterans Members of the class Insecta, order Hemiptera. These are the true bugs.

Hemocoel A body cavity filled with a blood-like fluid.

Hemolymph Blood-like fluid that bathes the internal organs of arthropods.

Hermaphroditic Having complete sets of both male and female reproductive organs; the tapeworms and the flukes (except for the schistosomes) are hermaphroditic.

Hexacanth embryos Type of tapeworm egg containing a six-toothed embryo (an embryo that contains six hooklets).

Hippoboscids Winged dipterans that parasitize wild birds.

Hirsute Very hairy.

Hirudin Anticoagulant produced in the oral cavity of leeches.

Hirudineans Members of the phylum Annelida, class Hirudinea. These are the leeches.

Hirudiniasis Infestation with leeches.

Holdfast organelle Scolex or head of the pseudotapeworm.

Homoxenous parasite Parasite that infects only one type of host; also called *monoxenous parasite*.

Host In a parasitic relationship, the member in which or on which the parasite lives.

Hydatid cyst Large, fluid-filled bladder that contains brood capsules, which bud from the internal germinal membrane; each brood capsule contains several protoscolices.

Hydrometer Tool for measuring the specific gravity of solutions.

Hymenopterans Members of the class Insecta, order Hymenoptera. These are the stinging bees, wasps, and ants.

Hypodermis Thin layer beneath the cuticle that secretes the cuticle layer of the nematode.

Hypostome Penetrating, anchor-like sucking organ of the tick.

I

Idiosoma Abdomen of a mite or a tick.

Immature proglottids Youngest segments closest to the scolex or bothria of the tapeworm or pseudotapeworm that contain sexually immature reproductive organs.

Incidental parasite Parasite that is found in a host in which it does not usually live.

Indirect life cycle Life cycle of a parasite that requires an intermediate host.

Infection A condition caused by an endoparasite within the host's body.

Infective third-stage larva Stage in the life cycle that is able to infect the definitive host.

Infestation A condition caused by an ectoparasite outside or on the host's body.

Inornate Species of ticks with a reddish or mahogany color.

Insecticides Chemical compounds developed to kill insects.

Insects Members of the phylum Arthropoda, subphylum Mandibulata, class Insecta.

Intermediate host Host that harbors the larval, juvenile, immature, or asexual stages of the parasite. A parasite may have more than one intermediate host.

Invaginated scolices Tapeworm heads turned inside out within the bladder worm life stage.

Ixodid Tick family with hard bodies.

L

Lappets Round protuberances behind the suckers of the scolex in *Anoplocephala perfoliata*.

Larval pentastome The stage that hatches from a pentastome egg. It is mite-like with four to six legs, each of which ends in pincer-like claws.

Larviparous Type of female nematode that retains her eggs within the uterus and produces live first-stage larvae.

Leaf crown The collection of papillae of nematodes.

Leeches Bloodsucking annelids.

Lepidopterans Members of class Insecta, order Lepidoptera. These are the moths and butterflies.

Life cycle Development of a parasite through its various life stages. Every parasite has its own distinct, individual life cycle with at least one *definitive host* and may have one or more *intermediate hosts*.

Linguatuliiasis See *Pentastomiasis*.

Linguatulosis See *Pentastomiasis*.

Linnaean classification

scheme Classification for all living organisms (animals, plants, fungi, protozoa, and algae) perfected by Carl Linnaeus, an early Swedish biologist. Every living organism can be classified using the following scheme: kingdom, phylum, class, order, family, genus, and species.

M

Maggots Fly larvae.

Mandibulata Subphylum of arthropods that possesses mandibulate mouthparts.

Mature proglottids The segments in the middle of the tapeworm or pseudotapeworm body that contain

sexually mature reproductive organs.

Measly meat Meat that is infected with the cysticerci (larval stages) of certain human and canine tapeworms; includes measly beef (*Cysticercus bovis*), measly pork (*Cysticercus cellulosae*), and measly mutton (*Cysticercus ovis*).

Megaloblastic anemia Anemia caused by the loss of vitamin B₁₂.

Metacercaria Asexual stage within the life cycle of a digenetic trematode. The cercarial stage emerges from the snail (first intermediate host) and produces one metacercarial stage. If the cercaria is ingested by the second intermediate host, it will encyst within its tissues. The metacercarial stage may be found encysted on vegetation.

Metacestode Larval tapeworm found within the intermediate host; types of metacestodes include cysticercoid, cysticercus, coenurus, hydatid, tetrathyridium, proceroid, plerocercoid, and sparganum.

Metamorphosis To achieve the adult stage, an insect must undergo a series of developmental changes in size, form, or structure called *metamorphosis*; two types are simple metamorphosis and complex metamorphosis.

Metazoan parasites Multicellular or complex organisms that include trematodes, tapeworms, pseudotapeworms, roundworms, thorny-headed worms, leeches, and arthropods.

Microfilaria Immature stage of filarial parasites.

Microfilaricide Dewormer that kills the immature filarial worm.

Micropyle A small pore at one end of some protozoan oocysts.

Miracidium Developmental stage in the life cycle of a digenetic trematode. This stage emerges from the operculated egg and penetrates the first intermediate host, usually a snail.

Molt Shedding of the outside cuticle.

Monoecious Hermaphroditic; having both sexes in a single organism.

Monogenetic fluke A rare type of trematode often parasitizing fish, amphibians, or reptiles. Monogenetic flukes do not occur in domesticated animals. They are not of veterinary significance.

Monoxenous parasite A parasite that infects only one type of host.

Morula Type of nematode egg that contains an undeveloped grape-like cluster of cells within the eggshell.

Mucocutaneous Pertaining to the mucous membrane and the skin.

Mutualism Type of symbiotic relationship in which both organisms derive some benefit.

Myiasis Infection or infestation of the tissues or organs of humans or domesticated or wild animals by larval members (maggots) of the order Diptera (two-winged flies).

Myositis Inflammation of the muscle tissue.

Myriapodans Members of the phylum Arthropoda, subphylum Mandibulata, class Myriapoda. These are the centipedes and millipedes.

N

Neck Germinal or growth region of a tapeworm that lies just posterior to the scolex.

Necropsy Postmortem examination or autopsy of an animal.

Nematodes Roundworms.

Neotenic A type of parasite in which the small male lives inside the vagina of the immature female or the uterus of the mature female parasite.

Neurocysticercosis Infection with the pork tapeworm that develops in the brain of a human.

Nit Egg of a sucking or chewing louse.

Nymphal pentastome The worm-like developmental stage found within the tissues of the intermediate host. It is the stage that is infective for the definitive host.

O

Obligatory myiasis Lesions caused by fly larvae that require a vertebrate host for their development.

Obligatory parasite Parasite that must lead a parasitic existence; most parasites of domestic animals are obligatory parasites.

Occult blood Blood present in such small amounts as not to be visible to the unaided eye.

Occult infection Parasitic filarial infection without the presence of microfilariae.

Ocular micrometer The eyepiece scale on a microscope.

Oncosphere Growth ball released by the ingested egg of *Echinococcus* species.

Operculum Tiny "door" at either end (pole) of an egg.

Oral sucker The organ of feeding/attachment on the anterior end of a mature digenetic fluke. The oral sucker connects to a muscular pharynx, and the pharynx connects to the blind caeca of the adult fluke.

Ornate Species of ticks with distinctive white patterns on the dark-reddish or mahogany background of the scutum.

Oviduct Female nematode reproductive organ that connects the tubular ovaries to the uterus.

Oviparous Type of nematode egg that contains either a single cell or a morula, a grape-like cluster of cells.

Ovoviviparous Type of nematode egg that contains a first-stage larva.

P

Palpi Mouthparts.

Palps Appendages found near the mouth in invertebrate organisms that are used for sensation, locomotion, and/or feeding.

Papillae Finger-like or bump-like projections on the cuticle of a nematode.

Papules Red bumps.

Parasite In a parasitic relationship, the member that lives on or within the host.

Parasitiasis Type of parasitic relationship in which the parasite is present on or within the host and is potentially pathogenic (harmful); however, the animal does not exhibit outward clinical signs of disease.

Parasiticides Chemical compounds (either very simple or very complex) used to treat specific internal and external parasites (endoparasites and ectoparasites); different types include anthelmintics, acaricides, insecticides, and antiprotozoals.

Parasitism Type of symbiotic relationship between two organisms of different species in which one member (the *parasite*) lives on or within the other member (the *host*) and may cause harm; the parasite is metabolically dependent on the host for its survival.

Parasitology The study of parasitic relationships.

Parasitosis Type of parasitic relationship in which the parasite is present on or within the host and causes obvious injury or harm to the host animal; the host exhibits obvious outward signs of clinical parasitism.

Paratenic host A host used for transport of a parasite. The parasite does not go through any developmental stages.

Parthenogenesis Modified form of sexual reproduction characterized by the development of offspring by a female nematode from eggs that have not been fertilized by a male nematode; genus best known for parthenogenesis is *Strongyloides*.

Pathogenicity Disease-causing potential.

Pedicels Stalks at the tip of sarcoptiform mite legs.

Pediculosis Infestation by either chewing or sucking lice.

Pedipalps Two leg-like accessory appendages attached to the capitulum that act as sensory support.

Pelage Hair coat.

Pentastome Tongue worms, or linguatulids. These annelid-like arthropods have a mite-like larval stage; nymphal stages are found in the visceral organs of many mammalian intermediate hosts; adults usually parasitize snakes and other reptiles. The one pentastome found in domestic animals is *Linguatula serrata*.

Pentastomiasis Infection with pentastomes.

Percutaneous Through the skin.

Periodic parasite Parasite that makes frequent short visits to its host to obtain nourishment or other benefits.

Pernicious anemia See *Megaloblastic anemia*.

Phoresis Type of symbiotic relationship in which the smaller member in the relationship is mechanically carried by the larger member.

Pilose antennae Antennae covered with fine hairs.

Piroplasmosis Disease caused by *Babesia canis*.

Pleomorphic Demonstrating a variety of morphologic forms or body forms.

Plerocercoid Type of metacystode stage unique to the pseudotape-worms (cotylodans); this solid-bodied metacystode stage with slit-like mouthparts is found within the second intermediate host, usually a fish or an amphibian; also called a *sparganum*.

Predator-prey relationship Extremely short-term symbiotic relationship in which one symbiont benefits at the expense of the other; for example, a lion (the *predator*) kills a zebra (the *prey*). The prey ultimately pays with its life and serves as a food source for the predator.

Prepatent period Time from the point of infection by a nematode until a specific diagnostic stage can be recovered.

Preputial washes Flushes of the prepuce of the male bull for analysis of genital tract parasites.

Probenzimidazoles Family of anthelmintics that includes thiophanate, febantel, and netobimbin.

Proboscis Retractable "nose" on the anterior end of an acanthocephalan that is covered with tiny, backward-facing spines and serves to anchor the acanthocephalan to the mucosa of the intestine.

Proceroid Type of metacystode stage unique to the pseudotapeworms

(cotylodans). This metacystode stage is found within the first intermediate host, usually a tiny aquatic crustacean.

Proglottid Individual box-like components of the tapeworm strobila; three types are immature, mature, and gravid proglottids.

Protoscolices Multiple tapeworm heads in a hydatid cyst that develop into adult tapeworms when ingested by a definitive host.

Protozoan parasites Unicellular, or single-celled, organisms that may be flagellates, amoebae, sporozoans, apicomplexans, or ciliates.

Pruritus Itch or itchiness.

Pseudocoelom Cavity between the middle layer and inner layer of the three body tissue layers of the nematode.

Pseudocoelomic membrane The tissue that surrounds and lines the pseudocoelom.

Pseudoparasites Living creatures or inanimate objects that are not parasitic but may be mistaken for, or erroneously identified as, parasites.

Pseudophyllidean egg Tapeworm egg type with an operculum at one end and an oval shape.

Pseudopodia False feet.

Pseudosucker A false sucker surrounding the mouth of a leech.

Psocids Primitive insects associated with vegetation.

Sarcoptidae Family of sarcoptiform mites that resides on the surface of the skin or within the external ear canal.

Pyriform apparatus The innermost lining (third lining) of the covering of certain types of tapeworm eggs; pear shaped.

Q

Qualitative testing Indicates the presence or absence of parasite ova, cysts, or larvae.

Quantitative testing Indicates the number of eggs or cysts present in one gram of feces.

R

Rectum Opening of the intestine of the female nematode to the outside.

Redia Asexual stage in the life cycle of a digenetic trematode. This stage is preceded by the sporocyst stage, which produces many rediae; each redia will form many cercariae.

Reportable parasites Parasites that must be reported to both state and federal authorities (e.g., *Cochliomyia hominivorax*, *Psoroptes* species in large animals, *Boophilus annulatus*).

Repugnatorial glands Areas beneath the legs of millipedes that produce caustic substances.

Reservoir host Vertebrate host in which a parasite or disease occurs in nature and is a source of infection for humans or other domesticated animals.

Rhabditiform esophagus Type of nematode esophagus that has a corpus, isthmus, and posterior bulb.

Rostellum Holdfast organ on the anterior end of an armed true tapeworm; has backward-facing hooks used to anchor the tapeworm to the wall of the host's gut.

S

Sarcomastigophorans Members of the kingdom Protista, phylum Sarcomastigophora. These are the flagellates and amoebae.

Sarcoptic acariasis Infection caused by *Sarcoptes* mites.

Sarcoptidae Family of sarcoptiform mites that burrow or tunnel within the epidermis.

Sarcoptiform mites A classification of mites that can cause severe dermatologic problems in the host.

Scabies See *Sarcoptic acariasis*.

Schistosome cercarial dermatitis Swimmer's itch; highly pruritic papular or pustular dermatitis in humans caused by the cercarial stages of bird schistosomes.

Scientific name Name for a living organism that is composed of two Latin words, usually written in italics. The *genus name* (capitalized; e.g., *Felis*) indicates the group to which a particular type of animal or plant belongs; the *specific epithet*

(lowercase; e.g., *catus*) indicates the type of animal itself.

Scolex The "head" of a tapeworm.

Scutum Hard, chitinous plate that covers the body of some ticks.

Seed ticks Six-legged larval stage of the tick life cycle.

Seminal receptacle A female nematode's reproductive organ used to store sperm.

Setae Tiny hair-like bristles found on *Musca domestica* and other arthropods.

Simple metamorphosis One of two types of metamorphosis by insects; three developmental stages are egg, nymph, and adult. The nymphal and adult stages are similar in morphology and structure; the nymphal stage is smaller than the adult and is not sexually mature.

Siphon A structure used by larvae to breathe oxygen from the air.

Siphonapterosis Infestation with fleas.

Skin scraping A procedure used to find mites on the surface or just under the skin.

Somatic muscular layer The layer of muscle below the hypodermis that is used by nematodes to move.

Sparganosis Infection with the plerocercoid stage within the tissues of the second intermediate host.

Sparganum See *Plerocercoid*.

Specific epithet The type of animal in a genus.

Specific gravity The weight of an object compared with the weight of an equal volume of pure water.

Spicule pouch Pocket that contains the male reproductive organs used to open the female nematode's vulva.

Spicules Male nematode's intromittent organs ("penis") associated with the copulatory bursa.

Spiracular plate Opening on the posterior end of some arthropod larvae used for breathing.

Spiruroid One of four egg types produced by nematodes (see Fig. 3.11 for characteristic look).

Sporocyst Asexual stage in the life cycle of a digenetic trematode. This miracidium penetrates the snail (first intermediate host) and forms the sporocyst stage.

Stenoxenous parasite Parasite with a narrow host range.

Stepping Inchworm-like manner of movement used by leeches when moving on land.

Strike See *Fly strike*.

Strobila Body of the tapeworm composed of individual proglottids (immature, mature, and gravid).

Strobilocercus Type of metacystode stage found in the liver of rats; has a scolex that attaches to a long neck, which connects to a fluid-filled bladder.

Stylostome Tube that forms in the host at the attachment site of chiggers.

Symbiont Each living organism in a symbiotic association.

Symbiosis Any association (temporary or permanent) between at least two living organisms of different species.

Synanthropic Living with humans.

T

Taenia egg Tapeworm egg type with a wide outer shell and thicker outer covering and with a single six-hooked hexacanth within.

Tachyzoites Rapidly multiplying stages of toxoplasmosis in sporulated oocysts.

Tegument Body wall of a helminth.

Tetrathyridium Solid-bodied metacystode stage with a deeply invaginated acetabular scolex. This stage is capable of asexual reproduction and divides by splitting into two stages; two then become four, four become eight, and so on.

Tick paralysis Paralysis seen in animals and humans caused by the toxic saliva in some ticks.

Transport host Special type of intermediate host in which the parasite does not undergo any development but instead remains arrested or encysted ("in suspended animation") within the host's tissues; also called *paratenic host*.

Trematodes The flukes.

Trichinelloid One of four egg types produced by nematodes (see Fig. 3.12 for the characteristic look).

Trichoroid See *Trichinelloid*.

Trichostrongyle type One of four egg types produced by nematodes (see Fig. 3.10 for the characteristic look).

Trophozoite stage Motile or moving form of a protozoan.

Trypomastigote Swimming life stage of trypanosomes.

Tubular ovaries Female nematode's reproductive organs.

Tubular testes Male nematode's reproductive organs.

U

Unarmed tapeworm True tapeworm that lacks a rostellum on its anterior end.

Urticating The act of stinging.

V

Vas deferens Male nematode's reproductive organ connecting the tubular testes to the cloaca.

Venation Possessing veins in a part of the body.

Vermicide Dewormer that kills the parasite so that it can be broken down by the host's body.

Vermifuge Dewormer that paralyzes (but does not kill) the adult parasite so that it passes in the feces.

Vesicles Tiny blisters.

Veterinary parasitology The study of parasitic relationships affecting domesticated, wild, exotic, and laboratory animals.

Visceral larva migrans Migration of the larval stages of a nematode through the organs or tissues of humans (e.g., lungs, liver, eye); most often seen with *Toxocara canis*.

Vitellaria Accessory genital gland that secretes the yolk and shell for the fertilized ovum.

W

Warbles Larvae of dipteran flies found in the skin of domestic or wild animals, producing cutaneous myiasis.

Wolves See *Warbles*.

Z

Zoonosis Any disease or parasite that is transmissible from animals to humans.

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