Wilson G. Pond,
Fuller W. Bazer, and
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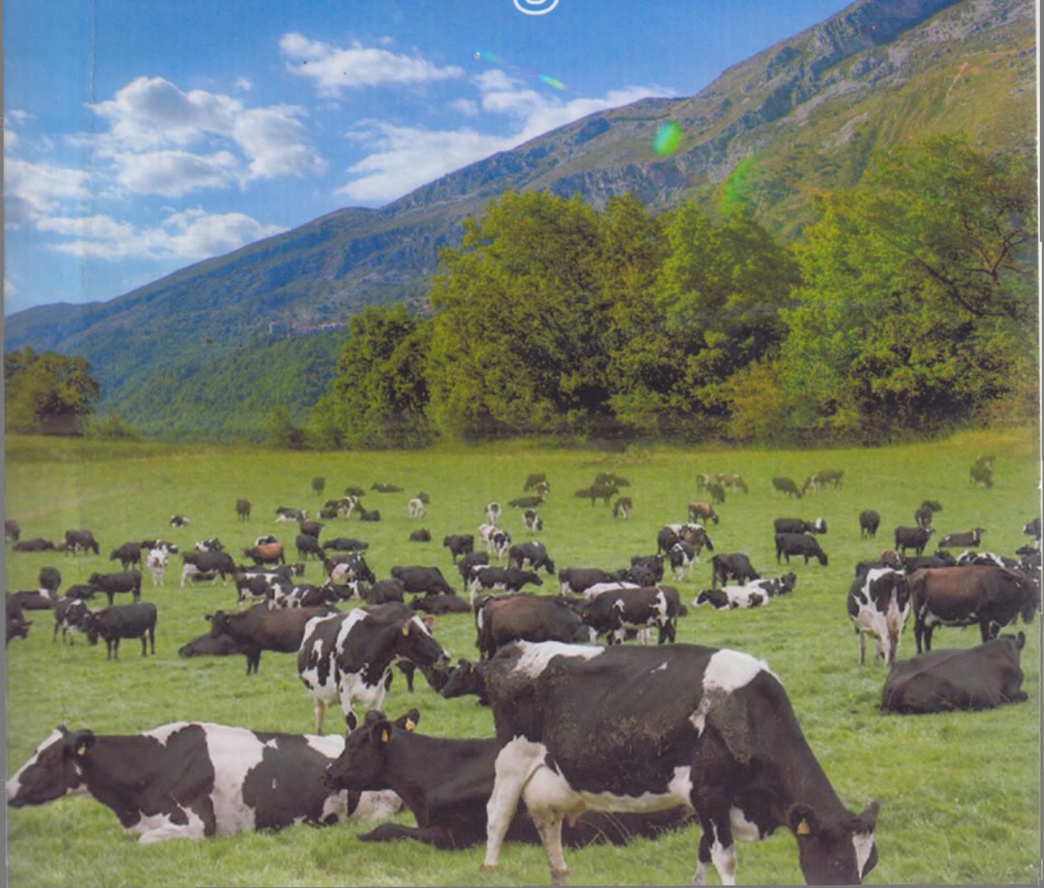

Animal Welfare in Animal Agriculture

Husbandry, Stewardship, and Sustainability in Animal Production

EDITED BY

Wilson G. Pond,
Fuller W. Bazer, and
Bernard E. Rollin

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Dedication

This book is dedicated to the memory of Dr. Stanley E. Curtis, whose seminal contributions to the advancement of the welfare and well-being of farm animals are legendary. The following excerpt from an article* written by Dr. Curtis in 2007 provides insight into the impact of his long-time contributions to the improvements of farm animal welfare. His lifetime efforts are an inspiration to all who seek to ensure animal well-being everywhere.

> An important issue in animal agriculture nowadays is the public demand for evidence that animals on farms and ranches are being treated humanely, that animal state of being (ASB) is high most of the time. But, right now, how should ASB be assessed in production settings?
>
> Important as this question is, scientists have yet to reach consensus as to how to accomplish that task. It is an unsettled area of knowledge that is seriously in need of more concerted attention. Animal-welfare scientists represent several disciplines, and therefore approaches, guiding principles, and vocabularies differ among them. These differences have led to confusion and misunderstanding among interested stakeholders.
>
> Many animal-welfare scientists, following the classic, pioneering contributions of observations and thought by I.J.H. Duncan (Duncan and Wood-Gush, 1971; Duncan, 1996, 2001), have concluded that assessing ASB should be based mostly on animal feelings (Dawkins, 1980; McMillan, 2005). This ultimately may be the ideal methodology. But unfortunately, right now we are unable for certain to measure animal feelings (e.g., anxiety, fear, frustration, and pain) directly, objectively, and scientifically in the laboratory, let alone is it possible to do so in a production setting. ("Measure" herein is used in the sense of "to ascertain the extent or quantity of by comparison with a standard.") As Duncan (2002) has pointed out, the measurement of the behavior patterns postulated to be correlated with negative conscious feelings in animals can itself be objective and scientific. It is at the step of the interpretation of such observations of behavior in terms of any associated ill feelings where the feelings approach is still scientifically uninformed and wanting with respect to the practical usefulness of that approach on farms and ranches today.
>
> So, until such time as we do know how to interpret putative behavioral indicators of reduced animal feelings, and how to quantitatively transform those indicators into valid measures of animal feelings, some are instead advocating the use of objectively measurable animal-performance traits as indicators. The bases of this performance-based approach include 1) the principle that what cannot be measured cannot be managed; 2) the fact that we now can objectively measure productive and reproductive performance traits but not animal feelings; and 3) the fact that reductions in performance traits are early, sensitive indicators that ASB is being deleteriously affected.
>
> Much of the impediment to answering the big question of how to assess ASB may reside in the fact that many — probably most — animal-welfare scientists have virtuously dismissed an approach based on animal functions and performance, favoring instead an approach based mostly or totally

* We are deeply grateful to Dr. Wayne Kellogg, Editor in-Chief, *Professional Animal Scientist*, for his efforts in granting permission to publish in this college textbook the "Introduction" to a manuscript titled "Commentary: Performance Indicates Animal State of Being: A Cinderella Axiom," written by Dr. Curtis and published in *The Professional Animal Scientist* 23(2007): 573–583.

on animal feelings and mind. Some hold that "animal welfare is about how the animal feels" (e.g., Duncan, 1996) and others that "animal welfare is characterized by the absence of behavioral problems" (e.g., Ladewig, 2003). However, still others think that animal functions and performance also are extremely relevant.

Mench (1998a) noted a "growing sense that animal-welfare science has reached an impasse," and this probably owes largely to disagreement over what constitutes farm-animal welfare. This dichotomy epitomizes the spirit of scientific dialogue.

Wilson Pond, Fuller Bazer, and Bernard Rollin, Editors

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Forewords

ACADEMIC

Students in the twenty-first century are learning in an environment where science and technology advance at a rate that encourages rapid dissemination and implementation of ideas. Deliberations on the morality and ethics of resulting changes occur at a much slower rate, and generally not in the same courses that teach the science. Hence, many individuals have perspectives on animal welfare that are largely influenced by public debate in the mass media, particularly electronic media.

An understanding of animal welfare within the food system and of how and where changes in production systems might need to be made requires the integration of knowledge from many fields, the antithesis of the "pigeon-holing" that occurs so easily in academic programs and student minds. Science and economics play critical roles, but must be seen within the context of how modern production systems evolved. The "sound bite" approach to ethics leads to misconceptions such as large-scale production systems being invariably careless of animal welfare and the idea that humanity "enslaved" other species for strictly selfish purposes.

Students need to be given opportunities to look at animal welfare in a context that includes the historical development of animal domestication and of modern animal production systems. Animal behavior played a critical role in the determination of which species were amenable to domestication, yet it has not had a recognized status alongside genetics, nutrition, and physiology in most animal science curricula. Behavior is an essential monitor of animal welfare, especially in intensive systems, and, as such, needs to be better integrated into curricula. The growth in size and intensity of production units is in response to the explosive growth in the human population and its food demands, with animal and human behavior and welfare intimately connected.

Academia changes with glacial speed in comparison to the world of applied science and technology. Tradition and fiscal constraints mean that offered courses often fail to give students the training and encouragement to integrate concepts across disciplines. The volume of factual material expands constantly and conscious efforts must be made to offer course time that requires and encourages students to think through the issues related to animal welfare. This ability to reflect and integrate is essential if humans are to be capable of evaluating and improving animal welfare in modern production systems.

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Public policy regarding the welfare of livestock and other animal species must be based on science and reason, not emotion. There is more need now for objective research and an informed public than ever before. Academia has been described as being largely preoccupied with lofty, remote, or intellectual pursuits, rather than those of practical application. In reality, academia is highly responsive to changing public attitudes and concerns, and the public is becoming increasingly interested in animal welfare. Academic institutions must compete for funding from public and private sources. Competition is also keen for the best students and for the reputation of being cutting edge and relevant.

Forewords

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Colleges and universities originally taught the art of animal husbandry, but when public interest in science increased after World War II, the term *husbandry* was dropped in favor of the word *science*. Recently, there has been renewed interest in changing the names of the courses that teach husbandry back to *husbandry*, but as those courses are now based on the latest advances in science, a name change is not likely.

At most colleges and universities, courses and extracurricular opportunities are reviewed regularly by faculty peer groups and administrators. Input from students, alumni, and employers of graduates are often solicited and may be directly incorporated into the review process. Although many academic departments may wish to start new courses on farm animal welfare and related issues, new courses and faculty have been difficult to add during periods of tight budgets. Many programs, however, are responding by updating their existing courses. For example, many species-oriented production (husbandry) courses, meats courses, applied ethology, ethics, and capstone courses are adding modules on the audit process. Audits (Chapter 6) are a system to ensure that good husbandry practices are being followed, so they are a natural fit into classes that already teach the latest husbandry practices. These courses may also devote more time to the latest events affecting animal welfare issues.

Extracurricular programs that provide additional opportunities for students to get involved in animal welfare-related activities have greatly increased. In addition to the traditional judging teams, students on many campuses have organized clubs that assist local shelters, or are otherwise involved in animal rescue or similar projects. Quiz bowls in which students compete based on their knowledge of animal husbandry have been popular for many decades. A particularly innovative program is the annual Intercollegiate Animal Welfare and Assessment Judging Contest pioneered at Michigan State University. Colleges and universities from Canada and the United States are invited to send teams to two days of seminars and competition.

Interest in the field of animal welfare science has grown so much over the past 30 years that there is a shortage of professionals with graduate training in the United States. For example, the USDA's Food and Agricultural Sciences National Needs Graduate and Postgraduate Fellowship Grants Program for 2010 listed "animal well-being (ethologists; bioethicists)" as their highest priority-targeted expertise shortage area.

One of the main goals of academia is to stimulate people to think critically and seek out alternative viewpoints. Most agricultural animal well-being issues are not simple, although special interest groups on both sides of the issue often promote a simplistic version. With many electronic, print, and other sources of information readily available, people can easily pick the news sound bites and entertainment that come closest to their personal biases and avoid exposure to the other sides of many issues.

Funding is the biggest single problem facing researchers in farm animal welfare science. Producer and commodity groups have and continue to make significant contributions to animal welfare research, although their resources are very limited. The USDA's competitive grants programs have been the largest source of funding in the United States, although the funds need to be greatly increased and the success rates of receiving funding for proposals submitted to the program are generally 20% or less. People often ask animal welfare and activist groups for assistance in funding research projects, but the answer is almost always *no*. One problem is what is known in the business as "the vegan police," the more radical members who do not support any research.

Extension programs have been at the forefront of creating quality assurance and auditing programs that have had an industry-wide impact. Most major meetings of state and national producer organizations include demonstrations of low-stress handling, and those demonstrations attract the largest crowds. Educational programs on proper animal handling, best practices, auditing, and emergency euthanasia of livestock are not only in demand at extension meetings with farmers and ranchers, but are also requested by auction barns, slaughter plants, and livestock transport companies.

In conclusion, academia is needed more than ever to help policymakers and the public make rational decisions regarding animal welfare, environmental, and ethical issues.

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In the past, welfare research has concentrated on prevention of negative welfare aspects such as hunger, thirst, inadequate feed, injuries, disease, and fear or chronic stress. The current research is more focused on stimulation of positive welfare aspects. Welfare is more than prevention of suffering. It also includes the satisfaction of desires and needs of animals.

Current modern housing systems are poorly designed when considering the behavioral and adaptive needs of animals. Systems are often simple in design and boring to live in with no distraction material other than the group mates of the animal. Routine treatments such as tail docking and beak trimming have to be used to allow animals to survive and produce well in these systems. This is part of the reason that welfare of farm animals is often so poorly perceived in public opinion.

Animals like pigs and poultry prefer a rich environment because of their behavioral needs to play (which is important to develop their social skills) and to root (to find feed).

Several recent developments in animal science and related disciplines show that environmental enrichment can have significant effects on prevention of maladaptive behavior such as tail biting in pigs and has stress-reducing effects, improves feed intake, and prevents diarrhea in piglets around weaning. The enrichment material (e.g., long straw, wood branches, or peat) should be ingestible, odorous, chewable, deformable, and destructible and should be replenished regularly.

Such enrichment measures result in satisfaction of desires and needs and therefore contribute to positive welfare. Moreover, the animals also seem more robust when going though transitions like weaning in piglets, suggesting that improved welfare and improved production go hand in hand. From a welfare and production point of view, it is therefore important that experts in the field of behavioral sciences join forces with system designers to design systems that are built based on behavioral and adaptive needs of animals instead of breeding animals that will fit the current systems. The latter route will bring us to ethical discussion on whether animals' intrinsic values may be changed to fit our current systems. In addition, systems built on behavioral and adaptive needs of animals must be realistic, ecologically sound, and economically viable to be successful.

Implementation of welfare in practice has become an interdisciplinary challenge where animal scientists, system designers, ecologists, and economists must join forces. Is it realistic to think that such systems will get a place in a world where low-cost prices for meat are so important? The public concern about animal welfare is increasing and retailers and governments are well aware of this. In Western Europe, cage housing for layer hens soon will be forbidden by law and retailers demand pregnant sows to be non-tethered. A recently developed welfare-friendly system for laying hens was supported by welfare organizations, and eggs from this system are sold by retailers. Animal products from those new systems, which are perceived better by the public, may get a bigger share of the market, thereby helping the producers of those products. Therefore, we think that the time is here to meet the challenges by research using a multidisciplinary approach. This multidisciplinary approach should also have a place in our teaching of undergraduate and graduate courses at universities and in training of students at other schools. First, students must gain knowledge of different aspects of animal welfare, and then integrate this knowledge using system design and analyses.

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COMMERCIAL OPERATIONS

Scientists studying animal behavior, pain perception, and other issues relevant to animal welfare provide information that can be used to determine the effects of different production systems and practices on animal welfare. Science provides information that can be used to make ethical decisions, but it cannot provide all the answers. For example, a scientific experiment can provide data indicating that a certain procedure causes pain, but it cannot provide an ethical judgment on how much pain is acceptable. Furthermore, there may be differences of opinion on what is ethical. This is one of the reasons there are so many different animal agricultural practices all over the world. Economics is also a big factor. Practices detrimental to animal welfare may be used to lower costs. For example, the productivity of each individual laying hen is decreased when too many hens are jammed into a small cage. However, the overall cost for the eggs may be lower because fewer expensive buildings are required. The individual hen may suffer in the process of lowering the cost of eggs. Some of the main factors that compromise animal welfare include the following:

Inadequate Management and Lack of Employee Supervision

Some of the worst abusive treatment of animals occurs when overworked, poorly supervised employees commit acts of abuse and cruelty. Some examples are beating animals, dragging a crippled animal, throwing small animals, or jabbing them with sharp objects. Abusive practices can occur on both large and small farms. Many people assume that big farms have more abuse problems, but size is not a determining factor. The most effective way to prevent abuse is through good management.

Neglect

Starvation or inadequate diets are examples of neglect. Allowing manure to build up in an animal's stall until the animal is covered in filth is also neglect. Neglect can happen on both large and small farms.

Animal Behavioral Preferences in Intensive Systems Versus Extensive Systems

Almost everyone who cares about animal welfare can agree that deliberate abuse of animals and neglect are very detrimental to animal welfare. However, there is a much greater controversy and disagreement on an animal's behavioral needs. Scientists can measure, in an objective manner, an animal's motivation for an environmental enrichment such as straw for pigs to chew on or a secluded nest box for a laying hen. Research shows very clearly that animals prefer specific amenities. Therefore, to provide an acceptable level of animal welfare in an intensive animal production system, environmental enrichments are needed to satisfy what the animals "want" most.

Examples of extensive systems of animal production are grass-fed beef and free-range chickens. Producers in this extensive segment will sell to high-end markets of affluent, concerned consumers. Intensive segments of animal production will remain large-scale commercial producers who will sell animal products at more affordable prices. This sector will need to eliminate some of the most objectionable practices such as sow gestation stalls and small, cramped chicken cages. To provide affordable animal products, these systems will have to be intensive, but must also provide for the most highly motivated behavioral needs. One example that is already being implemented is colony housing for hens that provides nest boxes, perches, and a place to scratch.

Biological System Overload

I predict that biological system overload will become one of the most serious animal welfare problems in the future. Animals have been pushed to produce more and more milk, meat, or eggs, and problems with lameness and weakness have already increased since the 1980s and may get worse.

Lameness in dairy cows has greatly increased and some pigs with heavy muscles are too weak to walk through the stockyard at a meat plant. There is a point where animal productivity should no longer be increased because the animal has difficulty functioning. Managers should strive for optimal productivity rather than maximum productivity. A dairy cow that lasts for three or four years of milking would probably be a good tradeoff between productivity, cost, and welfare compared to a cow that lasts for only two years of milking.

Economic Factors

Economic pressures can cause producers to cut corners and compromise animal welfare, but economic factors can also be forces to improve animal welfare. The treatment of animals at slaughter plants greatly improved after McDonald's Corporation and other restaurant companies started auditing slaughter plants. Large buyers are in a position to drive positive change. Handling and transport practices will improve when people are held financially accountable for death losses and injuries. When I worked with the restaurant companies to implement animal welfare audits, I saw huge improvements. Large buyers have the economic clout to enforce standards. This is why I spend large portions of my time working with large buyers of animal products to develop standards and conduct audits. The need for grocery stores and restaurants to audit animal welfare is equally important for both conventional agriculture and the organic/natural sectors.

Measuring Welfare Is Essential

People are able to manage the things that they can measure. To maintain high standards, managers need to measure welfare indicators such as the percentage of lame animals, skinny animals, animals with sores, animals with abnormal behavior, or dirty animals. In organic operations, coat condition should also be evaluated because lice treatments are often not used and bald spots on untreated cattle are not acceptable. Measuring is essential to prevent "bad from becoming normal." If a producer gets used to seeing a high percentage of lame cows, he or she may start to think that is normal. Animal handling should also be measured to prevent handling practices from reverting to being rough and inappropriate. Variables such as the percentage of immobile animals falling down or the percentage of those vocalizing during handling can be measured. Measurement enables a producer to determine if welfare is getting better or getting worse. Productivity is routinely measured. Welfare indicators should also be measured.

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Preface

Animal welfare is a topic of great interest and importance to society. Animals are used for companionship, service, research, food, fiber, and by-products. Ongoing efforts to ensure the well-being and comfort of food animals are imperative for fulfillment of sustainable agriculture. Animal source foods provide important nutrients in the diets of humans and animals. A major challenge for society is the maintenance of a stable environment to support human and animal needs. Our intent is to link the societal challenge of sustaining animal and human welfare with a strong and viable food system ensured by stewardship of land, crops, animals, and natural resources.

The book is presented in three parts: Section 1: Roles of Animals in Society, Chapters 1–3; Section 2: Treatment of Animals and Societal Concerns, Chapters 4–8; and Section 3: Sustainable Plant and Animal Agriculture for Animal Welfare, Chapters 9–14. The Forewords, written by individuals representing academia and industry, underscore the need for the animal welfare discussion in this textbook. Increases in food production have occurred because of scientific, technological, and global marketing advances. New knowledge in soil, water, crop, and animal science has increased concurrently with advances in transportation and communication. This industrialization of agriculture has created urban societies in which the vast majority have little awareness and understanding of agriculture and food production. For example, during the 1950s, approximately 20% of the U.S. workforce was in farming; in 2011, the figure is approximately 1%.

A major challenge for society in the coming decades is to provide sufficient global food to meet the needs of an increasing human population. Demand for animal source foods is growing, especially in developing countries, to counter widespread malnutrition that continues to be a major insult to infants and children.

During the past 40 years, economics improved and per capita consumption of milk, meat, and eggs in developing countries has increased. In contrast, during the same period in the developed countries, average per capita animal source food consumption has declined slightly.

The care and welfare of all animals is a high priority for society. A prominent milestone in this movement began with the exposure a century ago of questionable practices used in animal slaughter plants. Progress in animal welfare reforms and oversight is an ongoing effort by those engaged in food animal production and laboratory animal care.

Concurrent with these ongoing efforts in animal welfare reform, several small but well-funded organizations are active in promoting efforts to curtail or eradicate food animal production and the use of laboratory animals in biomedical research. Such efforts may affect animal source food production and the use of animals in biomedical and agricultural research. Consequently, the nutritional and physiological well-being of infants, children, and other vulnerable humans is at risk, particularly in developing countries. However, it is important to distinguish between abolitionists, who accept no legitimate animal use, and those who seek to improve the treatment and well-being of food animals as well as animals used in biomedical and agricultural research.

This book is intended to provide a framework for open discussions related to those issues that embrace the concepts of nutrition, animal welfare, and freedom of food choices. Chapter authors are highly qualified and recognized experts in their respective fields of teaching, research, and public service. The book is primarily written for undergraduate college students in varying fields of study: animal sciences, animal behavior, animal welfare, plant sciences, environmental sustainability, sociology, economics, and nutrition. The subject of animal welfare reaches across society in general, both urban and rural, and has a significant impact on consumer attitudes and choices.

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Section I

Roles of Animals in Society

1 Perspectives on Emergence of Contemporary Animal Agriculture in the Mid-twentieth Century

The Decline of Husbandry and the Rise of the Industrial Model

Bernard E. Rollin and Paul B. Thompson

CONTENTS

The domestication of animals occurred some 10,000 years ago and represented a milestone for the history of human civilization. The origin and sequence of domestication is a hotly debated topic among anthropologists and historians. Richard Bulliet (2005) argues that animals were probably first kept in captivity for use in sacrificial rites. This practice allowed ancient civilizations to observe which species were tame enough for use as work animals. Animals, notably cattle, provided labor and locomotion when they were harnessed to plows, sledges, and wagons beginning in about 4000 BC. Thus, animal agriculture was indispensable to accelerating the development of crop agriculture. The flesh and hides of sacrificial animals were routinely consumed by those in the royal house or the priesthood. Eventually, the habit of having the animals under human control at all times provided a constant and consistent food supply ready at hand. It also thereby created the leisure time necessary to societal progress.

However domestication actually occurred, humans selected among animals congenial to human management, and further shaped them in terms of temperament and production traits by breeding and artificial selection. These animals included cattle—dubbed by Calvin Schwabe the "mother of the human race"—sheep, goats, horses, dogs, poultry and other birds, swine, ungulates, and other animals capable of domestication. The animals provided food and fiber (meat, milk, wool, and leather); power to haul and plow; transportation; and served as weaponry (horses and elephants). As people grew more effective at breeding and managing the animals, productivity increased. As humans benefited, so arguably did the animals. They were provided with the necessities of life in a predictable way. Thus was born the concept of husbandry—the remarkable practice and articulation of the symbiotic contract humans made with farm animals.

"Husbandry" is derived from the Old Norse words "hus" and "bond"; the animals were bonded to one's household. The essence of husbandry was *care*. Humans put animals into the most ideal environment possible for the animals to survive and thrive, the environment for which they had evolved and been selected. In addition, humans provided them with sustenance, water, shelter, protection from predation, medical attention (as was available), help in birthing, food during famine, water during drought, safe surroundings, and comfortable appointments. Eventually, what was born of necessity and common sense became articulated in terms of a moral obligation inextricably bound up with self-interest. In the biblical story of Noah, we learn that even as God preserves humans, humans preserve animals. The ethic of husbandry is, in fact, taught throughout the Bible—animals must rest on the Sabbath even as we do; one is not to seethe a calf in its mother's milk (so we do not grow insensitive to animals needs and natures); and we can violate the Sabbath to save an animal. Proverbs tells us "the wise man cares for his animals." The Old Testament is replete with injunctions against inflicting unnecessary pain and suffering on animals, as exemplified in the strange story of Balaam who beats his ass, and is reprimanded by the animal's speaking through the grace of God.

The true power of the husbandry ethic is best expressed in the 23rd Psalm. There, in searching for an apt metaphor for God's ideal relationship to humans, the Psalmist invokes the good shepherd:

> The Lord is My shepherd; I shall not want.
> He maketh me to lie down in green pastures:
> He leadeth me beside the still waters.
> He restoreth my soul.

We want no more from God than what the good shepherd provides to his animals. Indeed, consider a lamb in ancient Judaea. Without a shepherd, the animal would not easily find forage or water, would not survive the multitude of predators the Bible tells us prowled the land—lions, jackals, hyenas, birds of prey, and wild dogs. Under the aegis of the shepherd, the lamb lives well and safely. In return, the animals provide their products and sometimes their lives, but while they live, they live well. Even slaughter, the taking of the animal's life, must be as painless as possible, performed with a sharp knife by a trained person to avoid unnecessary pain. Ritual slaughter was, in antiquity, a far kinder death than bludgeoning; most importantly, it was the most humane modality available at the time (despite its questionable status today).

The metaphor of the good shepherd is emblazoned in the Western mind. Jesus is depicted as both shepherd and lamb from the origin of Christianity until the present in paintings, literature, song, statuary, and poetry as well as in sermons. To this day, ministers are called shepherds of their congregation, and the word "pastor" is derived from "pastoral." In addition, when Plato discusses the ideal political ruler in the *Republic*, he deploys the shepherd–sheep metaphor: The ruler is to his people as the shepherd is to his flock. Qua shepherd, the shepherd exists to protect, preserve, and improve the sheep; any payment tendered to him is in his capacity as wage earner. So too the ruler again illustrates the power of the concept of husbandry on our psyches. Because of its close connection to God's putative relation to humans, husbandry has traditionally been a favored topic for sermons and homilies in the Judeo-Christian tradition. The concept of husbandry was regularly emphasized in the education of the young, both as a foundation for agriculture and as an exemplary value to reflect upon. Viewed from the perspective of agricultural ethics, the singular beauty of husbandry is that it was both an ethical and prudential doctrine. It was prudential in that failure to observe husbandry inexorably led to ruination of the person keeping animals. Not feeding, not watering, not protecting from predators, not respecting the animals' physical, biological, and physiological needs and natures, what Aristotle called their *telos*—the "cowness of the cow," the "sheepness of the sheep"—meant your animals did not survive and thrive, and thus neither did you. Failure to know and respect the animal's needs and natures had the same effect. Indeed, even Aristotle, whose worldview was fully hierarchical with humans at the top, implicitly recognized the contractual nature of husbandry when he off-handedly affirmed that although the natural role of animals is to serve man, domestic animals are "preserved" through so doing. The ultimate sanction of failing at husbandry—erosion of self-interest—obviated the need for any detailed ethical exposition of moral rules for husbandry. Anyone unmoved by self-interest is unlikely to be moved by moral or legal injunctions! Yet although one finds little written about animal ethics and little codification of that ethic in law before the twentieth century, there is no reason to suppose that husbandry was not also conceived in ethical terms. Indeed, the religious tradition discussed previously suggests just the opposite. If the shepherd did not tend his flock from a perspective of ethical compassion (along with self-interest), how could the metaphor of God as "my shepherd" have attained the resonance and meaning that it evidently has?

Given the overlap between ethics and self-interest in traditional husbandry, the bulk of what was articulated in animal ethics aimed at identifying overt, deliberate, sadistic cruelty, hurting an animal for no purpose or for perverse pleasure, or not providing food or water. The biblical prohibition against animal cruelty was continued and augmented in the rabbinical tradition as *Tsaar Baalei Chaim*—the suffering of living things. The prohibition against yoking an ox and an ass to the same plow arises out of concern of stress on the weaker animal. At the same time, of course, the Bible is replete with commandments that encourage good husbandry. Concern for cruelty to animals arises in the Catholic tradition in the writings of St. Thomas Aquinas. Despite the fact that animals enjoy no moral status in Catholic theology, Aquinas strictly forbids cruelty on the grounds (buttressed by modern psychology) that cruelty to animals leads inexorably to cruelty to humans.

Despite the sound and Solomonic basis for husbandry and its long history, this simple ethic was dealt a serious blow in the twentieth century. It is essential to stress that the widespread loss of husbandry among some producers was not the result of malice or thoughtlessness. It occurred through the eventual maturation of change processes that had long been at work in agricultural systems of European origin, ushered along by a series of technological innovations that were themselves accelerated in the years following World War II. By the closing decades of the twentieth century in some environments, these change processes had supplanted the ideas that had supported a relatively benign on-farm relationship between livestock and their human caregivers over the preceding centuries. By 1980, the philosophical vision of farming that held sway throughout the United States and other nations of European settlement had been swept away by a new understanding. In this new way of seeing things, agriculture is just another sector in the industrial economy. Like the energy or manufacturing sectors, the role of agriculture is to bring forth commodities for consumption in the marketplace, and to do so at the least possible cost. These changes were not brought about by a lack of concern for animals. The forces that created this philosophical revolution in the way that scientists, policymakers, and opinion leaders thought of agriculture are not uniquely or even primarily focused on the livestock sector.

Industrial agriculture is the inevitable result of unconstrained technological innovation on the one hand, combined with a singular neglect of the food system's unique contributions to quality of life on the other. The technology piece of the change process gave us industrial agriculture as a simple result of agricultural economics. Farm productivity is the ratio of farm output over input. Inputs include land, labor, and purchased goods such as seed, feed, fertilizer, and equipment. Outputs include salable farm products: in the animal sector, meat, milk, eggs, and animal by-products such as hides. A change in technology increases productivity when the new tools or techniques being used increase the outputs in the form of salable products while keeping the inputs in the form of land, labor, and other purchased goods constant. For an individual farm, an increase in productivity means that the farmer has more to sell. This is a good thing for the farmer as long as the price received for those commodity goods stays the same. With more to sell, the farmer has more income. The hitch is that as the new technology is widely adopted by other farmers, the entire farm sector has more to sell, and this creates a problem in agriculture that fuels the process of industrialization.

According to Economics 101, when supply goes up, prices must come down. Thus, as farm productivity grows, the total supply of farm commodities grows with it and prices fall. Eventually the farmer is back where he started. The ultimate benefit of an increase in productivity is passed on to consumers, who enjoy lower prices for food. However, something important has gone on in the meantime. Those farmers that adopted the new tools and techniques early made windfall profits before prices fell, while farmers who were late to adopt them were stuck with the problem of having to sell their meat, milk, and eggs for less than it cost to produce them. This, as any student of economics knows, leads to bankruptcy. When the bankrupt farms go up for auction, the early adopters are sitting there with windfall profits in their pockets, anxious to buy up the bankrupt farms. Agricultural economists call this the "technology treadmill." An individual farmer is running harder (producing more) to stay in the same place (maintain the same income). At the same time, less productive (and usually smaller) producers are constantly going bankrupt and leaving farming, while the ones still on the treadmill are getting bigger and bigger. When still newer tools and techniques come along, this process repeats itself all over again.

There are several ethical points to learn from the technology treadmill. The first point is that no farmer can afford *not* to adopt the most productive, state-of-the-art tools and techniques, and the smart ones are always the first to do so. If other farmers are producing for less, market prices will eventually adjust to reflect that fact, and the "laggard" (this is actually the term that rural sociologists once used to describe late adopters) will be forced to go out of business. From the individual farmer's perspective, there is no ethical choice to be made. Either you use the most productive technology or you are not a farmer at all. There is no point in trying to blame producers for this as a matter of ethics. They literally have no choice. The second point is if this were all that there was to say about the economics of farming, then there would be strong ethical arguments for thinking that the technology treadmill is a good thing. It is obviously *not* a good thing for the smaller, less productive farmers who are losing their farms, but it is important to remember that the cost of food is constantly coming down with every turn of the treadmill. This decline in the cost of food is a good thing for people who buy food. It is an especially good thing for people who spend a comparatively large portion of their income on food (i.e., the poor). Several generations of agricultural economists and policymakers were so impressed by this logic during the twentieth century that urging farmers to "get big or get out" was official U.S. government policy (Thompson, 2010).

However, there is more to the story.

Between the two World Wars, agricultural scientists and government officials became extremely concerned about supplying the U.S. public with enough cheap and plentiful food. First, after the Dust Bowl and the Great Depression, many people in agriculture had soured on farming. Agriculture was always subject to the vagaries of weather and economics, but never in U.S. history to the staggering extremes experienced in the unpredictable and incomprehensible events over which the individual was powerless. Second, reasonable predictions of urban and suburban encroachment on agricultural land were being made, with a resultant loss of land for food production. This tendency has in fact continued through the present. Today, rural property that was formerly used for dryland farming of winter wheat now can sell for $60,000 per acre for development use. Moreover, as farmland is developed into housing, homeowners do not wish to live next to animal production units that create odor and dust. Third, many farm people had been sent to both foreign and domestic urban centers as military personnel during both World Wars, thereby creating in them a reluctance to return to rural areas lacking in excitement and amenities. This problem is well illustrated by the post-World War I song, "How 'Ya Gonna Keep 'Em Down on the Farm (After They've Seen Paree)?" Fourth, having experienced the specter of literal starvation during the Great Depression, the American consumer was, for the first time in our history, fearful of an insufficient food supply. Fifth, projection of major population increases (that in fact happened) further fueled concern. Sixth, promises of better jobs in cities, for example in the automotive industry in Detroit, lured farm workers out of agricultural areas into urban areas by the promise of higher income than could be made on farms.

When the considerations of loss of land and diminution of agricultural labor are coupled with the rapid development of a variety of technological modalities relevant to agriculture during and after World War II and with the burgeoning belief in technologically based economies of scale, it was probably inevitable that animal agriculture would become subject to industrialization. This was a major departure from traditional agriculture and a fundamental change in agricultural core values—industrial values of efficiency and productivity replaced and eclipsed the traditional values of "way of life" and husbandry. Husbandry-based animal agriculture was about putting square pegs in square holes, round pegs in round holes, and creating as little friction as possible doing so. Animal welfare was linked conceptually to productivity—harming the animal's welfare diminished its productivity. To be sure, people did not always pursue their own interest and could be sloppy or abrasive in animal care despite the concomitant loss of productivity. However, the key point was that the two were closely tied together. As industrial agriculture began to take hold, academic departments of animal husbandry changed their names to departments of animal science, symbolically betokening a move to industry. Animal science, in fact, is defined in textbooks as the application of industrial methods to the production of animals. No husbandry person would ever dream of keeping animals evolved for extensive grazing confined in small cages. No husbandry person would ever dream of feeding blood and bone meal, poultry waste, or cement dust to farm animals, but such "innovations" are entailed by industrial/efficiency mindset and applied research.

With the industrialization of agriculture, people no longer needed to put square pegs in square holes, round pegs in round holes, but by using "technological sanders," could force square pegs into round holes and round pegs into square holes. In other words, animals could be placed into environments and housing systems that violated their biological and psychological natures without harming their productivity. Antibiotics, vaccines, bacterins, hormones, air-handling systems, and other technological innovations allowed us to put animals where their needs and natures were not met, where suffering in fact occurred. In a traditional husbandry system, these practices could have reduced farm productivity, but in the industrial system, they increased farm productivity from the economic standpoint. Using technology, productivity was severed from animal welfare. For example, the economically most efficient way to produce eggs maximizes the number of eggs produced per barn, rather than per bird. A modern poultry barn costs hundreds of thousands of dollars, while a chicken costs only a few cents. Stocking densities that maximize productivity sacrifice animal health in order to get the best return on the total investment.* Whereas, in husbandry agriculture, productivity and animal welfare went hand-in-hand, they were disconnected under an industrial approach, with animals suffering, but in ways irrelevant to productivity. However, small husbandry farms, operating on smaller profit margins, still exist today in the United States and worldwide.

By the last quarter of the twentieth century, a significant portion of animal agriculture had been channeled into industrialized confinement in the United States, Europe, Latin America, and Asia. Machines replaced human skilled labor, and industrialized agriculturalists boasted that agricultural intelligence was in the systems, not in husbandry-trained workers. Husbandry was often supplanted by industry in many areas of animal agriculture except for extensive sheep and cattle ranching. In these cases, not only was animal welfare adversely affected, but also new problems for agriculture arose. One issue was sustainability: in extensive cattle ranching, environmental sustainability was assured because if a cattle rancher overgrazed his pasture land, he essentially lost his livelihood. Industrial agriculture, on the other hand, did not represent a self-sustaining balanced equilibrium. A detailed account of the problems created by the industrialization of animal agriculture is presented in Chapter 4, but they are worth a brief summary here.

1. Environmental—Inexpensive fossil fuels are one of the main drivers for industrialization in all of agriculture, including animal production. Furthermore, such operations generate enormous amounts of manure. Unlike the valuable role of manure in pastoral agriculture, where it nourishes the soil, in confinement manure becomes a potential pollutant. Excess manure leaches into ground water and pours into surface water under conditions of high rain, as famously occurred in North Carolina. The wastes in turn produce significant odor, and eutrophication of streams, rivers, and lakes, that is, growth of undesirable algae and bacteria. In the central valley of California between San Francisco and Los Angeles, many

* In 2000, the Producer Committee for the United Egg Producers acknowledged this, increasing recommended space allocations from an industry average of 48 sq. in. per bird to 72 sq. in. per bird.

giant dairies have generated unprecedented air pollution consisting of organic volatile compounds, nitrous oxide, ammonia, and methane, eliciting unprecedented environmental regulations. Industrial operations also consume vast amounts of precious water.

2. Human health issues—Closely connected to environmental contamination are human health issues. Two-thirds of human infectious diseases are zoonotic, and close confinement allows infectious microorganisms to burn through populations, much like a cold in a dormitory. In addition, crowded conditions may be conducive to rapid mutation and development of new pathogens. When antibiotics or other drugs are used as a technological sander to compensate for unhealthy conditions or as a growth promotant at low levels, surface water from runoff of industrial animal production facilities can become polluted with pharmaceuticals. Many scientists believe that feeding antibiotics to livestock for growth promotion encourages resistance to antibiotic agents in important human pathogens and thus an end to such use of antibiotics in agriculture should be legislated. Others (De Haven, 2010) deny this claim. Worker health may also become a problem, both because of pathogens and because of bad air. In some swine barns, workers must wear respirators, although the animals do not! The air pollution mentioned earlier in the central valley of California is responsible for marked increased incidence of respiratory disease, cardiovascular problems, and pre-natal and neonatal health problems, as California health authorities told the Pew Commission on which one of us (BR) served.
3. Loss of small agriculture and destruction of rural communities—As mentioned, in some 26 years the United States had lost 87.8% of the swine producers operating in 1980 (Vansickle, 2002) with the hogs now produced by large companies. From over one million producers in the 1960s, by 2005 the number had fallen to 67,000 (USDA/NASS, 2005). As the small hog farmers have gone out of business, the once thriving communities they nurtured have become ghost towns. This in turn kills the communities. Moreover, in rural areas where large operators have become established, major cultural conflicts occur between traditional inhabitants and the migratory workers. In the face of these considerations, we must again recall Jefferson's admonition that small farms and farmers are the backbone of democracy; no one wishes to see major corporations monopolizing the food supply.
4. "Externalized costs"—What helped drive industrialized agriculture's evolution is the desire for "cheap food." Americans spend only 9% of their income on food, as opposed to the 20% spent by Europeans. However, it should be clear from our discussion that what one pays in the supermarket does not represent the true cost of animal products created by industrial methods. The Pew Commission was told by California state health officials that human health costs (in addition to the suffering associated with illness), for example, from pollution from dairies in the central valley of California cost every man, woman, and child in that area an estimated $3 billion, or $1000 per year in direct medical costs. The costs of environmental pollution and the cleanup it will eventually require are inestimable, and how does one cost-account the animals' suffering?

It has often been asked if those who developed industrial animal production methods were callous or oblivious to animal welfare. Most certainly not! They are, however, guilty of a major conceptual error. Since most of the developers come from experience and training in husbandry agriculture, they may have assumed that the same logic that governed husbandry would remain in industrial systems. That is, they thought that the new agriculture would preserve the close connection between productivity and animal welfare that one found in traditional agriculture. Hence, as we shall see in Chapter 5, industrial agriculturalists were disposed to treat productivity as definitive of welfare, forgetting the role of what we have called "technological sanders" in preserving productivity even while welfare is severely compromised.

Industrial agriculture created major welfare problems for farm animals that did not arise, or were insignificant, under husbandry agriculture.

In general, all animals in confinement agriculture (with the exception of beef cattle who live most of their lives on pasture, and are "finished" on grain in dirt feed lots, where they can actualize much of their nature) suffer from the same generic set of affronts to their welfare absent in husbandry agriculture.

1. Production diseases—By definition, a production disease is a disease that would not exist or would not be of serious epidemic import were it not for the method of production. Examples are liver and rumenal abscesses resulting from feeding cattle too much grain, rather than roughage. The animals that get sick are more than balanced out economically by the remaining animals' weight gain. Other examples are confinement-induced environmental mastitis in dairy cattle and "shipping fever." There are textbooks of production diseases, and well over 90% of what farm animal veterinarians treat is production diseases (Rollin, 2009).
2. Loss of workers who are "animal smart"—In large industrial operations such as swine factories, the workers are minimum wage, sometimes illegal, often migratory, with little animal knowledge. Confinement agriculturalists will boast that "the intelligence is in the system" and thus the historically collective wisdom of husbandry is lost, as is the concept of the historical shepherd, now transmuted into rote, cheap labor.
3. Lack of individual attention—Under husbandry systems, each animal is valuable. In intensive swine operations, the individuals are worth little. When this is coupled with the fact that workers are no longer caretakers, the result is obvious.
4. The lack of attention to animal needs determined by their physiological and psychological natures—As mentioned earlier, "technological sanders" allow us to keep animals under conditions violative of their natures, thus severing productivity from assured well being.

THE EGG INDUSTRY

Let us briefly examine some representative industrial systems to understand in specific terms the problems of animal welfare generated by industrialization of animal agriculture. Consider, for example, the egg industry, one of the first areas of agriculture to experience industrialization. On a typical nineteenth-century American farm, chickens ran free in barnyards, able to express their natural behaviors of moving freely, nest-building, dust-bathing, escaping from more aggressive animals, defecating away from their nests and, in general, fulfilling their natures as chickens. They fed on a combination of natural forage and waste products (table scraps, generally) from the farm household. Chickens were typically kept near the house and tended by women and children, who were not paid for their labor. "Egg money" is a phrase that refers to the income that a household would make by selling a few excess eggs off the farm. During this era, eggs were typically available only seasonally, as these free-ranging hens would turn their energies elsewhere as spring gave way to summer. This farmstead practice was first supplemented and then eventually often displaced by operations in which hundreds and eventually thousands of egg-laying hens were kept on litter in low buildings. Eggs were still gathered by hand, although now increasingly by low-wage workers, who also distributed milled feeds, collected dead birds, and were responsible for hygiene. The key technologies in this transition were in breeding, on the one hand, as the genetically diverse but broody flocks of yesteryear were displaced by leghorns that would lay eggs constantly, and electric lights, on the other, which regularized light cycles and broke the seasonal nature of egg production. Although still free ranging, birds in these systems were also beak trimmed to minimize cannibalism (Friedberg, 2008). This middle system, already well in place by the 1930s, was supplanted by the caged layer systems of the 1960s and 1970s in which hens were kept on wire and methods of egg collection and manure removal were completely automated. In its most economically efficient configuration, hens were stocked so densely in small cages so that some must stand on others. The trade association for the shell egg industry (i.e., eggs sold in shells) no longer recommends these stocking densities, although many producers who sell liquefied eggs to the food industry, as well as a minority of shell egg producers, still use them. Putting chickens in cages and putting the cages in environmentally controlled buildings requires large amounts of capital, energy, and technological "fixes." For example, it is necessary to run exhaust fans to prevent lethal build-up of ammonia. The value of each chicken is negligible so more chickens are needed; chickens are cheap, cages are expensive so as many chickens as is physically possible are crowded into cages. The vast concentration of chickens requires antibiotics, vaccines, and other drugs to prevent wildfire spread of disease in crowded conditions. Breeding of animals is oriented solely toward productivity; genetic diversity—a safety net allowing response to unforeseen change— is lost.

THE DAIRY INDUSTRY

Consider another example, the dairy industry, once viewed as the paradigm case of bucolic, sustainable animal agriculture, with grazing animals giving milk and fertilizing the soil with their manure for continued pasture. Although the industry wishes consumers to believe that this situation still exists—the California dairy industry ran advertisements proclaiming that California cheese comes from "happy cows," showing the cows in pastures—the truth is radically different. The vast majority of California dairy cattle spend their lives on dirt and concrete, and in fact never see a blade of pasture grass, let alone consume it.

Ubiquitous across contemporary agriculture, animals have been single-mindedly bred for productivity—in the case of dairy cattle, for milk production. Today's dairy cow produces three to four times more milk than 60 years ago. In 1957, the average dairy cow produced between 500 and 600 pounds of milk per lactation. Fifty years later, it is close to 20,000 pounds (The Colorado Dairy Industry, 2005; USDA/NASS, 2006). From 1995 to 2004 alone, milk production per cow increased 16%. A high percentage of the U.S. dairy herd is chronically lame (Nordlund, 2004; some estimates range as high as 30%), and these cows suffer serious reproductive problems. Whereas in traditional agriculture, a milk cow could remain productive for 10 or even 15 years, today's cow lasts slightly longer than two lactations, a result of metabolic burnout and the quest for ever-increasingly productive animals, hastened in the United States by the use of bovine somatotropin (BST) to further increase production. Such unnaturally productive animals naturally suffer from mastitis, and the industry's response to mastitis in portions of the United States has created a new welfare problem by docking of cow tails without anesthesia in a futile effort to minimize teat contamination by manure. (No husbandry person would so mutilate a cow, leaving her with an open wound and no way to chase flies.) Still practiced, this procedure has been definitively demonstrated not to be relevant to mastitis control (see Bagley, 2003). Arguably, the stress and pain of tail amputation coupled with the concomitant inability to chase away flies may well dispose cows to more mastitis. In a dairy, calves are removed from mothers shortly after birth, before receiving colostrum, creating significant distress in both mothers and infants. Bull calves may be shipped to slaughter or a feedlot immediately after birth, generating stress and fear. (Under husbandry, these animals would have been eaten as veal or sold locally.)

THE SWINE INDUSTRY

The intensive swine industry, which through a handful of companies is responsible for 85% of the pork produced in the United States, is also responsible for significant suffering that did not affect husbandry-reared swine. Certainly the most egregious practice in the confinement swine industry and possibly, given the intelligence of pigs, in all of animal agriculture is the housing of pregnant sows in gestation crates or stalls—essentially small cages. The recommended size for such stalls, in which the sow spends her entire productive life of about four years, with a brief exception we will detail shortly, according to the industry is 3 feet high ×2 feet wide ×7 feet long—this for an animal that may weigh 600 pounds or more. (In reality, many stalls are smaller.) The sow cannot stand up, turn around, walk, or even scratch her rump. In the case of large sows, they cannot even lie flat, but must remain arched. The exception alluded to is the period of farrowing—approximately three weeks—when the sow is transferred to a "farrowing crate" to give birth and nurse her piglets. The space for her is no greater, but there is a "creep rail" surrounding her so the piglets can nurse without being crushed by her postural adjustments.

Under extensive conditions, a sow will build a nest on a hillside so excrement runs off; forage an area covering a mile a day; and take turns with other sows watching piglets and allowing all sows to forage (Rollin, 1995). With the animal's nature thus aborted, she may exhibit bizarre and deviant behavior such as compulsively chewing on the bars of the cage, and endure foot and leg problems and lesions from lying on concrete in her own excrement. Keeping the sow confined is seen as more efficient, as she uses less feed and less labor is required to manage the animals.

Jim and Pamela Braun (1998), now activists opposing industrial pork production, explain how such changes seemed entirely rational to them when they were involved in installing a confinement system on their own farm. Their family-farm system of raising pigs outdoors in a barnyard began to fail in the late 1960s when they encountered difficulties in managing a porcine disease called MMA.

The only treatment was a series of shots strategically timed immediately after farrowing. If the sequence was missed, the piglets died. Even the tamest sows became very leery after receiving the first shot, and thousands of field-farrowed piglets died.

> In order to solve this and other problems in hog production, …[a] concrete pit was built, and concrete slats were installed to service a 144 foot by 44 foot farrowing house that was totally enclosed. … Each stall was its own self-contained sow hotel, with an automatic feeder, waterer, and manure removal system. We farrowed year round and the sows could not run from their shots, thereby helping to ensure the health and safety of the piglets. By the fall of 1974, six more buildings were added, and all of my father's hogs were on slatted floors and under aluminum roofs. … Confinement solved many problems associated with hog production. The pigs were protected from the elements, which increased their feed efficiency and their rate of gain. Sow productivity was increased because they could be weaned and rebred to farrow no matter the season or weather. Also, left on their own outside, hogs develop a social structure and a pecking order that is rigidly enforced. Only those at the top of the hierarchy thrive. They receive the larger portions of feed by bullying the smaller and weaker hogs. Stronger and more dominant pigs mutilate and often kill weaker and smaller pigs. Grouping hogs into smaller, protected numbers inside helped to reduce the "Boss Hog" syndrome. (Braun and Braun, 1998, pp. 40–41)

They go on to acknowledge weaknesses in these systems (such as antibiotic use), but the main thrust of their indictment of industrial pig production emphasizes unfair and illegal pricing structures, unfair credit practices, and state and federal tax credits that corporations (seeking to integrate pig production) use to put the squeeze on independent producers (Braun and Braun, 1998, p. 50).

Two striking anecdotes tellingly underscore the difference between husbandry agriculture and its practitioners and industrial agriculture and its practitioners with regard to animal welfare. A few years ago, we observed some sharply contrasting incidents that dramatically highlight the moral difference between intensive and extensive agriculture. That particular year, Colorado cattle ranches, paradigmatic exemplars of husbandry, were afflicted by a significant amount of scours. Over two months, I (BR) talked to a half dozen rancher friends of mine. Every single one had experienced trouble with scours, and every one had spent more on treating the disease than was economically justified by the calves' monetary value. When these men were asked why they were being what an economist would term "economically irrational," they were quite adamant in their response: "It's part of my bargain with the animal; part of caring for them," one of them said. It is, of course, the same ethical outlook that leads ranch wives to sit up all night with sick marginal calves, sometimes for days in a row. If the issues were strictly economic, these people would hardly be valuing their time at 50 cents per hour—including their sleep time!

Now, in contrast to these uplifting moral attitudes, consider the following: One animal science colleague related that his son-in-law, who was raised on a ranch, was an employee in a large, total confinement swine operation. As a young man, he had raised and shown pigs, keeping them semi-extensively. One day he detected a disease among the feeder pigs in the confinement facility where he works, which would necessitate killing them because this operation did not treat individual animals, their profit margin being allegedly too low. Out of his long established husbandry ethic, he came in on his own time with his own medicine to treat the animals. He cured them. Management's response was to fire him on the spot for violating company policy! He kept his job and escaped with a reprimand only when he was able to prove that he had expended his own—not the company's—resources. He continued to work for them, but felt that his health had suffered by virtue of what I (BR) have called the "moral stress" he experienced every day; the stress growing out of the conflict between what he was told to do and how he morally believed he should be treating the animals. Eventually, he left agriculture altogether. These contrasting incidents, better than anything else we know, eloquently illustrate the large gap between the ethics of husbandry and industry.

This chapter has detailed the historical/conceptual basis for recent societal demands regarding farm animal welfare. Chapter 5 will interpret what form the social demand is currently taking. Viewpoints and approaches from a multidisciplinary group of educators and scientists are offered.

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FARM ANIMALS IN DRAUGHT AND TRANSPORT

R. Anne Pearson

INTRODUCTION

Animals have been used for agricultural work throughout the centuries, starting soon after cultivation began. They have been used to carry loads, cultivate fields, and pull carts as well as more specific tasks in harvesting and processing crops and trees and in water lifting and irrigation. As such, they make significant, but often ignored contributions to society. Despite the increase in mechanization and use of motor [illegible] forms of power throughout the world during the twentieth and twenty-first centuries, many people today continue to rely on animal power to complement human labor in agriculture and transport.

USE OF ANIMALS FOR WORK

Cattle are the most commonly used animals for work throughout the world. Water buffalo are also used

in the humid tropics, and donkeys, horses, mules, and camels in the drier and temperate areas. Camels,

yaks, llamas, dogs, and elephants are used in speci■c tasks in speci■c environments and even small rumi

nants have been used to transport agricultural goods in mountainous areas where ■ocks move locations

with the seasons. Hence, working animals are maintained over a wide range of agro-ecological zones,

but are particularly common on small mixe d farms where rain-fed crops are grown mainly for food pro

duction. On 70% of farms in developing countries, draught animals and humans provide the only power

input. This is largely because on farms where size and scale of enterprise rule out mechanical power,

animal power is the only means the farmers have of cultivating land, other than use of family labor.

Although draught animals make their greatest contribution in agriculture, they also have an

important role in transport. It has been estimated that about 20% of the population of the world

relies largely on animal transport of goods. Animal carts and sledges are used to transport goods and

people in rural areas, especially where roads are unsuitable for motor vehicles. Animal power reduces

the drudgery of many of the household activities such as water and fuel collection. Where wheeled

vehicles cannot be used, such as in mountainous areas where roads are absent or poorly developed,

pack animals may be used to transport goods. Working animals, particularly in North Africa and

Asia, make a considerable and important contribution to the urban economy, being used to transport

produce within urban areas. Many of the people owning and using these animals are landless people

for whom the animal represents the main way of earning a living (see Pritchard, 2010).

Draught animals are also used in the timber industry and to power stationary equipment such as

water pumps, sugar cane crushers, and grinding mills. Less widespread is their use in the movement

of materials in small-scale building projects and road, dam, and reservoir construction. Working

animals can also be found in certain niche operations in industrial enterprises—transporting fruits

and sugar cane to road heads in plantations and moving bricks in brick factories, for example.

NUMBERS OF ANIMALS USED FOR WORK

It is impossible to obtain precise information on the number of animals used for work purposes in

the world. Most countries maintain statistics on livestock numbers, but for ruminants, they do not

identify use for work separately from use for beef or milk. In many places, large ruminants are

multipurpose, being used for work, calf production, and ultimately beef as farmers try to make the

best use of the feed resources available on their farms. Most donkeys and mules kept in developing

countries can be assumed to be kept mainly for work. At least 60% of the horses kept in the trop

ics are kept for draught work. In recent years, mules have become more popular—farmers in Latin

America are tending to replace their work oxen with mules and horses, and in North Africa, mules

are increasingly being favored over donkeys and horses where available. Speed, stamina, longev

ity, and an ability to maintain body condition on low protein, high ■ber diets have always made

mules popular but expensive to purchase. A review commissioned by the Food and Agriculture

Organization (FAO) gives details of recent trends in the use of livestock for work around the world

(Starkey, 2010).

SKILLS IN SOCIETIES USING ANIMAL POWER

In some areas of the world, draught animals are part of the traditional way of cultivating the land.

For instance, in Asia, North Africa, Ethiopia, Somalia, and in most of Latin America, people are

accustomed to training and managing their work animals. Implements are readily available locally,

usually made from local materials, with a local system to repair and replace them.

In other areas of the world, draught animal power is a more recent technology in cultivation

and crop production. For instance, until recently in West Africa and much of Sub-Saharan Africa,

animal diseases prevented the keeping of animals in many areas, and the traditional methods of

cultivating the land used manual labor only. It is only within the twentieth century that many people

have made use of draught animals on their farms in these areas. This follows the reduction in dis

ease vector habitat and increased availability of veterinary treatments for the diseases. Because of

the relative newness of the animal power technology in these areas, the support infrastructure is not always available locally. As a result, the animals and implements for purchase are expensive, and

they involve considerable investment by the farmers before the farmers can see the benefits and the

drawbacks for themselves. Often, implements are imported or manufactured by companies selling

a range of agricultural equipment. Although spares may be available, the manufacturers or retailers

can be some distance from the farm, and so repairs cannot be done in situ in the fields, as they often

can be in systems that are more traditional.

A lack of skill can often be seen where farm animals are used in transport enterprises in more

urban areas. In these operations, while some users have a long experience of working with animals,

others have little experience in livestock keeping. Equids tend to be favored over ruminants for their

greater speed in transport. The horse, mule, or donkey is used to provide a daily income, rather

as a vehicle would be used, and may be regarded as an expendable item by some, with little care

given in working practices or to the animal's management and health. Cattle, buffalo, and camels

generally fare better, largely due to their resale value for meat. Thus, it is not surprising that the

nongovernmental organizations (NGOs) and animal charities operating to improve working animal

welfare and health more often voice welfare concerns for the working horse and donkey than for

the ruminant.

PRODUCTION FROM WORKING ANIMALS

The output from work animals as a contribution to the [illegible] is more difficult to assess than

that from beef or dairy animals. Draught force, speed, work, and power have all been used to assess

output of working animals. Area ploughed or cultivated and distance traveled or load carried in

transport are outputs that can be measured easily. Less immediate, perhaps, but important to the

farmer, is the yield of the crop their working animals have helped to produce. Manure is an impor

tant by-product and one many small-scale farmers rely on to help maintain soil fertility, particularly

as the costs of chemical fertilizers continue to rise, putting them out of reach of many small-scale

farmers.

The amount of work an animal can do depends on the speed at which it works and the draught

force generated. For a particular draught force, the speed determines the power output of the ani

mal, that is, the rate at which the animal does the work. Therefore, these parameters are all closely

related. Various aspects of the animal, the implement, the environment, and the operator all interact

to determine the amount of work done in a day.

NUTRIENT REQUIREMENTS OF WORKING ANIMALS

Researchers have determined the nutrient requirements of working animals. Ruminants have

received the most attention (Lawrence and Pearson, 1991). However, interest in the performance

of working horses and donkeys has increased in recent years and their requirements are now more

fully understood (Perez, Valenzuela, and Merino, 1996; Pearson, 2005). The main requirement for work is energy. Extra requirements for protein, minerals, and vitamins for work are not as large and can usually be met by the increase in food given to meet the additional energy requirements. Energy requirement during a working day is more closely related to distance covered than to the draught force required to pull the implement or cart. Hence, animals doing light work such as pulling a cart can expend more energy in a day than animals doing heavy work such as plowing. Even when oxen are working for six to seven hours a day, their total energy expenditure in a working day is rarely more than two times maintenance requirements. Horses and donkeys can exceed a requirement of two times maintenance in a working day, but this is usually only when they are working steadily for six or more hours per day.

CONSTRAINTS TO PERFORMANCE

Many studies of the husbandry and use of working animals have been undertaken over the last 30 years (e.g., Copeland, 1985; EAAP, 2003; Pearson, Muir, and Farrow, 2008). As well as determining their capabilities, it is important to examine the constraints that can limit the contribution that working animals can make. High ambient temperature and disease (e.g., Jaafar-Furo, Mshelia, and Suleiman, 2008; Pritchard, Burn, Barr, and Whay, 2008) are well-known constraints to performance. However, the constraint most often identified by working animal owners is nutrition. The main problem is how best to meet the nutritional requirements for work with the feed resources available. Location and season determine which feeds are given to work animals.

For most of the year, work animals consume poor-quality forage diets that have a high cell-wall content, low nitrogen content, and poor digestibility. The metabolizable energy (ME) content of these diets is rarely more than 9 MJ ME/kg and crude protein of 90 g/kg dry matter (DM). Research studies have shown that any increase in rate of eating or improvement in digestibility on working days, which results from increased energy demand during working periods, is not sufficient to meet the additional energy requirement for most types of work when animals are fed such diets. In practice, most farmers working with animals expect their animals to lose weight during the work season unless the diet is supplemented with better-quality feed. The start of the cropping season, when animals are required to do the most work, is usually the time when food stocks are at their lowest, particularly in areas that have a long dry or cold season. This further exacerbates the problem of feeding for work.

The need for supplementation is greatest when animals are multipurpose, also being required to maintain weight (if ultimately they are to be sold for meat), or if they are cows used for work and are required to produce a calf.

Various strategies are available to improve feed supply to work animals, dependent upon the financial resources of the owner. The benefits of these techniques are well researched and widely reported (e.g., Pearson, 1995; FAO, 2010), but adoption by draught animal farmers is often poor.

THE FUTURE

Continued mechanization of agricultural practices will occur where it is economically feasible, and work animals will be replaced or used to complement mechanization on those farms that can justify hire or maintenance of two- or four-wheeled tractor power. On steep, inaccessible, or terraced hill sides, and on mixed farms where farm size and scale of crop production are small, animal power is still a better option than motorized power to supplement manual labor. On small farms of less than 3 ha, animal power can compete economically with gasoline-fueled tractors. Farmers using animal power will have to cope with competition for their land from a growing human population and increasing pressure on natural resources. This is likely to lead to the cultivation of more marginal land and greater use of animals for multiple purposes (e.g., manure, work, and milk, or work and calf production, or meat). Cropping of marginal land will require more attention to soil and water conservation and animal-drawn tillage techniques. Reduction of grazing land may require more farmers to move to a cut-and-carry system of managing their work animals. With the need to use resources more efficiently, it is important to recognize that animal energy can be harnessed to provide several income-generating activities for the smallholder farmer outside of their use in the production of food and cash crops and their role in manure production. More versatile, and therefore more frequent, use of animal power is an ideal way to spread the maintenance costs. A resting draught animal still uses resources, unlike a resting tractor. Hence, broader use of animal power

in the areas where it is found should also be encouraged. However, despite the value farmers put

on work animals in reducing their drudgery and supporting their food production and trade within

communities, as Starkey (2010) points out, animal power continues to have a “poor out-moded

image" within governments and many of the organizations and other institutions helping to improve

the livelihoods of their farming populations and those people supporting them. This is disappoint

ing in view of the continuing contribution of animal power to food security and farm income on

many small farms around the world.

SUMMARY

The use of animals for work and the general contribution that they can make to alleviating drudgery

in the livelihoods of the people who use them are discussed in this section. Cattle are the most com

monly used animals for work, followed by water buffalo and donkeys, but many other domesticated

animals are also worked in suitable environments where the need arises. In some areas, use of work

ing animals goes back many centuries; in other areas, use is more recent commencing within the

twentieth century. Outputs, feed requirements, and constraints to performance are also discussed.

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CROP AND ANIMAL PROCESSING WASTES

Wilson G. Pond and Kevin R. Pond

The human population is expected to increase from the current 6 billion to 8 to 9 billion by 2030.

Land available for food production is finite. The dramatic increases in food production resulting

from agricultural research and technology and other contributing advances have provided increased,

although not adequate, food for a growing world population. A major challenge to society now is to

continue to meet the demand for food and other products of agriculture within the constraints of a

finite land area and limited natural resources. One factor contributing to a solution is the improved

utilization of crop and animal processing wastes. Recycling of wastes from an array of animal and

plant sources is used effectively and widely in animal and crop production.

Uses of processing wastes are described as follows:

… food processing waste generally is either a potential feed ingredient for farm animal or pet food

or a potential nutrient source for crops. For example, in cereal processing firms such as breweries,

distilleries, and feed mills, by-products are not wasted but marketed as livestock feed ingredients.

Similarly, in meat processing firms, poor-quality meat by-products can be converted to better-quality human food products by means of breakdown and recombination of by-product components. Other by-products such as stomachs, intestines, and fish wastes are converted to pet foods. Finally, poor-quality effluent may be used on cropland as a nutrient source. (CAST, 1995)

In addition to animal feed constituents, inedible animal fats and other animal food processing wastes are used to produce soap, lubricants, cosmetics, candles, floor waxes, paints, varnishes, and other products of value to society.

Crop residues can be utilized in several ways: fuel, animal feed, bulking agents in manure and sewage sludge composting systems to produce organic wastes that are safe, stable, and unobjectionable for land application as fertilizer (CAST, 1995). These and other approaches are being used to reduce crop-processing losses. These advances include the following:

1. Composting of manure, bedding, dead animals, and hatchery wastes for land application.

2. Production of methane and other biogas fuels from the above composted products by anaerobic fermentation.

3. Improving the digestibility of nutrients in common feedstuffs to reduce levels of carbon (C); nitrogen (N) and phosphorus (P) lost in manure by using new technology (e.g., use of the enzyme phytase to improve utilization of P bound in plant feedstuffs).

4. Developing methods to reduce water volumes used in animal source food production.

5. Continuing pursuit of innovative, safe, and cost-effective ways of utilizing food-processing wastes in food animal production (CAST, 1995) to enhance sustainable agriculture through improved resource utilization. In addition, a worthwhile goal (CAST, 1995) for animal

agriculture is to reduce wastes during food processing that currently occur between harvest and delivery to the consumer. Meeting this goal will improve the welfare of food animals on a global basis by enhancing efficiency of utilization and improved nutrition of food animals.

SUMMARY

A major challenge to society in the twenty-first century is the rate of increase in the global popu

lation in a finite space on the planet. Large quantities of processing wastes are generated from

crop and animal production. These wastes are used to produce soap, cosmetics, candles, paints,

methane, ethanol, and many other products that improve the welfare of food animals globally by

enhancing efficiency of feed utilization and total food and feed production for a burgeoning human

population.

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ANIMAL FIBERS, HIDES AND PELTS, AND LEATHER

Wilson G. Pond and Kevin R. Pond

Wide genetic variation exists in mature size and other traits among animals native to different

regions and climates in which they are raised. This variation offers an opportunity for breed

ers to tailor the genetic base of animals to the local environment for improved performance

and efficiency. This concept has been adopted for use in temperate and tropical environments.

There are now more than 250 registries and associations in the United States and Canada that

promote particular species or breeds and that maintain breeding records (Bixby, Christman,

Christman, and Sponenberg, 1994). Some are concerned with the common breeds of farm ani

mals. Others focus on uncommon breeds of domestic animals and their crosses and on wild

species. Worldwide, there is interest in dozens of other species, hybrids, and breeds and their

crosses that have potential for commercial or subsistence level of food, hide, and fiber pro

duction. The U.S. National Research Council (1991) published a paper on micro-livestock, a

term used for species within which some individuals are phenotypically and genetically small

compared with the breed average. Such micro-livestock are found in cattle, sheep, goats, pigs,

and poultry in which some individuals are less than half the mature sizes of average repre

sentatives of the breed. Because of a survey of many animal scientists in 80 countries, it was

determined that about 40 breeds and species have sufficient genetic diversity to select for

small size to expand micro-livestock populations for use in developing countries. This would

allow taking advantage of the ecological interdependence of animal, plant, and human life, the

limited amount of the earth's surface that can be safely cultivated, and the innate advantages

of small animals to the subsistence family with no refrigeration, and with limited cash, space,

and animal feed. Animal well-being would be expected to improve because of a better match

of feed supply with animal needs.

Several species of mammals and birds contribute to society through production of wool, hair, feathers, leather, pelts, and other inedible by-products used in the manufacture of clothing, uphol

stery, carpets, bedding, and other products of the livestock industry. Here we describe brie¤y exam

ples of the importance of many domesticated mammals and birds in providing leather, ■bers, and

other by-products of the food animal industry.

MAMMALS

Cattle (beef cattle, dairy cattle, and swine), in addition to their production of meat and milk for food,

contribute signi■cantly to the economic value of the animal by yielding hides for leather and hair

used in clothing, accounting for approximately 50% of the total by-product value of cattle. Similarly,

sheep and goats produce wool and mohair, respectively, widely used in the clothing industry and

representing a signi■cant fraction of the total value of the products of the sheep and goat industry,

including meat and milk production.

Other mammals used in some cultures for both food and ■ber or hides include rabbits, camels,

llamas, alpacas, and vicunas (Ullrey and Bernard, 2000). Collectively, camels and llamas are known

as camelids, with an even number of toes on each foot and anatomical characteristics that distinguish

them from true ruminants. For example, the muscle attachments in the hind legs allow them to rest

on their knees when lying down. The Old World camelids include the two-humped Bactrian camel

and the one-humped Arabian or dromedary camel. The Bactrian camel is found in the cool desert

regions of Central Asia, while the dromedary is found in the hot deserts of North Africa. Both are used for transport, draft, meat, milk, fiber, and hides. The New World camelids include the guanaco, vicuna, and domestic llama and alpaca. The guanaco ranges from the Andean highlands in Ecuador and Peru to the plains of Patagonia. Vicunas live near the snow line of the Andes and have a highly prized fine wool fleece. Alpacas are bred primarily for their wool (Nowak, 1991). Llamas are used mostly as beasts of burden, but their meat may be used for food, fleece for clothing, hair for rope, and hide for leather. The four South American camelids (llamas, alpacas, guanacos, and vicuna) have the same chromosome number (Clutton-Brock, 1987) and will interbreed. Llamas and alpacas have become increasingly numerous in the United States as pets and for production of fibers.

BIRDS

Chickens, Ducks, Geese, and Turkeys

Commercial production of poultry and eggs in the United States began in the early 1800s and gradually evolved into a massive industry in the United States and globally. The poultry industry in the United States involves specialized production units devoted to broilers for meat and layer hens for egg production. Animal welfare concerns are of paramount interest for both industries. Ongoing changes in regulations regarding animal care and welfare of chickens (both broilers and layers) and other poultry continue to receive attention.

Vertically integrated production systems involving thousands of birds have been so success ful that today nearly all broilers in the United States are produced under some type of contract arrangement. The system is less frequently used in turkey production; however, if a contract is not used, production is coordinated by some other arrangement between the processor and the growers.

Modern chicken meat strains have been developed by cross-breeding layer lines with meat lines.

Turkey growing is similar to growing of broiler chickens, but involves a two-stage system in which day-old turkey poults are started in a brooder house and transferred to a larger growing house at about six weeks of age and marketed weighing 10 to 40 pounds.

Ducks and geese can be raised successfully in confinement on litter floors and do not require swimming water for growth, health, or reproduction. Young ducklings are sometimes started on slatted floors or raised wire. Commercial houses often provide an indoor litter area and an outside run.

Geese are excellent grazers and can be grown on pasture with limited supplemental feeding, although many geese are raised indoors without pasture.

Ostriches

Ostriches are large, flightless birds that are 2 to 2.4 m tall and weigh between 110 and 150 kg. Along with emus and several other large bird species, they are known as ratites. Ostrich feathers were used widely by the fashion industry nearly a century ago, and ostrich leather has been used in boots, shoes, and other leather goods for many years. The commercial ostrich industry began in the mid-nineteenth century in Africa, where the ostrich is indigenous. Ostrich breeding in the United States began in the 1980s. More than one-half of ostrich breeding in the United States is in Texas, California, Arizona, and Oklahoma. Some ostrich meat is imported from South Africa, but most is produced in the United States. A marketing system for ostrich leather is developing in the United States.

Emus

Emus are indigenous to Australia. Emus are 1.5 to 1.8 m tall and weigh between 50 and 65 kg at maturity. Emu production in the United States is relatively new, but is growing steadily. Products include garment leather, plumage, and meat for gourmet restaurants.

SUMMARY

Animals that produce food for people also provide a wide range of non-food products, including wool, mohair, and feathers, as well as hides and pelts used in clothing, shoes, and other leather products. A wide genetic variation within and between breeds and crosses results in opportunities to increase quantity and quality of animal products available for human populations everywhere and also offers new opportunities to enhance the welfare of both humans and animals.

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USE OF ANIMALS IN NUTRITIONAL AND PHYSIOLOGICAL RESEARCH

Wilson G. Pond and Kevin R. Pond

The use of farm animals and other animals as surrogates for humans, and animals in agricultural and biomedical research has a long history. Virtually every advance in human and veterinary medicine over the past century has a foundation in animal research. Nutrients, including vitamins, mineral elements, protein, amino acids, fat, and fatty acids known to be required by humans were discovered to a large degree by research in animals, including pigs and other farm animals, along with laboratory animals such as rats, mice, and other small animals and birds. Metabolic processes were defined, and the safety and effectiveness of consumer products, drugs, medical devices, and medical procedures were established.

Continuing research on techniques to repair congenital heart defects, control cancer, cure diabetes, reverse Alzheimer's disease, treat cystic fibrosis and muscular sclerosis, and control HIV and many other diseases requires the use of animals.

Diagnostic tools such as electrocardiography, angiograms, endoscopy, and cataract removal, as well as surgical procedures, organ transplantation (e.g., heart and heart valves), and artificial joint replacement continue to be developed because of animal

animal research as a vehicle for improved human health and well-being. Major advances have been made in the use of allotransplantation (human-to-human replacement) of kidneys and heart valves. Transplantation of animal organs in human patients (xenotransplantation) is complicated by tissue rejection of the xenograft. The use of pig hearts for xenotransplantation in humans offers promise (Platt, 2005). These well-established approaches for the bene■t of humans raise legitimate concerns and questions related to animal welfare. The ethical and social implications of the use of animals as surrogates for humans in biotechnology and biomedical research have been and continue to be addressed by the scienti■c community. (CAST, 1995; Clutton-Block, 1991; Crawford, 1996; National Research Council, 1996; Pond and Pond, 2000).

Worldwide, it is estimated that 50 to 100 million vertebrate animals are used annually (from zebra ■sh to nonhuman primates). Invertebrates and vertebrates, including mice, rats, ■sh, frogs, and animals not yet weaned are not included in the ■gures. One estimate of mice and rats used in the United States alone in 2001 was 80 million.

SUMMARY

Agricultural and laboratory animals have contributed to major advances in knowledge of human and animal health and progress in knowledge of nutrition and physiology. Most advances in human and veterinary medicine had a foundation in animal research. Metabolic processes were de■ned and the safety of consumer products was established with animals. The ethical and social implications of the

use of animals as surrogates for humans in biotechnology and biomedical research continue to be

addressed by scientists and palicymakers. See Chapter 14 for detailed accounts of these advances. Also,

see sections titled "Pharmaceutical and Biomedical Products," "Laws, Regulations, and Oversight

Mechanisms for Research Studies with Agricultural Animals in the United States," and "The Role of

Animal Agriculture in Enrichment of Youth Development Through Organized Hands-On Exposure to

High standards of Animal Welfare in Food Animal Production" for additional related information.

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PHARMACEUTICAL AND BIOMEDICAL PRODUCTS

Christian E. Newcomer

HISTORICAL HIGHLIGHTS OF PROGRESS IN THE USE OF FARM ANIMALS IN BIOSCIENCES

The use of farm animals for scientific advances in the
development of pharmaceutical products

and in biomedical research has a long historical precedent
dating to the antiquities and several

important contemporary medical practices had their origins
in farm animal studies. Regrettably,

animal welfare considerations were not featured in those
early studies. Galen, the famous physician

(of Greek origin) in Rome during the second century
vivisected pigs and goats in an effort to for

mulate an understanding of the circulatory system,
concluding erroneously that there were two

separate and unlinked systems. Avenzoar (also known as Ibn
Zuhr), a Spanish Muslim surgeon

and physician of the twelfth century rejected Galen's views
and established the general concept of

experimental surgery and that the principles of surgery
should be proven in animal subjects before

being applied to humans (Abdel-Halim, 2005). Among his many
other contributions, Avenzoar

performed a tracheotomy in a goat to demonstrate the safety
of this procedure for use in humans.

During the late nineteenth and early twentieth centuries,
drawing on the work investigating electri

cal conductivity of animal tissues, Dutch physiologist
Willem Einthoven developed a more sensi

tive string galvanometer than had previously been used for
recording heart muscle conductivity

and also successfully imaged and identified the different
wave formations of the electrocardiogram

(ECG), assigning the letters P, Q, R, S, and T to the
various deflections. He later commercialized

the first electrocardiograph and described the
electrocardiographic features of a number of car

diovascular disorders. Using Einthoven's device, Thomas Lewis, who is credited with introducing cardiology into clinical practice, published a paper detailing his careful clinical and electrocardiographic observations of atrial fibrillation (Lewis, 1912). Lewis had worked with a veterinarian to identify a horse with this condition. Using the string galvanometer's ECG recording, and then following the horse to the slaughterhouse, he could visually confirm the fibrillating atrium. The use of the ECG as a basic medical parameter has now been practiced for decades, and large animal models continue to contribute to the development of new measures for cardiovascular health in humans and animals through the collaborations of physicians, veterinarians, and scientists in various disciplines.

In addition to the role farm animal species have played historically in anatomical and physiological studies of import to the concepts of medicine and surgery, the observations of parallels and associations of contagious diseases in farm animals with humans has stimulated many important medical discoveries. In 1796, William Jenner conclusively documented that material in the crusts of cowpox lesions was capable of inducing protective immunity against smallpox, and introduced the concept of vaccination. Louis Pasteur, along with Robert Koch, is credited with the establishment of the germ theory. They used sheep to demonstrate the role of anthrax bacteria in disease and later to develop a protective vaccine for treatment of anthrax. Pasteur's studies on the elimination of bacterial contamination in fluids, or pasteurization, brought us safe milk products and served as the stimulus for Joseph Lister to develop the principles of aseptic surgery. In the late 1800s in the United States, Theobold Smith, a veterinarian studying cholera in swine, was the first to discover, isolate, and describe organisms in the genus Salmonella, a major group of pathogens in humans and animals although not the causative agent of hog cholera. The speed with which we could identify the retrovirus HIV as the causative agent of AIDS has its origins in studies with farm animals. Retroviruses were detected in solid tumors of chickens in the early twentieth century and have been studied extensively since that time (Medawar, 1997). Scientific efforts to understand the biology of bovine leukemia virus since the 1970s have aided in the identification of HTLV-1 and HTLV-2 retroviruses that cause human cancer. There are many examples of human health improvement resulting from product development for farm animals. For example, ivermectin, an anthelmintic compound, was developed primarily for the elimination of parasites in livestock. However, due to the positive therapeutic effect of ivermectin in equine parasitic (Onchocerca) eye infections, the agent was used in human clinical trials for the treatment of river blindness caused by the human parasite Onchocerca volvulus. When this program was launched, 1 million people in West Africa alone (and 18 million worldwide) suffered from this parasitic infection; 100,000 of these had serious eye problems (including

35,000 who were blind). Because of this intervention, ocular Onchocerca infection has largely

been eliminated as a public health problem and as an obstacle to socioeconomic development

globally.

CURRENT ADVANCES IN THE USE OF FARM ANIMALS IN THE DEVELOPMENT

OF PHARMACEUTICAL AND BIOMEDICAL PRODUCTS

Farm animals continue to play a significant role in pharmaceutical and biomedical product develop

ment, both as an extension of the inherent characteristics that made them valuable models initially

and now increasingly as a result of the fact that they can be genetically engineered to express novel

products of medical and commercial importance (e.g., in the mammary gland to be harvested from

milk). Farm animals also have been recognized for several decades to be useful models for spon

taneous animal and human disease, many of which have a clear genetic underpinning, and these

animal models are invaluable for the elucidation of the basic disease mechanisms (Andrews, Ward,

and Altman, 1979). In the era of modern molecular biology and genetic engineering, genetically

engineered rodent models have become the favored models for understanding molecular mecha

nisms and developing therapeutic interventions such as new pharmacological compounds, biophar

maceuticals, small interfering RNAs, and gene therapy. However, once the proof of principle for

these compounds is met in small animal models, a resurgence in the use of the larger farm animal models for the demonstration of their clinical efficacy is only likely if relevant animal models are available. A few representative examples of the use of farm animals for the development of pharmaceutical and biomedical products are presented in the following paragraphs.

Birds

Chickens and, to a lesser degree, quail are used for the generation of polyclonal antibodies (the active component in antiserum), which can be simply extracted from the yolk of the immunized bird. The immunization of hens represents an excellent alternative for the generation of polyclonal antibodies and affords a substantial animal welfare benefit because egg collection is noninvasive compared to the usual method of collection of serum for isolation of antibodies that requires repeated blood withdrawal (Hau and Hendriksen, 2005). Moreover, chickens are inexpensive to maintain and produce abundant numbers of eggs. These antibodies can be used as experimental or diagnostic reagents and are showing promise as therapeutic agents in animal and human diseases, particularly for infectious diseases of the gastrointestinal tract. Chickens with ovarian cancer have molecular markers of disease similar enough to those in humans to define a model for predicting the stage of progression of human ovarian cancer (Gonzalez Bosquet et al., 2010). In addition, genetically modified chickens have been developed that fail to propagate avian influenza virus and, therefore, do not perpetuate the cycle of contagion (Lyall et al., 2011). This approach could be used in commercial flocks and thereby eliminate their contribution to the spread of pandemic flu and the emergence of new strains

of influenza through interspecies transmission of viral infections.

Mammals

Equine species are used for the production of equine estrogens, which are useful therapeutic agents

in the management of some of the conditions and symptoms of the postmenopausal period in women

(Stovall, 2010). In addition, the horse has been used historically for the development of antiserum to

toxins (e.g., tetanus antitoxin) and to snake and other venoms. Although horse antiserum has been

replaced in many instances, especially since its use is highly associated with "serum sickness,"

which is an immune complex disorder, there are still many types of venom for which it remains the

sole therapeutic agent. In many regions of the world, purified horse antiserum is also the primary

therapeutic agent for botulism.

Small Ruminants

Sheep and goats are also used in the production of antiserums (antibodies) for use as experimen

tal and diagnostic reagents and, to a lesser degree, as therapeutic antitoxin agents for enveno

mations (Seger and Krenzelok, 2005). Sheep and goats are also occasionally used as models to

train personnel in the techniques of minimally invasive surgery involving the urogenital tract

and as models for the study and treatment of urologic conditions. Sheep and goats have been used

extensively for the development and testing of artificial joints, bone cements, bone and cartilage replacement products, and therapeutic approaches to osteoarthritis (Martini, Fini, Giavaresi, and Giardino, 2001). Sheep and goats also have been used for the development and testing of various types of cardiac assist devices (Weiss, 2005) and for materials used in vessel surgery and repair. Genetically modified goats have been created to produce valuable novel proteins in their milk, allowing ease of collection and an abundant supply following purification of the desired product. One product reportedly nearing approval by the Food and Drug Administration is produced from goats genetically modified to produce the human form of the protein antithrombin, which prevents blood clotting (http://www.gtc-bio.com/). One in 5000 individuals produces insufficient amounts of antithrombin, and patients prone to clotting following coronary bypass surgery may also benefit from this product to prevent excessive clotting and complications such as stroke. Another genetically modified goat model developed at the University of California-Davis produces lysozyme in its milk; this molecule is important for the destruction of harmful bacteria in the digestive tract, offering some hope of a convenient means for protecting infants in the developing world where diarrheal disease kills 2 million infants annually (Maga et al., 2005). A goat also has been developed that produces the soluble components of spider silk (the material of the spider's web). This material is stronger and more flexible than steel and is a lightweight alternative to carbon fiber (Boyle, 2010). It is important to note that in each of these genetically manipulated goat lines, the animals are behaviorally, clinically, and reproductively normal, which limits the ethical and practical issues related to the expansion and maintenance of their populations (Fahrenkrug et al., 2010).

Cattle

Genetically modified cattle that are otherwise normal in phenotype have been generated using various types of transgenic technology. One genetically modified bovine developed by the USDA secretes the antimicrobial protein lysostaphin in the milk, which confers greater resistance to the development of mastitis in the cow from staphylococcal infection. This achievement marks a significant step toward the development of disease-resistant livestock. Using a different transgenic approach, scientists inserted a human artificial chromosome containing the entire human immunoglobulin loci into the germ line of cows (Robl, 2007). These cattle generate human antibodies in their blood, creating the potential for the generation of a variety of valuable medical therapeutic products. The products have application to the management of antibiotic-resistant infections, immune deficiency, biodefense, and many other immune-mediated conditions simply through immunization of the animal with the agent of interest followed by the collection and purification of the antibodies from the blood of the cattle (http://www.hematech.com/). Bovine calves also have been used extensively since the mid-1960s for the development and testing of artificial hearts, cardiac assist devices, other cardiovascular instruments, and materials to overcome disease conditions of the heart (Delano, Mischler, and Underwood, 2002).

Swine

Swine have been an especially prominent animal model for the investigation of cardiovascular diseases of humans and for the development of apparatus, materials, and approaches used in the medical and surgical management of human cardiovascular diseases. The cardiovascular system of swine has unique anatomical and physiological parallels with that of humans. Swine are omnivores and readily susceptible to dietary-induced atherosclerosis, a major contributing factor to human heart and vascular disease (Swindle, 1998). This has facilitated their extensive use for the development of techniques to treat atherosclerosis and its complications. The skin of pigs also has characteristics very similar to those of humans, making them extremely valuable models for plastic surgery and studies of skin injury and repair and associated therapeutic agents. Swine are proven to be valuable in many other clinical research applications (Laber et al., 2002). Due to their abdominal size and overall comparability of the anatomy of their abdominal organs to those of humans, swine have served as the primary model for surgical training in laparoscopic and endoscopic techniques and the development of new surgical instruments and surgical procedures (Srinivasan, Turs, Conrad, and Scarbrough, 1999; van Velthoven and Hoffmann, 2006). Approximately 1000 articles have been published on the use of swine in this area alone. Pigs also have been genetically modified for various research and future commercial applications. In one of the genetically modified models, the cellular surface marker responsible for the acute rejection of pig organs by humans and other primates has been removed, which offers the prospect that pig organs might one day be available for xenotransplantion into humans (Platt, 2001, 2011a,b). Organs from these pigs have a markedly prolonged survival rate compared to that for normal pig organs transplanted into nonhuman primates (Ekser et al., 2010). Through additional genetic modification to further protect graft survival via modulation of the immune response in the graft recipient (i.e., nonhuman primate or human), these pigs may solve the problem of the critical shortage of human-compatible donor tissues, cells, and organs (http://www.revivicor.com/index.html).

SUMMARY

Farm animals have filled an important niche in our efforts in biological discovery, product and technique development, and product testing historically and into the current era. The use of farm animal species as animal models will likely intensify as cellular and molecular biology advances yield new approaches to disease therapy and leaps in technology provide new products that must be tested in animal models deemed clinically relevant to humans. In addition, the husbandry, management systems, and veterinary care of farm animals are already well established, of high quality, and subject to continuous review and improvement efforts.

with due consideration of satisfactory

ethical review and outcomes, this facilitates an easy transition from our humane use of farm ani

mals for the natural characteristics we value (i.e., food and fiber) to the pursuit of newly introduced

characteristics by transgenic technology that benefit the advancement of medicine and improve

patient care.

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[illegible] REGULATIONS, AND OVERSIGHT MECHANISMS FOR RESEARCH

[illegible] WITH AGRICULTURAL ANIMALS IN THE UNITED STATES

Christian E. Newcomer

INTRODUCTION

The legal and regulatory framework for the oversight of research using laboratory animals in the

United States is now approaching its 50-year landmark, and the use of agriculturally important

mammalian species as animal models pertaining to the exploration of the biology and diseases

of humans has fallen under the purview of these regulations for most of that period. The regula tory framework has strengthened over time and has become considerably more focused with the significant and convergent changes that occurred during the mid-1980s. In 1985, working under independent statutory authorities, the Animal Welfare Act Regulations (AWAR) (AWA, 1990) and the Public Health Service Policy on the Humane Care and Use of Laboratory Animals (PHS Policy) (PHS 2002) adopted new progressive provisions emphasizing institutional accountability. The policies and regulations worked together to harmonize the approach and expectations for federal oversight of the care and use of animals used for research in the United States. The convergent interest of these regulations was the manifold considerations of and attention to the promotion of animal welfare and the controls that needed to be in effect to detect and impede potential points of failure in assuring animal welfare within institutions. The key regulatory advancement was the requirement that an organization conducting animal research that fell under regulatory jurisdiction must develop an institutional animal care and use committee (IACUC). The IACUC serves to foster, review, and monitor an institution's program of animal care and use to ensure ongoing regulatory compliance and to provide a thoughtful and deliberative platform for the institution to address emerging needs of animal models and scientists as scientific knowledge advances and new requirements and opportunities become evident. Two excellent professional guidance documents used in conjunction with the regulatory oversight of research in the United

States and abroad also re-emphasize the importance of the IACUC in meeting the institution's requirements for the care and use of research animals. These are The Guide for the Care and Use of Agricultural Animals in Research and Teaching, 3rd edition (Ag Guide) (FASS, 2010) and The Guide for the Care and Use of Laboratory Animals, 8th edition (Guide) (ILAR, 2011). These two important guidance documents are also used as primary standards for the independent, voluntary, peer-review accreditation program performed by the Association for Assessment and Accreditation of Laboratory Animal Care International. The balance of this section briefly explains the interrelationships and key features of the regulatory and oversight entities, mechanisms, and guidance documents mentioned.

DEFINING THE REGULATORY FRAMEWORK AND GUIDANCE DOCUMENTS

Congress enacted the original legislation in the United States governing research animal care in 1966 under Public Law (P.L.) 89-544 as the Laboratory Animal Welfare Act (LAWA). At that time, the LAWA regulated animal dealers that handled dogs and cats and laboratories that used dogs, cats, rabbits, guinea pigs, hamsters, and nonhuman primates. During the 1970s' amendments under P.L. 91-579, Congress changed the name of the law to the Animal Welfare Act (AWA, 1990) and authorized the Secretary of Agriculture to regulate other warm-blooded animals when used in research, exhibition, or the wholesale pet trade. This was the first time that agricultural animals used in some research applications were included in the regulatory framework. The basis for cover

age under the AWA regulations rests with its definition of the term "animal" and there are important

exclusions. Specifically, quoting from the section on definitions in the AWAR,

This term (animal) excludes birds, rats of the genus Rattus, and mice of the genus Mus, bred for use

in research; horses not used for research purposes; and other farm animals, such as, but not limited to,

livestock or poultry used or intended for use as food or fiber, or livestock or poultry used or intended for

use for improving animal nutrition, breeding, management, or production efficiency, or for improving

the quality of food or fiber.

Thus, a vast majority of the research activities currently conducted in agricultural species is not

covered today by the AWAR, but with the growth of agriculturally important animal models in a

wide variety of facets of biomedical research and product development, the coverage of agricultural

animals is increasing. The Research Facility Inspection Guide (APHIS, 2001) provides the crite

ria and examples used by the Veterinary Medical Officers (VMO) from APHIS's (APHIS, 2006)

Animal Care (AC) program to determine whether the farm animals in particular studies at an insti

tution should be included in the inspection process.

An AC VMO inspects institutions registered and licensed as research animal facilities at least

annually, and their findings are the basis for evaluating the institution's regulatory compliance.

Institutions are expected to have effective IACUCs, personnel training efforts, and programs of vet

Programs are to ensure ongoing compliance with the AWAR. With regard to compliance with standards, institutions are expected to adhere to Part 3 of the AWAR (Standards), which covers facilities and operating standards, animal health and husbandry standards, and transportation standards. Although the standards are specific and even prescriptive for many of the covered species, the standards in the AWAR for farm animals are written in general terms. In instances where the institution's provisions of oversight are deemed ineffectual, regulatory enforcement is achieved through increased inspections, the opportunity for prompt corrective action in many instances, the issuance of fines for serious or repetitive noncompliance, or the suspension or revocation of licensure.

Institutions that receive funding from the Public Health Service are required to comply with the Public Health Service Policy on the Humane Care and Use of Laboratory Animals (PHS Policy). As authorized by the Health Research Extension Act of 1985, the PHS Policy requires institutions to establish and maintain measures to ensure the appropriate care and use of all vertebrate animals involved in research, research training, and biological testing activities conducted or supported by PHS. Some other federal agencies also expect the programs operating under their jurisdiction to follow PHS Policy standards (e.g., the Veterans Administration Policy requires compliance with the PHS Policy even if PHS funds are not received by the research unit in question). The PHS Policy requires compliance with the Guide and the American

Veterinary Medical Association Guidelines for Euthanasia. Institutions are required to have an approved Assurance on file with the Office of Laboratory Animal Welfare within the PHS. The Assurance document explains the institution's provisions for compliance with the Guide. It is permissible for an institution to delimit the scope of PHS coverage in its Assurance extending compliance with the provisions of the Guide only to those studies required by the source of funding, but excluding all other studies. Institutions that choose to take this approach, therefore, could make the claim that many studies conducted in farm animals for the purpose of improving food and fiber production are required to comply with Guide standards. On the other hand, if the institution states that all vertebrate animals at the institution are covered by the Assurance, then the PHS will expect the institution to comply with either the Guide or the Ag Guide when agricultural species are used in research or teaching depending on the source of funding for the activity and other discriminating criteria provided by the institution.

RECENT REVISION OF EXISTING GUIDES

The Guide for the Care and Use of Laboratory Animals has recently been revised, and the release of the Guide, 8th edition (ILAR, 2011) has already generated considerable interest and discussion. It is a very comprehensive document that expands the discussion of many issues in animal care and use significantly in comparison to the previous edition published in 1996, and it offers an institution a roadmap to establishing a sound program for the purpose of biomedical research, testing, and teaching in research animal models. The Guide describes the essential components of an institution's overall animal care and use program; considerations and provisions for the animals' environment, housing, and management; multiple facets of a competent program of veterinary care; and the requirements for an adequate physical plant. The Guide also addresses the issue of dichotomous treatment of agricultural animals in research depending upon whether their use is aligned with a biomedical inquiry versus an agricultural inquiry. It also notes that the institutions occasionally find that the categorization of research animal studies presents a dilemma. It suggests, therefore, that IACUCs should make the decisions concerning the standards of care for the agricultural animals used in research studies based upon the researcher's goal and the concern for well-being of the animals. The Guide also acknowledges that the Ag Guide is a useful resource for agricultural animals maintained within typical farm settings.

The Ag Guide, 3rd edition, is a scholarly and authoritative professional guidance document published by the Federated Animal Science Societies (FASS) in 2010. Although the document lacks regulatory standing, it carries enormous credibility by virtue of its expert authorship and the careful consideration and extensive review of scientific literature on many topics. As noted previously in this section, there are many circumstances in which agricultural animals could be used in research without any regulatory oversight if neither the funding source for the research nor the category of the research (as non-food and fiber related) dictated. The voluntary adoption of the recommendations of the Ag Guide by institutions conducting studies under these circumstances would be an ideal solution for the protection of the quality and integrity of the scientific research, as well as an effective tool in assuaging public concerns about the use of agricultural animals in research. Although it seems fair to speculate that most institutions subscribe to the Ag Guide in these situations, the number of outliers is unknown. The Ag Guide has many parallels with the Guide, especially pertaining to the expectations of an institution's essential policies and provisions for the program of animal care and use. For example, it identifies the need for a properly structured and functioning IACUC with written operating procedures for animal health care, biosecurity, personnel qualifications and training, occupational health, and special considerations. Individual chapters are dedicated to animal health care including husbandry, housing and biosecurity, environmental enrichment, animal handling, and transport, as well as six key animal species areas. There are also several key inconsistencies between the Ag Guide and the Guide in the areas of space recommendations, sanitation schedules, and environmental conditions, which will require reconciliation by the IACUC through the review of scientific literature and expert opinion or by prevailing regulatory mandates.

Since 1985 when IACUCs were established by U.S. Public Law as noted previously, they have been recognized as a seminal development for the improvement of the welfare of animals used in research. The regulators, the regulatory community, and the professional scientific societies who produce guidance documents have acknowledged the importance of strong internal institutional oversight provisions embodied in the IACUC. In addition, the guidelines or national legislation for animal care and use in research in many other countries mimic this general approach, which further validates its value. There are variations in the committee structure and function of IACUCs across the United States with respect to regulations and the non-regulatory guidelines offered by nongovernmental agencies or professional societies, which are beyond the scope of this discussion. However, the central features are very similar. Committee members should have appropriate training and expertise and represent a variety of perspectives to achieve an appropriate balance in their oversight of the program and the approval of research activities. For example, the Ag Guide, which has enhanced membership requirements, specifies that committee members should include an agricultural scientist with teaching or research experience; an animal, dairy, or poultry scientist who has agricultural animal management experience; a veterinarian knowledgeable about agricultural animal medicine; a member whose primary concerns are in an area outside of science; and a person who is not affiliated with the institution and who represents general community interests in the proper care and treatment of animals. The IACUC is required to review and approve, when appro priate, animal use protocols for research and teaching at the institution to ensure that it is justified, scientifically sound, prudent, and conducted under conditions that consider and preserve animal welfare throughout all phases of the activity. In addition to the information in the regulations, the Guide and the Ag Guide aid IACUCs in conducting a conscientious and competent protocol review process. There are other sources of extensive information on this subject (Silverman, 2007). The IACUC is also empowered to disapprove inappropriate proposals and suspend ongoing activities that prove to compromise animal welfare. In addition to the vital function of protocol review and approval, IACUCs are responsible for evaluating the facilities available for research animal studies and the entire program of animal care and use at the institution. Programmatic review entails knowing and critically assessing the institution's resources pertaining to the following requirements for acceptable animal care and use: Conditions of the physical plant in animal facilities and animal study areas; expertise, training, and staffing levels of personnel supporting or conducting research with animals; occupational health and safety concerns related to animal care and use and experimental conditions; provisions for veterinary care to ensure the health, welfare, experimental reliability, and robustness of animals used in research in accordance with prevailing standards; and assurance that the operations provide the appropriate environment, housing, husbandry, and management of research animals. Through the IACUC's rigorous process of facility and programmatic review, the institution, at a minimum, is afforded the opportunity to plan and take timely, effective, and corrective actions to correct weaknesses or deficiencies in the institution's resources dedicated to the care and use of animals in research and teaching. Under optimal conditions, the IACUC can play a helpful role in encouraging the institution to be forward thinking in initiatives to meet emerging scientific and educational needs in a contemporary manner.

VOLUNTARY PARTICIPATION OF INSTITUTIONS IN AAALAC

Many institutions choose to participate in a voluntary, confidential, expert peer-review accreditation program developed by the Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC International). This includes institutions that fall under regulatory mandates in the United States or other regions of the globe, as well as programs that operate in unregulated environments. AAALAC International is a non-profit, nongovernmental organization that has operated its accreditation program for more than [illegible] years and now accredits more than 830 organizations in 33 nations around the globe. Within the United States, more than 600 organizations are accredited and these include university, pharmaceutical, governmental, commercial, and contract research programs with substantial agricultural components. Among those accredited in the United States are 19 Land Grant Institutions and other universities emphasizing agricultural research and teaching programs. AAALAC International accreditation relies upon three primary

standards. These are The Guide, The Ag Guide, and the new European Directive 2010/63/EU on

the Protection of Animals Used for Scientific Purposes, which contains accommodation and care

standards from the European Treaty Series 123. The peer-review process is comprehensive and

entails the thorough review of an institution's facilities, policies, programs, procedures, and person

nel qualifications in support of animal care and use programs. Institutions must meet all regulatory

requirements that pertain to activities with research animals in their environment as well as relevant

portions of the standards identified previously. The experts chosen to conduct the site visit are

selected with due regard to the type of institution, the animal models used in research and teach

ing, the scientific areas emphasized in the institution's research, and the avoidance of any conflicts

of interest. Subsequently, the experts on the site visit team must engage a much larger delibera

tive body, the Council on Accreditation, who determines whether accreditation should be granted.

Organizations that attain accreditation must meet or exceed applicable standards and maintain

quality programs that ensure animal health, well-being, and welfare as the platform for productive

scientific inquiry using animal models for research.

SUMMARY

The regulatory standards and framework governing the use of farm animals in research have

improved significantly since the mid-1980s, and many organizations are required to comply with these regulations. In addition to the mandated regulatory standards that are selectively applied, the

number of organizations electing to adopt and adhere to the guidelines proposed in the authoritative

reference, The Ag Guide, and participate in the voluntary, peer-review accreditation program of

AAALAC International is increasing. The combination of the mandated and voluntary provisions

for the oversight of the use of farm animals in research, teaching, and testing appears to be work

us well and increases our prospects of ethical and successful outcomes in these endeavors. These

measures also help build the public's support and confidence in our use of farm animals in research

applications. However, they do not comprise an impervious system of farm animal research over

sight sufficient to detect and correct problem areas in every instance.

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During this same period, FFA was being established through the Smith-Hughes Vocational

Education Act in 1917. Similar to the origins of 4-H, the idea for what would be known as FFA was

initiated with the introduction of agricultural clubs in schools with Virginia being the first to estab

lish such a club. The actual formation of the FFA was in 1928. In terms of membership growth, the

trends were the same for FFA as for 4-H. The FFA program experienced tremendous growth during

the late 1920s and into the 1930s.

It is also worth pointing out that high school students learned about animal agriculture through

agriculture science courses offered in middle and high school. This is separate from 4-H club and

FFA chapter experiences. These classes demonstrated academic rigor and relevance related to ani

mal welfare. More than a “club,” classroom instruction afforded a focused opportunity of learning

and it was then complemented by the “hands-on” aspects of supervised programs for agriculture

experience.

Since 1939, both 4-H and FFA have evolved to include even more members and a wide variety

of programs and projects. However, the pledges and mottos remain the same. The 4-H motto and

pledge are as follows:

In support of the 4-H club motto, to make the best better, I pledge my head to clearer thinking, my heart

to greater loyalty, my hands to larger service, and my health to better living, for my club, my commu

nity, my country, and my world.

The FFA motto is as follows:

Learning to do, doing to learn, earning to live, and living to serve.

Obviously, these mottos help to reveal the relevance of these organizations in the past, the present, and into the future. In addition, they help to recognize the fact that these youth members who exhibit livestock projects at county, state, and national livestock shows and rodeos are indeed "learning by doing" and "making the best better."

THE GROWTH OF LIVESTOCK PROJECTS

Calf, swine, and dairy clubs increased significantly during World War I. Reck (1951) said that these projects increased because private donors supported these efforts by donating livestock to the youth for their projects. By 1917, states began to have youth shows. According to Wessel and Wessel ([illegible]), the Minnesota State Livestock Breeders Association was the first show to offer youth cash prizes and to help counties hold calf and colt shows. By 1917, two men, T.A. Erickson and W.A. McKerrow, joined this livestock breeders association to establish Minnesota's first junior livestock show (Reck, 1951).

Livestock shows have grown since 1918 and become a symbol of the 4-H and FFA youth organizations. Although it is very challenging to determine the total number of livestock projects exhibited by youth across the nation, a study in Texas in 2000 revealed that Texas 4-H and FFA members accounted for over 70,000 entries for cattle, swine, meat goats, and sheep across the state (Boleman, Howard, Smith, and Couch, 2001).

STUDIES SPECIFIC TO YOUTH LIVESTOCK PROJECTS

According to Boyd, Herring, and Briers (1992), the development of life skills through experiential learning is the cornerstone of the 4-H program and the same can be said for FFA. More specifically, livestock projects are an extremely valuable vehicle for developing life skills.

A study conducted by Hard (1996) asked 4-H alumni to reflect on the impact that exhibiting livestock projects had on their development of life skills. According to respondents, the meaningful life skill impacts were accepting responsibility, relating to others, spirit of inquiry, decision-making, public speaking, maintaining records, and building positive self-esteem.

Rusk, Martin, Talbert, and Balshweid (2002) came to similar conclusions from their study of Indiana 4-H youth that judged livestock. For this study, the most meaningful results noted were that youth learned how to defend a decision, gained knowledge of the livestock industry, and developed oral communication skills, as well as decision-making skills, self-confidence, problem solving, teamwork, self-motivation, self-discipline, and organizational skills.

Finally, Boleman, Cumming, and Briers (2004) ascertained the life skills gained from youth exhibiting beef, swine, sheep, or goat livestock projects. They concluded that the five highest life skills gained were accepting responsibility, setting goals, developing self-discipline, self-motiva tion, and knowledge of the livestock industry.

THE ROLE OF 4-H AND FFA YOUTH IN ENHANCING WELFARE OF ANIMAL AGRICULTURE AND COMPANION ANIMALS

The learning process about animal care responsibilities begins with the careful example and influence of adult leaders and advisors responsible for training and guiding youth. This influence is fundamental to the continuance of animal-friendly husbandry practices that ensure animal health and well-being. Animal welfare is indeed one of the fundamental educational priorities within youth and animal projects. Over the past 10 years, many state 4-H and FFA programs have implemented quality assurance programs that ensure youth are learning and applying the appropriate quality assurance practices. These include Pork Quality Assurance and Quality Counts (Boleman, Chilek, [illegible], Kieth, and Sterle, 2003).

SUMMARY AND CONCLUSIONS

Youth development is definitely enhanced by hands-on experience gained through interactions with animals. Many people hear testimonials from adults who once raised livestock as youth to learn about their positive experiences and the impact raising these livestock had on their lives. In many instances, the livestock project enhanced the child's relationships with his or her family and friends. The livestock project requires the help and cooperation of family members. Parents, siblings, and grandparents often become involved in the project. It helps the family unit develop common goals and an understanding of the financial side of agriculture.

Quite simply, the farm animals they raised

helped shape who they are, the character attributes they possess, and the positive life skills they

develop and use every day of their lives.

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EDITORS' NOTE TO THIS CHAPTER SECTION

The book editors commend the authors of this chapter section for the historical overview of the important role that 4-H and FFA programs have in youth development and in animal welfare improvements in farm animals. Also included in this chapter section is a brief account of a major challenge to the ideals and mission of leaders of 4-H and FFA. In the last decade of the twentieth century and extending into the early years of the twenty-first century, episodes of cheating to alter animal appearance or weight have been documented. These cases of animal abuse and unethical behavior among adult and youth exhibitors in show rings have been chronicled in the popular press and consequently the issues and remedies have been addressed by youth leaders, show managers, and judges. A strict code of ethics is required in the show ring. 4-H and FFA are primarily youth development organizations. As emphasized by the authors of this chapter section, the exhibition of projects is only the final stage of a process intended to develop responsibility, goal-setting, and leadership skills. A major role of 4-H and FFA in livestock projects is to advance the concept of improving farm and companion animal welfare as well as personal integrity in future leaders in our society.

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ENDNOTES

1 Commission members were: former Kansas Governor John Carlin, chair; Michael Blackwell, DVM, MPH former Dean of the College of Veterinary Medicine at the University of

Tennessee/Knoxville, Assistant Surgeon General, USPHS (Ret.), vice chair; Brother David Andrews, CSC, JD; Fedele Bauccio, MBA, Founder and CEO of Bon Appetite Management Company; Tom Dempster, South Dakota State Senator; Dan Glickman, JD, former United States Department of Agriculture Secretary; Alan M. Goldberg, PhD, Johns Hopkins Bloomberg School of Public Health; John Hatch, DrPH, University of North Carolina; Dan Jackson, Montana Cattle Rancher; Frederick M. Kirschenmann, PhD, Distinguished Fellow, Leopold Center for Sustainable Agriculture, Iowa State University; James Merchant, MD, DrPH, Dean, University of Iowa School of Public Health; Marion Nestle, PhD, MPH, Department of Nutrition, Food Studies, and Public Health, New York University; Bill Niman, founder of Niman Ranches, Inc.; Bernard Rollin, PhD, Distinguished Professor of Philosophy, Colorado State University; and Mary Wilson, MD, Associate Professor, Harvard School of Public Health, Associate Clinical Professor, Harvard Medical School.

2. Source: fawc, 2007 at http://www.fawc.org.uk/freedoms

3. Joy A. Mensch, Professor, Department of Animal Science, University of California, Davis; Harvey James, Associate Professor, Department of Agricultural Economics, University of Missouri; Edmond A. Pajor, Associate Professor, Department of Animal Sciences, Purdue University; and Paul D. Thompson, W.K. Kellogg Professor of Agriculture, Food, and Community Ethics, Michigan State University.

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SECOND VIEWPOINT: FROM A SUSTAINABILITY

AND PRODUCT QUALITY PERSPECTIVE

Donald M. Broom

INTRODUCTION

The scientific study of animal welfare has developed rapidly in recent years. The concept is defined here and its relationship with other concepts, such as health, stress, and needs, is discussed.

The welfare of animals is a matter of substantial public concern and is an aspect of our decisions about whether animal usage systems are sustainable. A system that results in poor welfare is unsustainable because it is unacceptable to many people. The various criteria for sustainability are briefly discussed. The quality of animal products is now judged in relation to the ethics of production, including impact on the welfare of the animals, as well as on price, taste, and consequences for consumers.

Animal welfare is a term that describes a potentially measurable quality of a living animal at a particular time and hence is a scientific concept. It requires strict definition if it is to be used effectively and consistently. A clearly defined concept of welfare is needed for use in precise scientific measurements, in legal documents, and in public statements or discussion. Welfare refers to a characteristic of the individual animal rather than something given to the animal by people (Duncan, 1981). Broom (1986) defined the welfare of an individual as its state as regards its attempts to cope with its environment. It has been emphasized (Duncan, 1981; Broom, 1986, 1991a,b; Broom and Johnson, 2000; Fraser, 2008) that welfare can be measured scientifically, independently of any moral considerations. Once the welfare has been objectively assessed, ethical decisions can be taken about what is to be done about it. This definition of welfare refers to a characteristic of the individual at the time, that is, how well it is faring (Broom and Fraser, 2007; Broom, 2008). This state of the

individual will vary on a scale from very good to very poor. Welfare will be poor if there is dif

ficulty in coping or failure to cope so that the individual is harmed. One or more coping strategies

may be used to attempt to cope with a particular challenge so a wide range of measures of welfare

may be needed to assess welfare.

Feelings, such as pain, fear, and pleasure, are often a part of a coping strategy and they are a

key part of welfare (Duncan and Petherick, 1991; Broom, 1998b, 1998). They are adaptive aspects

of an individual's biology that must have evolved to help in survival just as aspects of anatomy,

physiology, and behavior have evolved. Fear and pain can play an important role in the fastest acting

of our coping responses, such as avoidance of predator attack or risk of immediate injury. Positive

and negative feelings, as well as other brain processes that involve no affect, are among the causal

factors determining what decisions are taken in longer time-scale coping procedures, where various

risks to the ﬁtness of the individual are involved. Aspects of suffering also contribute signiﬁcantly

to how the individual tries to cope in attempts to deal with very long-term problems that may harm

the individual. In the organization of behavior to achieve important objectives, pleasurable feelings

and the expectation that these will occur have a substantial inﬂuence.

Coping with pathology is necessary if welfare is to be good so health is an important part of the broader concept of welfare, not something separate (Dawkins, 1980; Webster, 1994; Broom, 2006; Broom and Fraser, 2007). However, health is not all of welfare, as those with a medical or veterinary background have sometimes assumed. Health is the state of the individual as regards its attempts to cope with pathology. This refers to body systems, including those in the brain, which combat pathogens, tissue damage, or physiological disorder.

When considering how to assess the welfare of animals, it is necessary to start with knowledge of the biology of the animal and of all of its needs. It is important to be aware that needs have a biological basis, but this does not mean that degree of naturalness is a part of the definition of welfare (Fraser, 2008). Some events that occur in nature, such as starvation or predation, result in very poor welfare. The needs of individuals will vary according to genotype and will be affected by conditions during development. It is more useful to consider the needs of animals of a given species, using scientific information about them, than to use the vaguer concept of freedoms.

The word "stress" should be used for the part of poor welfare that involves failure to cope, as the common public use of the word refers to a deleterious effect on an individual (Broom and Johnson, 2000). Reference to stress as just a stimulation that could be beneficial, or as an event that elicits adrenal cortex activity, is of no scientific or practical value. One indicator of adversity is whether there is an effect on biological fitness. Stress can be defined as an environmental effect on an indi state that over-taxes its control systems and reduces its fitness or seems likely to do so. Using this definition, the relationship between stress and welfare is very clear. First, while welfare refers to a range in the state of the animal from very good to very poor, whenever there is stress welfare is poor. Second, stress refers only to situations in which there is failure to cope, but poor welfare refers to the state of the animal, both when there is failure to cope and when the individual is having difficulty in coping.

In the early 1990s and later, Broom's definition was referred to by some as a functional definition and was contrasted with the feelings-related definition of Duncan (see also Broom, 2008). Duncan argued that welfare is wholly about feelings (e.g., Duncan and Petherick, 1991). A more common position was that of Dawkins (1990), who stated that the feelings of the individual are the central issue in welfare but other aspects such as the health of that individual are also important. As explained earlier, feelings are biological mechanisms that form part, but not all, of the set of coping systems. The term welfare means essentially the same as well-being but, in most of the world, welfare is used as the scientific term.

SUSTAINABILITY

A central question, when decisions are made about whether a system for exploiting resources should be used, is whether the system is sustainable (Aland and Madec, 2009). The fact that something is profitable and there is a demand for the product is not sufficient reason for the continuation of production. A system or procedure is sustainable if it is acceptable now and if its effects will be acceptable in future, in particular in relation to resource availability, consequences of functioning, and morality of action (Broom, 2001, 2010). A system might not be sustainable for several possible reasons. For animal usage systems, examples of such reasons are: (1) because it involves so much depletion of a resource that it will become unavailable to the system, (2) because a product of the system accumulates to a degree that prevents the functioning of the system, or (3) because members of the public find an action involved in it unacceptable. Where there is depletion of a resource or accumulation of a product, the level at which this is unacceptable, and hence the point at which the system is unsustainable, is usually considerably lower than that at which the production system itself fails. Other reasons for unacceptability are exemplified in the following. A system could be unsustainable because of harms to the perpetrator, other people, the environment, or other animals (Table 5.1).

No system or procedure is sustainable if a substantial proportion of the local or world public finds aspects of it now, or of its consequences in the future, morally unacceptable. Each of the examples in Table 5.2 is unsustainable. Adverse effects on people or animals can be reported in the media around the world and there are now consequences of unacceptable practices in manufacturing, animal production, or other human activities because of increased efficiency of communication.

Some results of activities or events that the public find unacceptable may result in consumers in

many countries refusing to buy animal and other products from the companies or countries involved

(Table 5.3; Broom 2002).

Consumers drive legislation and retail company codes of practice for animal production (Bennett,

1997; Bennett, Anderson, and Blaney, 2002). Legislation on animal welfare has developed in the

European Union and in many countries because of pressure from voters (Broom 2002, 2009). In

general, the standards of retail companies have a substantially greater effect on the welfare of farm

Table 5.7

Sustainability – Categories of Unacceptable Harms and Examples That Led to

Headlines in Newspapers

1. Harm to perpetrator: Resource loss or poor welfare [a] System for energy production uses more energy than it produces. [b] Machinery for process made of poor quality materials so injury to working person likely. [c] Toxic insecticide spread on fields – spreaders poisoned by insecticide in China.

2. Harm to other humans: Resource loss [a] factory/agricultural system outflow into lake or river – fishing industry lost because of the pollution by manure of a river in Thailand. [b] Heavy metals from industry – reduces farm production. [c] Radiation from energy production system – reduces farm production.

3. Harm to other humans: Poor welfare [a] Dioxin released from factory – people become sick, some die. [b] Cheap cattle protein fed to other cattle – bovine spongiform encephalopathy in cattle and people catching new-variant Creutzfeldt-Jacob disease by eating beef in the U.K. Also, consumer health risk from slaughtered sick cattle in United States. [c] Work that is too demanding – some workers become injured, depressed, or psychotic.

4. Harm to other, nonhuman, animals: Poor welfare [a] Traditional entertainment for people, for example, bull-fight, dog-fight, cock-fight, bear-bait, throw goat off church tower. [b] Use leg-hold trap for pests or fur-bearing animals. [c] Veal production from calves kept in small crates and fed only milk. [d] Sheep on an Australian ship dying in large numbers en route to Saudi Arabia. [e] Slaughterhouse cruelty in the United States. [f] Chickens killed by inhumane methods during avian influenza control in Indonesia.

5. Harm to environment including that of other animals [a] Use of CFCs in refrigerators – ozone layer damage. [b] Use of chlorinated hydrocarbon insecticides – birds, which are insectivores, or top predators killed or unable to reproduce. [c] Produce too much carbon dioxide and other greenhouse gases – global warming.

Modified after Broom, 2010.

TABLE 5.1

Reasons for Lack of Sustainability of a System

1. Resource depletion to a level that is unacceptable to a level that prevents system function

2. Product accumulation to a level that people detect and find unacceptable to a level that affects other systems in an unacceptable way to a level that affects the system itself, perhaps blocking its function

3. Other effect to a level that is unacceptable

The consequences of acts or of system functioning (in 1, 2, and 3) could be unacceptable because of immediate or later:

[a] Harm to the perpetrator: resource loss or poor welfare

[b] Harm to other humans: resource loss

[c] Harm to other humans: poor welfare

[d] Harm to other animals: poor welfare

[e] Harm to the environment including that of other animals.

Modified after Broom, 2010.

animals than legislation. The codes of practice of food companies have international impact. For example, many pig producers in Brazil have to comply with the animal welfare standards of United Kingdom supermarkets in order to sell to them, and egg producers in Thailand have to rear their birds according to the standards of the increasing numbers of U.K. food chain companies who have animal welfare standards.

WHAT IS FOOD PRODUCT QUALITY?

The idea of quality for the goods that people buy has changed in the last 10 to 20 years. Quality formerly referred to immediately observable aspects, that is, for an animal food product, its visual qualities and taste. These aspects of quality are still important, and expectations about taste are tending to become more refined, but other factors are now becoming incorporated into what constitutes good quality. Consumption has consequences and a higher proportion of these are now considered. If a food causes people to become sick, the quality is considered poor. If the food tends to make you fat, for some people the quality is considered poor. If food has added nutrients, some consider the quality better. In addition, a major recent change is that the ethics of the production methods are taken into account. Factors considered by purchasers include: (1) the welfare of the animals used in production, (2) any impact on the environment, including conservation of wildlife, (3) ensuring a fair payment for producers, especially in poor countries, (4) the preservation of rural communities so that the people there do not go to live in towns, and (5) the carbon footprint of each

product as factors leading to global warming are now high on the agenda of many discriminating

consumers.

If food is not safe, in that it contains damaging levels of toxins or pathogens, most consumers

will never buy it no matter how cheap it is. Individual food production companies are expected to

be responsible for this aspect of food quality, but the public expects their government to ensure that

adequate standards and adequate checking systems exist. National governments have fallen and

companies have gone bankrupt because of known failure on this issue. TABLE 5.3 Examples of Actions that Led to Consumers Refusing to Buy Products Action Reported by Media Consequences Dolphins being killed in nets set for tuna. The sales of tuna dropped sharply. This was a long-term effect and resulted in a permanent change in ▮shing practices. In France, poor welfare of calves kept in small crates for veal production. In U.K., a drop in the sales of all French products, including unrelated products such as wine. For most consumers, this was temporary but for some it continued until the introduction of European Union legislation banning the production of veal using crate-housing and low iron and low ▮ber diets. The death of thousands of sheep on an Australian ship going to Saudi Arabia. In several countries, a temporary drop in sales of Australian products. Very low payments to poor coffee farmers in Third World countries supplying a coffee shop chain reported in many countries. Temporary and permanent loss of customers at coffee shop chain. Rainforest destruction for beef production for restaurant company. A drop in sales of company in many countries. Some permanent loss of customers. Cruelty to poultry in slaughterhouse shown in one television program and cruelty to cattle in another. Temporary reduction in poultry sales. Reduction in beef consumption, duration not known. A few people respond to information about poor welfare in animals by becoming vegetarian but a much larger number make some changes to their food purchasing practices.

In parallel with the FDA in the United States, in the European Union the European Food Safety

Authority (EFSA) has been set up. A difference from the FDA is that (1) many aspects of sustainability are part of the work of EFSA and (2) the major part of its work is done by independent scientists, appointed solely on scientific expertise and not as representatives of countries or interest groups. In producing scientific reports, a significant part of their work is the assessment of risks and benefits. The subject area covered by EFSA is wide, reflecting the public concern. One panel deals with animal disease and animal welfare. The reports that it produces has led to changes in EU legislation and scientifically based standards in Europe and elsewhere in the world. A scientific committee producing reports on animal welfare is of value in any major country. Measures to check that there is compliance with legislation exist in the member states of the EU and in other countries, such as the United States with regard to food content.

In order that the ethics of the production method can be properly taken into account, products must be traceable. If foods can be traced, it is less likely that toxins, other poor quality materials, or pathogens will be in them. If animals can be traced, the sources of animal disease outbreaks are more likely to be found and places where injuries or other causes of poor welfare occurred are more likely to be found (Broom, 2007). Legislation and industry initiatives ensuring traceability are important.

ASPECTS OF SUSTAINABILITY AND PRODUCT QUALITY

Consumers will refrain from purchasing animal products if they judge that the production proce dures are unsustainable and thus not of good quality. The quality may be judged poor based on

negative effects of the production or the product on human health, human diet, the acceptability of

genetic modification, animal welfare, environmental effects such as pollution, conservation and car

bon footprint, the efficient use of world food resources, fair trade, that is, considering poor produc

ers, and preserving rural communities. Each of these factors, now an aspect of both product quality

and the sustainability of the production method, is considered here.

Human Disease Resulting from a Food Product, Sustainability, and Product Quality

Some examples of human health issues that affect views of product quality are Salmonella in eggs and

meat, Campylobacter in chicken carcasses, and avian influenza (H5N1 or H1N1) and bovine spongi

form encephalopathy (BSE) in beef products. In the late 1980s and early 1990s, the British government

failed to initiate measures that would prevent the large-scale mortality of people from new-variant

Creutzfeldt Jacob Disease (CJD) if they ate meat products from animals with BSE. Luckily, for the

British public, the number dying is likely to be a few thousand rather than hundreds of thousands.

Eventually, with scientific expertise from EU committees, an appropriate policy was developed. The

one good consequence of this has been the development of the risk assessment approach in dis

ease management and in animal welfare in Europe. However, the subsequent unwillingness of other

governments, faced with an unknown amount of BSE, to damage their beef production industries is disturbing. Recent actions in the United States make it clear that cattle showing abnormal locomotion

and other behavior on arrival at the slaughterhouse must still be considered a BSE risk.

Human Diet, Sustainability, and Product Quality

In recent years, there have been large effects on animal production because of concern about human

diet. In particular, saturated fats increase risks of heart disease and farm livestock are a major

source. Because of the benefits of consuming fish oils, fish production is increasing rapidly. The

production of fish that consume vegetable matter, rather than predators like salmonids, which have

to be fed mainly fish products, is likely to increase the cost because much of the fish product fed

to the salmonids could have been consumed by humans and less resource wastage occurs if the fish

are herbivorous. The value of farmed fish production is already larger than that of open water fish

production, and the weight of farmed fish will be greater than that of fish from open water within

a few years.

Genetic Modification, Sustainability, and Product Quality

In some countries, genetically modified plants are not accepted because of ethical concerns, the issue

being whether living things should be modified in the laboratory as opposed to genetic changes that

occur naturally. There is also concern because protein changes can cause allergies. Genetic modi

fications in animals can benefit the animals (e.g., confer disease resistance), help to treat human

disease (e.g., a blood clotting factor in the milk of a sheep), develop new products for other purposes, or increase efficiency of animal production. Some people accept all of these but others accept some or none as sufficient justification for genetic modification. A major reason for this is that, in some cases, animal welfare may be poorer because of the modification. The conclusion of many people is that any production of genetically modified animals should occur only if it has been demonstrated by scientific studies of animal welfare that the welfare of the animals is not poorer than that of unmodified animals.

Animal Welfare, Sustainability, and Product Quality

Poor welfare of animals that are used in the production system is a major reason why the public regards some animal production systems as unacceptable. Hence, these systems become unsustainable unless there is some modification to them. Animal welfare is becoming more important to members of the public as a reason for demanding change from farmers, food retail companies, and governments. Members of the European Parliament receive more letters about animal welfare than about any other subject (Broom, 1999). However, most people think about animal welfare issues infrequently, unless their attention is drawn to it by media coverage. When the information is drawn to public attention, there is a point at which the welfare of the animals becomes so poor that the majority consider the system to be unacceptable. Hence, animal welfare and public attitudes toward it must be considered wherever the sustainability of an animal production system is evaluated. In

In order to produce laws or codes of practice, scientific evidence is needed.

Conservation, Carbon Footprint, Sustainability, and Product Quality

A major harm that results from agriculture is that it generally reduces biodiversity as compared with the original natural vegetation. Where wild or semi-wild areas are cleared for animal production, substantial harm can be done to populations of animals and plants. Hence, some animal production is not considered acceptable and products are not bought because these harms have been done. One solution to this problem, for animals that currently consume pasture plants, is to keep the animals in areas where they can browse on bushes and trees as well as grazing (Murgueitio et al., 2009, 2010). A second solution is the creation of significant areas of nature reserve, as demanded by the public in most countries. Preservation of wildlife can sometimes result in greater income through eco-tourism than would have been possible by farming. The purchase of land to conserve natural resources can often stimulate local economies and lead to a sense of regional pride that would not have existed if low-level animal production had continued. A further example of a possible adverse impact of animal production on conservation is the inappropriate use of antimicrobials and other medicines. The numbers of several species of vultures in India have declined by 96.8 to 99.9% in 15 years (Prakash et al., 2007). This is a consequence of poisoning by the pain killer Diclofenac and the Indian government has recently banned its use (Pain et al., 2008).

Mismanagement of resources and production of effluents that can result in contamination of water supplies, loss of plant nutrients, greenhouse gas production, and increased human disease are also a cause of unsustainability. The animal producer should pay any costs of environmental pollution and, wherever possible, animal waste should be efficiently recycled.

Efficient Use of World Food Resources, Sustainability, and Product Quality

Many people consider that the inefficient use of world food resources is unsustainable. However, animal production activities can be changed to exploit existing resources. Some animals used for food production can eat food that humans cannot eat (see Chapter 13). Hence, keeping grazers and browsers will often be more advantageous than raising pigs or poultry, since the latter do compete with humans for food. There will be energy loss if we eat animals that consume food that we could have eaten. There is also an effect on greenhouse gas production because carbon dioxide and other greenhouse gases are emitted in the course of production of animals such as poultry and pigs, for example because of the combustion of materials in the course of food production and the transport of food and animals. The advantage of using grazers or browsers can be weighed against any adverse consequences for greenhouse gas emissions of methane production by ruminants.

Fair Trade, Preserving Rural Communities, Sustainability,

Many traditions and ways of life for people are associated with animal agriculture. Many human

communities exist as they do because of particular animal production systems. If that production is

changed so that the number of farms is greatly reduced in the original areas, or the whole production

system is moved away from those areas, there are social and environmental consequences. The

destruction of rural communities is thus another factor that is taken into account by those considering

whether animal production systems are sustainable (see Chapter 6). A central aim of the EU's Common

Agricultural Policy was to preserve rural communities and to reduce the number of people who leave

country areas and move to large cities, thus increasing their size. That policy has been successful in

minimizing such movement and some U.S. government agricultural policies that prevented the prices

of certain agricultural goods from falling to a low level have had this effect. In many other countries,

in contrast, cities have become much bigger and rural communities have declined or disappeared.

Similar destruction of rural communities has occurred where the number of people employed on

farms has been drastically reduced because machinery, often with high consumption of energy, has

replaced the people. When all of the real costs of agriculture are evaluated properly, major changes

will ensue. Areas for change include the welfare of agricultural animals, energy usage, conservation

of natural environments, the welfare of human consumers and agricultural workers, and the preser vation of rural communities. Sustainable agriculture is the only way forward.

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THIRD VIEWPOINT: UNDERSTANDING ANIMAL WELFARE

FROM A RESEARCH SCIENTIST'S PERSPECTIVE*

David Fraser

INTRODUCTION

The treatment of animals has been a topic of ethical concern since classical times (Sorabji, 1993) and

showed a major resurgence during the 1700s and 1800s in Europe and the English-speaking countries

(Harwood, 1928; Radford, 2001). In the 1900s, during the span of the two World Wars and the Great

Depression, concern about the welfare of animals seemed to take a back seat. However, as human

prosperity and security returned in the 1950s, concern about animals began to regain its former prom

inence. Both the United States and Canada passed their first humane slaughter legislation in 1958 and

1960, respectively, and some jurisdictions added humane animal transport requirements soon after.

As long as the focus was on slaughter and transport, the nature of the concern seemed clear sought to protect animals from avoidable pain, distress, and misery after they left the safe confines

of the farm. Beginning in the 1960s, however, attention also turned to the relatively new "confine

ment" systems for raising farm animals, and here the nature of the concerns was less easy to define.

As debate over these systems developed, it became apparent that different people were raising some

what different issues, all under the umbrella term of "animal welfare."

1 This section brings together material from several of my previous publications, especially my book Understanding

Animal Welfare: The Science in its Cultural Context (Fraser, 2008), which gives a much more detailed treatment of the

issues. I am grateful to Wiley-Blackwell (Oxford) and the Universities Federation for Animal Welfare for allowing me to

re-use some of that material here.

THREE VIEWS OF ANIMAL WELFARE

The first major criticism of confinement production systems came in the book Animal Machines, by

the English animal advocate Ruth Harrison. She described cages for laying hens and crates for veal

calves, and she claimed that these highly restrictive systems caused animals to lead miserable and

unhealthy lives. She asked:

How far have we the right to take our domination of the animal world? Have we the right to rob them of

all pleasure in life simply to make more money more quickly out of their carcasses? (Harrison, 1964)

Later, in Animal Liberation, Australian philosopher Peter Singer based his criticism of animal production on the principle that actions should be judged right or wrong based on the pain or plea

sure that they cause, and he claimed:

There can be no moral justification for regarding the pain (or pleasure) that animals feel as less impor

tant than the same amount of pain (or pleasure) felt by humans. (Singer, 1990)

In these and many other criticisms of modern animal production, concerns centered around

words like "pleasure," "pain," "suffering," and "happiness." There is no simple English word to

capture this class of concepts. They are sometimes called "feelings,"but the word seems too insub

stantial for states like pain and suffering. They are sometimes called "emotions," but emotions do

not include states like hunger and thirst. Perhaps the most accurate (if rather technical) term is

"affective states," a term that refers to emotions and other feelings that are experienced as either

pleasant or unpleasant rather than hedonically neutral.

In discussing confinement systems, however, some people put the main emphasis elsewhere.

A British committee that was formed to evaluate the issues raised by Ruth Harrison concluded:

In principle we disapprove of a degree of confinement of an animal which necessarily frustrates most

of the major activities which make up its natural behaviour. (Brambell, 1965)

Astrid Lindgren, the famous author of the Pippi Longstocking stories and a driving force behind

animal welfare reform in Sweden, proposed:

Let [farm animals] see the sun just once, get away from the murderous roar of the fans. Let them get to breathe fresh air for once, instead of manure gas. (Anonymous, 1989)

American philosopher Bernard Rollin (1993) insisted that we need:

... a much increased concept of welfare. Not only will welfare mean control of pain and suffering, it

will also entail nurturing and fulfilment of the animals' natures.

In these quotations, although affective states were often involved implicitly or explicitly, the cen

tral concern was for a degree of "naturalness" in the lives of animals: That animals should be able

to perform their natural behavior, that there should be natural elements in their environment, and

that we should respect the "nature" of the animals themselves.

All of the previous quotations reflected the views of social critics and philosophers, but when

farmers and veterinarians engaged in the debate, they brought a different focus. For example, one

veterinarian defended the early confinement systems this way:

My experience has been that ... by-and-large the standard of welfare among animals kept in the so

called 'intensive' systems is higher. On balance I feel that the animal is better cared for; it is certainly

much freer from disease and attack by its mates; it receives much better attention from the attendants, is

sure of shelter and bedding and a reasonable amount of good food and water. (Taylor, 1972)

On the other hand, as the veterinary educator David Sainsbury (1986) put it:

Good health is the birthright of every animal that we rear, whether intensively or otherwise.

Here the primary emphasis is on the traditional concerns of veterinarians and animal producers

that animals should have freedom from disease and injury, plus food, water, shelter, and other neces

sities of life—concerns that we might sum up as the basic health and functioning of the animals.

In these various quotations, then, we see a variety of concerns that can be grouped roughly under

three broad headings: (1) the affective states of animals, (2) the ability of animals to lead reasonably

"natural" lives, and (3) basic health and functioning.

These are not, of course, completely separate or mutually exclusive. Allowing a pig to wallow

in mud on a hot day improves its welfare because it can use its natural cooling behavior (a natural

living criterion), because it will feel more comfortable (an affective state criterion), and because its

bodily processes will be less disrupted by heat stress (a basic health criterion).

Nonetheless, the different concerns are sufficiently independent that the pursuit of any one does

not necessarily improve animal welfare as judged by the others. An intensive pig producer may feel

that the most important elements of animal welfare are basic health and functioning as reflected by

neonatal survival, longevity of sows, rapid growth, and low incidence of disease. For such a person,

a well-run, high-health confinement unit might seem to provide the best welfare for pigs. An organic

pig producer, in contrast, may feel that for pigs to have a good life, it is most important that they are

free to live in fresh air and sunlight with ample space to roam and socialize. For such a person, a free range system is far better for animal welfare than any confinement unit is, even if parasites are

not as well controlled and rates of growth are lower. An animal protectionist might attach particular

importance to affective states and not be too concerned whether pigs are indoors or outdoors, so

long as fear, pain, and hunger are minimized. Thus, different beliefs about what is important for

animals to have a good life can lead to very different conclusions.

These disagreements are not, of course, disagreements about facts. The intensive producer and

the organic producer may agree on factual matters such as the rate of mortality in a herd or the

concentration of ammonia in the air. Their disagreement is about values—about what they consider

most important for animals to have good lives.

The situation can perhaps be captured by a simple Venn diagram (Figure 5.1), which serves to

summarize three points: (1) most of the concerns that people express about animal welfare can be

grouped roughly under three main headings; (2) these involve considerable but incomplete overlap; Basic health and functioning Affective states Natural living

Figure 5.1 Three conceptions of animal welfare. (Adapted from Appleby, M.C. 1999. What Should We Do

about Animal Welfare? Oxford: Blackwell Science; and Lund, V. 2006. Natural living – a precondition for

animal welfare in organic farming. Livestock Science 100: 71–83.)

and (3) the pursuit of animal welfare as defined by any one criterion does not guarantee a high level

of welfare as judged by the others.

When these differences began to emerge in the debate about confinement production systems, many people looked to scientific research as the way to decide among the different, value-based interpretations of animal welfare and thus turn the assessment of animal welfare into an objective, value-free scientific process. What actually happened, however, proved to be much more interesting.

Some scientists focused on the basic health and functioning of animals as a basis for assessing and improving animal welfare. In one classic example, Ragnar Tauson and co-workers improved the welfare of laying hens by studying the basic health of birds in cages of different types, and then developing cage designs that would prevent the various health problems they observed. The scientists found that the birds developed foot lesions if the floor was too steeply sloped, and neck lesions if the feed trough was too deep and installed too high for comfortable access. There was often feather damage that could be reduced by using solid side partitions and overgrown claws that could be prevented by installing abrasive strips on the cage floor. Thus, just by focusing on injuries it was possible to make large improvements in animal welfare and, coincidentally, in the productivity of the flock. These results formed the basis of the early animal welfare standards for cage design in Sweden and later in the European Union (Tauson, 1998).

Other scientists tried to improve animal welfare by creating living conditions that were more nat goal for animals. For example, in an effort to design better housing for pigs, Alex Stolba and David Wood-Gush began by observing pigs that had been released in a hilly, wooded area. They found that the pigs showed certain characteristic types of behavior: they rooted in the soil; they exercised their neck muscles by levering against fallen logs; they built nests in secluded areas before giving birth; and they used dunging areas well removed from their resting areas. The scientists then designed a complex commercial pen that allowed the animals to behave in these ways. It included an area with peat moss for rooting, logs for levering, a separate dunging area, and secluded areas where a sow could be enclosed to build a nest and farrow (Stolba and David Wood-Gush, 1984). The authors claimed that the animals' welfare was significantly improved by the complex pen; however, because some aspects of basic health (especially neonatal survival) were not as good in this system as in well run confinement systems, some people disagreed with that conclusion.

In less radical approaches, scientists have incorporated simple elements of natural behavior into existing rearing systems. On many commercial dairy farms, calves are separated from their mothers on the first day after birth, and are then fed milk by bucket, usually twice per day. This, of course, is highly unnatural. Under natural conditions, calves would stay close to the cow for the first two weeks, and would consume many small meals per day by sucking rather than drinking. Although normally it is not feasible to leave calves with the cow on a diary farm, feeding systems can still be made to correspond more closely to the animals' natural behavior. First, if the calves suck from an artificial teat rather than drinking from a pail, the sucking action seems to stimulate certain digestive processes more effectively (de Passillé, Christopherson, and Rushen, 1993). Second, if the teat system allows the calves to feed with a more natural frequency and meal size, then they can gain substantially more weight than calves fed twice daily by bucket (Appleby, Weary, and Chua, 2001).

In other cases, scientists have used animal welfare research to reduce unpleasant affective states in animals. Many dairy calves are subjected to "hot-iron disbudding." This involves the use of a ring-shaped iron heated to 600°C and pressed against the head of the calf to burn through the nerves and blood vessels that would allow the horn-bud to develop. In some countries, this procedure is commonly done without any form of pain management. A research group in New Zealand used levels of cortisol (a stress-related hormone) in the blood as an indicator of the pain caused by disbudding. They found that disbudding is followed immediately by a large increase in cortisol, but that the reaction is blocked if calves are treated with a local anesthetic to freeze the area first. However, the treated calves showed a later rise in cortisol level, several hours after the disbudding, probably because the injury remained inflamed and painful when the anesthetic had worn off. This later rise in cortisol could be eliminated by giving the calves an analgesic. Thus, the research showed that assessment of the pain of disbudding requires both a local anesthetic and a longer-acting analgesic (Stafford and Mellor, 2005).

All of the approaches described previously—some designed to improve basic health, others incorporating natural behavior, and others focused on affective states—have been useful for identifying and solving animal welfare problems. However, rather than the science providing an objective means of arbitrating among the different views of animal welfare, the different views of animal welfare were actually adopted by the scientists as the rationale for their scientific work. In fact, the different views of animal welfare enriched the science by providing a wide and complementary range of ways in which animal management could be improved, often with benefits to animal producers as well as to the animals.

CLARIFYING AND APPLYING THE VIEWS

If the science has not arbitrated among the different views of animal welfare, it has nonetheless done a great deal to clarify the different views and put them into practice.

For one thing, science has helped clarify how "naturalness" relates to animal welfare. Clearly, modern methods of keeping animals raise concerns because they are so unnatural, but how should we determine what is natural for these animals? For example, because sows living outdoors typically wean their young at three to four months of age, critics often assume that "natural" weaning means delaying weaning until this late age, and that sows and litters should be left together throughout this time. In fact, research shows that starting about 10 days after farrowing, many sows choose to spend less and less time with their young and thus force the offspring to start using a solid diet. Hence, although removing the piglets from the sow at two to three weeks is not natural, leaving them confined together in a pen for many weeks is not natural either. On this basis, "get-away" farrowing systems have been designed that allow sows to initiate the weaning process and better prepare the young for transition to solid food (Pajor et al., 1999).

One problem in invoking natural behavior to improve animal welfare is that natural behavior falls, very roughly, into two types: Behavior that animals generally want to do, such as eating and playing, and behavior that animals generally do not want to do, such as shivering in the cold and fleeing from predators. When we encounter a type of natural behavior, how do we know in which category it belongs?

One way is simply to ask the animals. Hens, for example, can be trained to perform "instrumental" tasks, such as pecking a key or pushing against a weighted door, for rewards such as food or the opportunity to perform such natural behavior as dust bathing or roosting on a perch. By determining the amount of work a bird will do to obtain a given reward, we can better understand the nature and strength of their motivation (Duncan, 1992; Dawkins, 1998). Using such methods, it has been shown that hens are motivated to obtain a modest space allowance (somewhat more than is provided in standard commercial cages), a perch where they can roost at night, a nest box where they can retreat to lay eggs, and litter for dust bathing and feather care. Based on such research, the European Union will soon require that caged hens have some form of "furnished" environment with 750 cm 2 of floor space per bird, plus a perch, a nest-box, and litter (Appleby, 2003).

Animal welfare science has also provided many ways of using research to understand better the affective states of animals. As one example, Francis Colpaert and co-workers have done many studies in which rats had the opportunity to self-administer analgesics. In one case, they gave arthritic and non-arthritic rats a choice of drinking from two water bottles, one of which contained sweetened water and the other a dilute but unpalatable solution of the opiate analgesic fentanyl. Healthy rats consumed very little of the fentanyl, but arthritic rats consumed substantial amounts, and the time course of self-administration corresponded with changes in the severity of the arthritis. Based on this and other lines of evidence, Colpaert et al. (2001) concluded that self-administration of fentanyl provides an objective indicator of chronic pain in rats.

Finally, science has helped to clarify the relationship between health, productivity, and animal welfare. It is uncontroversial to say that preventing disease and injury is fundamental to animal welfare, but some people have made much bolder claims. Some have proposed, for example, that "suffering of any kind is reflected by a corresponding fall in productivity" (Brambell, 1965, pp. 10-11),

and that "the goal of maximum profitability pursued by animal producers (and others) leads automatically to improved welfare" (CAST, 1981, p. 1). Scientific analysis has shown the need for caution over such claims. For example, modern hens have been bred so strongly for egg production that they will mobilize calcium from their bones to create eggshells. This can lead to significant weakness in the leg bones and a high frequency of broken bones when the birds are removed from their cages for slaughter (Knowles, and Wilkins, 1998). Genetic selection of beef cattle for very large muscles has produced certain breeds whose carcasses have high commercial value, but these breeds are prone to difficult calving and poorer calf survival, and some animals react to heat stress with an excessive build-up of lactic acid in the muscles, sometimes to the point of paralysis (Gregory, 1998). Many dairy cows are bred and fed for very high levels of milk production, but this is associated with a high incidence of certain diseases and short life span (Sandøe et al., 1999). Hence, arguments linking productivity and animal welfare need to be treated with caution, especially if genetics, diet, or hormones have been manipulated in ways that enhance one aspect of functioning to the detriment of others.

Arguments linking animal welfare and profitability are especially suspect. Profit requires a certain level of productivity, but profit can also be increased by limiting input costs. Reducing space allowance, staff time, bedding, veterinary care, and other amenities can help to reduce costs; and

Even if these cutbacks reduce productivity to some extent, the net result may still be greater profit.

A striking example was provided by Adams and Craig (1985), who analyzed how space allowance for hens in cages is associated with different levels of productivity and profit. Their analysis showed that if egg prices are high and feed costs are low, profit could often be increased by adding extra birds to a facility so that crowding is severe, even though the death rate is increased and the birds' individual rate of egg production declines.

As we see in these examples, research and thoughtful scientific analysis can do a great deal to improve our understanding of animal welfare. Specifically, research can show what elements of natural behavior are important to the animals themselves; research can put the affective states of animals on a scientific footing so that we do not just project human emotional reactions onto other species; and scientific thinking can clarify the complex relationship between animal welfare, health, and productivity.

CONCLUDING REMARKS

The idea of applying science to a value-based concept may sound strange to some scientists. Surely (they might argue) when scientists confront a new term—whether it be metabolic rate, feed efficiency, or animal welfare—they should first agree on how to define the term, and then they can measure it in a purely objective and value-free way.

In fact, many of the concepts studied by scientists incorporate values in a fundamental way.

"Food safety," "environmental integrity," "agricultural sustainability," "mental health," "animal

welfare"—each of these topics contains a word (safety, integrity, etc.) that invokes notions of better

or worse. To say that safety or integrity has increased implies not simply a charge, but a change for

the better. We might call these "evaluative concepts" (Fraser, 1999). We can certainly use scientific

methods in the assessment of evaluative concepts, but the empirical work is underlain by value

based presuppositions about what constitutes a better or worse situation.

Animal welfare is also an "everyday" concept. Unlike concepts such as atomic weight and meta

bolic rate, which arose in science and took their meaning from science, many evaluative concepts

arose in everyday language and acquired a meaning (or meanings) in everyday life before scientists

began paying attention to them. When society calls on science to help resolve questions about ani

mal welfare, food safety, or other topics that are the subject of everyday concern and policy-making,

the scientists need to understand and respect the everyday meanings of the concepts that they study.

If they do not—if, for example, they try to give the term a new, technical meaning that does not cor

respond to its everyday meaning—then their conclusions may be irrelevant or (worse yet) mislead

ing to the very issues that the scientists were trying to address.

SUMMARY

Science can make major contributions to understanding and improving animal welfare, and to find [illegible]uctive solutions to animal welfare debates; but [illegible] animal welfare and in selecting

[illegible]ding research methods, scientists need to be [illegible] to the everyday meaning of the term

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[illegible] VIEWPOINT: UNDERSTANDING ANIMAL

[illegible] FROM A VETERINARIAN'S PERSPECTIVE

[illegible]

INTRODUCTION

In the United States, veterinarians take an oath (AVMA, [illegible]) to provide for their animal patients,

while ensuring that the interests of society are met through responsible animal use.

Being admitted to the profession of veterinary medicine, I solemnly swear to use my scienti[illegible]c knowl

edge and skills for the bene[illegible]t of society through the protection of animal health and welfare, 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.

Similar obligations exist and similar promises are made by veterinarians around the world (Hewson, 2006).

In serving both animals and society, veterinarians bring a unique skill set to the table. First, most veterinarians enter the profession because of their empathy for animals and their desire that they are cared for properly (Sprecher, 2004; Serpell, 2005). Empathy serves as a starting point in the examination of animal use and care. It leads to fundamental questions as to whether specific uses of animals are necessary and appropriate, and whether related animal care practices (e.g., genetic selection and manipulations, housing, handling, physical alterations) are important to facilitating that use. If that is so, are they being performed with due regard for the health and other welfare needs of individual animals and animal populations?

Second, during their training, veterinarians are provided with strong science-based knowledge about animal health and husbandry, and are schooled in the technical and practical application of that information. This combined skill set helps ensure that recommended approaches to animal care are likely to improve animal health and other aspects of animal welfare and can be realistically implemented.

Third, direct practitioner access to animals, the environments in which they are housed, and the people who own and care for them allows observation of what is actually occurring and provides a mechanism whereby veterinarians can actively encourage and demonstrate appropriate animal

care). Veterinarians also interact regularly with the multiple individuals indirectly responsible for

the welfare of those animals, including other scientists, policymakers in governmental agencies

(local, state/territory, national, international), producers in the animal agricultural industries and

nongovernmental organizations, and the public.

Finally, veterinarians have tremendous credibility. A 2006 poll conducted in the United States on

professional honesty and ethics ranked veterinarians third among 21 types of professionals (Gallup,

2006). Degree of credibility may vary by society, over time, and be affected by animal-related

events; however, in general, veterinarians appear to be well respected. Credibility means that rec

recommendations made by veterinarians are likely to be taken seriously.

Together, these attributes make veterinarians valuable advocates in assuring good animal

welfare.

WHAT IS GOOD WELFARE?

There is general agreement that good welfare means satisfying an animal's needs, but when asked

whether a particular situation or condition in which an animal finds itself is welfare-friendly, respon

dents, including veterinarians, may have different views.

Consider the question of whether the welfare of laying hens is better when they are kept in cages,

barns, or allowed to range freely in a field (LayWel, 2006). In cages, hens have easy access to feed

and water, individual birds are easily observed, aggressive interactions are infrequent and cannibal

ism is minimal, and their eggs are protected and easily
collected. However, in conventional cages

movement is restricted, and nest boxes and litter for dust
bathing (both of which support the behav

ioral aspects of animal welfare) generally are not
provided. Laying hens raised in barns most often

have access to nest boxes and litter for dust bathing, but
aggression, cannibalism, and flightiness are

other behavioral characteristics of that environment, and
feed and water are less easily monitored.

Free-range systems allow great freedom of movement, usually
include enclosures for sleeping and

nesting, and natural substrates are readily available that
provide multiple opportunities for expression

of natural behaviors. On the other hand, laying hens in
free-range systems have increased exposure

to adverse weather conditions, pests, and predators (see
Chapters 4 and 8 for further discussion).

Given these trade-offs, which of the three systems
described does a veterinarian recommend to

best ensure the hens' welfare? Would that veterinarian's
colleague in the next town or state choose

the same system? Are the veterinarian's recommendations
likely to be consistent with client pref

erences? What about the expectations of the public (which
may or may not be well-informed)? As

health professionals, how veterinarians approach animal
welfare will largely reflect their knowledge

of the science behind animal care and use practices and
their practical experience in applying that

scientific knowledge; however, it will also depend upon
their personal values, the needs and prefer

needs of their clients, and various social influences. Veterinarians are challenged to assist in the decision-making process, while recognizing that even they are not immune to personal prejudices and external influences when making animal welfare decisions.

Personal Values

With respect to the laying hen example provided previously, many veterinarians are most comfortable with hens being kept in cages. That is because veterinarians (and many other biological scientists and producers) tend to emphasize measures of health, growth, and productivity in their evaluation of an animal's welfare. The veterinarian recognizes that keeping hens in cages allows better monitoring and control of disease, minimizes the risk of attack by the hen's conspecifics, protects the hen from predators, and ensures consistent provision of food and water. In other words, the veterinarian concludes that the hen is in a good state of welfare because its health, safety, and physical needs are met.

However, for others (including behavioral and social scientists, retailers, members of the public, and even colleagues of the veterinarians, scientists, and producers mentioned previously), the answer may not be so clear-cut. Fraser et al. (1997) suggested that views on animal welfare generally fall into three categories: Individuals who emphasize basic health and function of the body; those who are most concerned with how an animal "feels" (i.e., its psychological or affective states, such as pain, suffering, or contentment); and those who emphasize the animal's ability to lead a reasonably natural life and perform behaviors in which it might normally engage. None of these views can be

classified as being inherently right or wrong, nor are they mutually exclusive. Rather, they represent

different areas of focus or emphasis. Physical and health scientists are generally most comfortable

with the functional view of animal welfare, animal behaviorists and psychologists tend to equate

good animal welfare with positive affective states, and many members of the public, particularly

those who rebel against what they perceive to be the wrongs of an industrialized society, look for

components of natural living.

Sometimes the various views of what constitutes good animal welfare go hand-in-hand. For

example, allowing a hen to nest may help it protect the integrity of its eggs (a functional criterion),

may provide some comfort (an affective state criterion), and permit it to perform a natural behavior

(a natural living criterion). Other times the various views conflict. For example, an owner feeding

his or her dog treats on a regular basis may result in the dog having a positive psychological response

and, depending on how the treats are provided, may meet its needs for exploratory or play behavior.

However, too many treats can also cause the dog to become obese. In considering the welfare of

animals, and through experience gained in practice, veterinarians soon learn the importance of bal

ance in satisfying both their physical and psychological needs.

Experiences and Influences

While their patients are animals, veterinarians provide services for a human clientele. As such, what veterinarians recommend will be affected by social norms, and the relationship between people and their animals has changed dramatically over the past several decades. Since the 1950s, there has been a shift in the American family unit from the nuclear family (represented by a mother, father, and children with extended family often living nearby) to families that may comprise younger or older couples with no children in the household, single parents with children, single persons, or same-sex partners, with or without children. Grandparents, parents, children, aunts, uncles, nieces, and nephews are often spread across the country. Both mothers and fathers often work outside the home, and latchkey children are the norm rather than the exception. Substantial traditional social support has been removed in the process and pets have filled the void as dependable companions. Higher per capita incomes have allowed owners to treat their animal companions more and more like the human companions they have replaced and to perceive such treatment as normal and appropriate. Almost simultaneously, direct experiences with animals as sources of food and fiber (i.e., functional animal uses) have been reduced. Since the 1950s, the United States has seen a dramatic trend toward urbanization ([illegible], 1995) with fewer than 2% of the American public currently residing on farms. Together these factors put the American public in the position of viewing all animals and expectations for their care with the same spectacles they apply to the family dog, cat, or bird.

While the structure of families has changed, businesses have changed as well. After World War II, the United States saw a market-driven intensification of almost all industries, including those using animals (Colyer et al., 2001). Profit margins narrowed as production costs (especially wages) increased and prices dropped. Economies of scale and type were discovered and translated to animal production and care. A business culture emphasizing efficiency emerged, leading to increased specialization and economy of scale (e.g., farms became larger and shifted to a single species and, later, to a single phase of production), contract operations, and selection for animal characteristics (e.g., increased muscle mass, hardiness, susceptibility or resistance to particular diseases [as beneficial to their particular use]) that maximize return on food, housing, and care investments.

Animal care interests correspondingly moved from a focus on the health of individual animals to an emphasis on the health of the herd and the quality and quantity of the final product.

Most members of the American public recognize, accept, and support the need to use animals as sources of food and fiber; however, the picture of animals as “commodities,” with an emphasis on herd health and production, does present conflicts with their vision of animals as “family members,” with its corresponding emphasis on the individual. Attempts to resolve this ideological conflict have resulted in (1) closer scrutiny of traditional animal use and care practices; (2) increasing prominence the public support of existing nongovernmental organizations focused on ensuring animal welfare, as well as the emergence of new ones; (3) retailers and their suppliers recognizing that members of the public can vote with their pocketbooks and acquiescing to their demands by creating business centers focused on issues of social responsibility, including animal welfare; and (4) governmental regulations and legal obligations directed toward aspects of animal use and abuse that the public finds most troubling. Because of their recognized scientific and practical expertise, as well as their regular contact with various stakeholders, veterinarians often find themselves in the challenging position of trying to bridge gaps between those with conflicting paradigms of animal use and care, while ensuring the needs of animals continue to be met. In the case of animal agriculture, veterinarians must protect the well-being of animals, assist farmers in producing sufficient product in a profitable way, and simultaneously respect the ethical norms of how society expects animals to be used and cared for.

Applying Science

Veterinarians want to believe that decisions about animal care primarily will be based on science. A look at the history of animal welfare decision making, however, tells us otherwise. Science directed at the needs and wants of animals did not actually play a substantial role in animal welfare decision making until the 1950s and 1960s, in concert with the publication of The Principles of Humane Experimental Technique by Russell and Burch (revised 1992; originally published in 1959) and the report of the Brambell Committee (1965). Concerns about animal welfare, however, have been raised since at least the time of Aristotle and it can be argued that mythological, cultural, and religious histories suggest an even earlier focus. Science (and scientists) emerged as a player in the animal welfare debate when it was proposed as a possible way to help resolve conflicting perspectives. The strongest growth in animal welfare science has occurred since the mid-1980s, and the field is inherently inter- and multidisciplinary. Peer-reviewed information was initially published in journals of various established fields (e.g., animal science, laboratory animal science, animal behavior, veterinary medicine); more recently, animal welfare science-specific journals have been established. Today's veterinarian who looks to use science in the evaluation of animal welfare includes multiple parameters to ensure a complete assessment. These parameters include the animal's biologic function (e.g., growth, reproduction, ability to maintain homeostasis), its health (e.g., absence/presence of disease or injury), and its behavior and social functions (e.g., adaptation, emotional states provided for the animal (also referred to as inputs, resource-based criteria, or engineering criteria) or the effects of these inputs on welfare performance (also referred to as outputs, animal-based criteria, or performance criteria). More recently, animal welfare science and its proponents, including veterinarians, have shifted from an emphasis on easily measurable parameters (e.g., morbidity, mor (e.g., production indices) to asking questions about the animal's perception of its own situation.

Interestingly, the basic parameters identified as being necessary components of a complete science-based animal welfare assessment mirror the views (i.e., function, affective states, natural living) discussed previously. The implication of this, of course, is that any data obtained may be differentially interpreted and emphasized based on these views. Therefore, a critical review and interpretation of the science demands the veterinarian be cognizant of the approach taken by the researcher involved, as well as his or her own views, and consider both during interpretation and in its application. Science is almost never value-free or immune to experiential prejudice and animal welfare science and its applications are not exceptions to that truth.

CHALLENGES FOR VETERINARIANS

What [illegible] pose the biggest challenges for veterinarians in successfully addressing animal welfare and the related concerns of other veterinarians, clients, customers, policymakers, and the general public? To find out, the author asked 50 influential individuals that question. The individuals included veterinarians and non-veterinarians who worked in private practice, industry, not-for-profit organizations, and governmental service, and whose views on animal welfare were diverse. Their answers were amazingly consistent and relatively easily distilled into the following six challenges for the veterinary profession in addressing animal welfare questions.

Professional Homogeneity

Individuals attracted to veterinary school are generally science-focused, smart, conscientious, com passionate, and fascinated by animals, and are able to work under conditions that can be physically demanding (e.g., handling 1000+-lb cattle) and aesthetically (e.g., blood, animal pain or discomfort, feces/urine) difficult. Training in veterinary school instills knowledge about the various types, uses, and many of the practical realities of working with animals and acquaints these future veterinarians with a variety of owners and expectations. As students, veterinarians are taught to respect species differences and, as they mature in practice, they become very good at evaluating and predicting the responses of animals to various situations.

However, the attributes and training that allow veterinarians to become skilled practitioners can also create some separation from the experiences and expectations of the public. Most members of the public have a perspective reflecting their experience with mostly companion animals and they tend to apply that experience to everything animal-related. Veterinarians' experiences reflect a broader range of animals, uses, and owners, as well as a greater familiarity with animal pain and discomfort, its trade-offs with other stressors (e.g., handling), and the resulting choices that need to be made (e.g., restraint stress versus short-term pain). The result is that veterinarians working with agricultural animals can find themselves defending practices, and even their own activities, which [illegible] training and experience tells them are appropriate, but the public sees as questionable, based on

[illegible] the public may draw from how veterinarians [illegible] companion animals. Conversely,

[illegible] veterinarians may find themselves urging [illegible] to change long-respected prac

tices, based on new information about animals and their [illegible], the availability of new drugs and

[illegible], and the expectations of society for animal use and care. Disconnects in experiences,

perspectives, and information are a significant challenge because veterinary medicine is a service

[illegible] and reaching satisfactory animal welfare [illegible] (particularly for animals) requires

that dialog and mutual understanding take place, not only between veterinarians and animal own

ers, but between veterinarians and a more encompassing public.

Veterinarians in the United States are currently largely Caucasian and middle to upper-middle

class. This can create challenges in conveying animal welfare concerns and animal care needs

to culturally diverse populations. Such failures in communication create a potential for animal

suffering.

Professional Diversity in Service

Today's veterinarians are functionally diverse and different veterinary practice types carry different

obligations. Companion animal practitioners focus on individual animals, and advanced medical

and surgical procedures are common as pet owners seek health care for their pets that approximates

what they seek for themselves. Companion animal owners expect a normal aging process for their pets, accompanied by interventions for treatable conditions, followed by as natural a death as possible. Care decisions are framed by owner attachment and ability to pay, and are less affected by the dollar value of the animal.

In contrast, veterinarians working with animals used to produce food and fiber most often focus on population health. Individual animals may need to be sacrificed for diagnostic purposes or the benefit of the herd or flock. Care decisions are framed by the goal of bringing a product to market and, in this context, a natural death is often a clear failure. Advanced procedures are limited by the market value of the animal, and some procedures traditionally performed by other types of veterinarians may be outsourced to non-veterinarian providers. Many farm animal species, while domesticated, are not as accustomed to handling as those species commonly kept as pets, and decisions made about animal care need to consider the impact of (and ways to ameliorate) that additional stressor, as well as inherent human safety risks associated with working with large, heavy animals.

Equine veterinarians deal with animals used for both pleasure and function. Care decisions are often framed by the horse's use, and return on investment can be a primary driver in the application of advanced procedures. Laboratory animal practitioners care for animals in the context of both individuals and groups. They may be faced with the additional challenge of research protocols that are expressly designed to affect the health and well-being of their patients.

While veterinarians are provided with a broad-based education and exposure to all of these areas of practice, concentrating their efforts in one segment or another will, over time, affect their perspectives and approach to animal care.

Veterinary clients are diverse as well. They may be individual owners (e.g., pet owners, small breeding facilities, or farms), companies or institutions (e.g., large food animal production facilities, research facilities, commercial breeders), governmental agencies (e.g., public health agencies, slaughterhouses, animal control, wildlife refuges), or nongovernmental agencies. Each of these clients has their own expectations for value in veterinary services and their definition of good (or even acceptable) animal welfare. Correspondingly, each may have less familiarity and comfort with the animal use and care paradigms embraced by others and may see different roles for veterinarians and society in defining and assuring good animal care.

Professional Diversity in Demographics

Demographic changes occurring within the profession during the past 30 years (Brown and Silverman, 1999) have also substantively affected veterinary attitudes toward what is necessary for good animal welfare (Narver, 2007). Fewer students with rural roots are entering the profession (Prince, Andrus, and Gwinner, 2006; Andrus, Prince, and Gwinner, 2006), fewer students are choosing rural veterinary practice as a career (although modest increases appear to have resulted from recent recruitment efforts; Chieffo, Kelly, and Ferguson, 2008), and there has been an increase in the number of second-career entrants, particularly from non-science fields. In addition, the gender shift is dramatic. In 1950, there were 139 female veterinary graduates. By 1985, more than 50% of students attending veterinary schools in the United States were female, and it is estimated that women will comprise 67% of veterinary professionals by 2015 (Brown and Silverman, 1999). These demographic changes have combined to create more interest in the affective and social components of agricultural animals' welfare. Data show that women focus more on social concerns and relationships (Heath and Lanyon, 1996; Paul and Podberscek, 2000; Hart and Melese-d'Hospital, 1989; Serpell, 2005; de Graaf, 2007) and animal welfare issues involve both. The perspectives of students and new graduates reflect their urban experiences, and the pace of demographic change has only served to increase the speed of the philosophical shift. Functional and social diversity, not surprisingly, can create (and has created) conflicts among the various segments (e.g., practice types, generations) of the veterinary profession. If veterinarians in the various segments fail to consider the important insights that can be obtained from their colleagues, the result may be different recommendations as to what constitutes appropriate animal use and care. Inconsistent recommendations can give the [illegible] profession that is unfocused,

[illegible] indecisive. In turn, this can reduce the [illegible] and the public and negatively

[illegible] profession's ability to ensure that good [illegible] and appropriate care is deliv

[illegible]

[illegible] professional experience, however, has also [illegible] When veterinarians with

[illegible] experiences and perspectives collaborate, the [illegible] comprehensive look at animal

[illegible] recommendations that re-ect a wealth of [illegible] practical expertise and strike an

[illegible] balance between the needs of animals and people.

[illegible] Accepting the Role of Science

[illegible] previously, veterinarians are most comfortable [illegible] decisions are sci

[illegible] Science can be of tremendous value in helping [illegible] resolve disputes in animal

[illegible] decision-making. However, science regarding the [illegible] implications of particular

[illegible] practices can be of greater or lesser quality, [illegible] exist, may be ignored, or

[illegible] misrepresented and used selectively (by all sides) [illegible] public policy debates.

[illegible] can determine what type or degree of animal [illegible] exists with regard to a

[illegible] animal care practice, it cannot determine what [illegible] of risk is acceptable. This

[illegible] component of decision-making means that if the [illegible] perception is that a particular

[illegible] welfare risk is unacceptable (i.e., that doing [illegible] "wrong"), then what the science says can become less relevant for those making the animal use/care decision. That science can be relegated to the back seat when animal welfare decisions are made is a reality that can be difficult for veterinarians to understand and accept.

As scientists, veterinarians are encouraged and trained to approach problems objectively.

Unfortunately, veterinarians' efforts to be objective can sometimes give the appearance (or create the reality) of professional detachment. Such detachment is inconsistent with the aura of compassion that the public expects from those who serve as the protectors of animal welfare. As we strive toward science-based care decisions for agricultural animals, veterinarians cannot afford to forget that those looking for advice often do not care how much we know until they know how much we care.

Finally, our engagement with science is sometimes a love/hate relationship. As it was put by one respondent to my informal survey, "We're sometimes afraid to embrace the science because it may have implications for how we practice and what positions we may take as a profession. We make decisions based on their scientific merit, except when we don't like what the science says." More comfort with some animal welfare measures (e.g., physiologic and production indices, health status) than others (e.g., behavior) can be a source of conflict that exacerbates any tendency we may have to pick and choose. Incomplete application of the available science in animal welfare decision-making is in no way unique to veterinarians; there is ample [illegible] that other scientists, those in the [illegible] and animal advocates, have all been guilty of selective appropriation. As trusted professionals, veterinarians must make a conscious effort to seek new knowledge, critically examine, and (if of good quality) embrace information from a spectrum of disciplines to ensure that they continue to deliver the best possible recommendations for animal care.

The Value of Multidisciplinary Contributions

A veterinary degree plus compassion goes a long way toward ensuring animal welfare; unfortunately, it does not guarantee perfect knowledge of the subject matter nor does it mean we are the only individuals who can or should make valued contributions. Expertise in animal welfare is inherently multidisciplinary and a lot of specialized information contributes to the overall animal welfare knowledge base and the associated decision-making process. While some aspects of animal welfare (e.g., physical health, disease prevention, and treatment) are comprehensively addressed during veterinary medical education, other aspects (e.g., animal behavior, animal ethics) may not be. The goal should be continued assimilation and consolidation of as much information as possible so that the best decisions can be made.

A single animal welfare decision might take into account the animal's physiologic state, behavioral/social wellness, extent/absence of injury and disease, and adaptive potential, as well as ethical considerations and political and economic realities. Just as veterinarians work to develop special expertise in medicine, surgery, pathology, or epidemiology, they must work to develop expertise in the animal welfare field. Fortunately, courses on animal welfare science and ethics are becoming integral to veterinary curricula and opportunities for continuing education are expanding rapidly.

The Actuary, the Mechanic, or the Pediatrician?

Veterinarians may assume a variety of roles when it comes to animal welfare decision-making and choosing between those roles can be exceedingly difficult. We tend to vary between three approaches: The actuary, the mechanic, and the pediatrician (Rollin, 2006).

When behaving as actuaries, we try to base decisions on measurements and statistics and suggest that if we cannot measure it, we should refrain from making recommendations. Such an approach is clearly science-based and, accordingly, carries with it little outcome and professional risk. However, it also fails to take into account the social reality that if we do not see fit to make recommendations in the absence of irrefutable evidence, someone else will, and perhaps from a less knowledgeable and experienced perspective.

When we act like mechanics, we identify animal welfare problems and communicate our concerns and recommendations, but ultimately acquiesce to do what those “in charge” want, irrespective of what may be best for our patients. The ultimate risk resulting from this approach lies with the animal (or society, if the resulting animal care approach [illegible] unacceptable), but we assign

[illegible] for that risk to another.

[illegible] like pediatricians, we act like the
[illegible] advocate for the patient. This

[illegible] in the best animal welfare decision-making,
[illegible] the perspective of the ani

[illegible] it also presents the greatest risk for the
[illegible] because it makes him or her subject to

[illegible] criticisms.

[illegible] veterinarians believe their role should be limited to
[illegible] scientific information

[illegible] can measure and that advocacy (and
[illegible] decisions) should be left to others.

[illegible] most) veterinarians agree that an
[illegible] role for the profession in animal wel

[illegible] making means that, most of the time,
[illegible] need to behave like pediatricians.

[illegible] pediatrician can be difficult when we are
[illegible] with the subject matter

[illegible] limitations in our knowledge base or the
[illegible] of the associated ques

[illegible] also be put off by potentially aggressive
[illegible] criticism. For many veterinar

[illegible] desired "James Herriot" image is not consistent
[illegible] in relationships. We are

[illegible] alienating other stakeholders, particularly
[illegible] Sometimes, like any other

[illegible] may simply not like being told (or be
[illegible] acknowledge) that we might be

[illegible] we should do.

[illegible] IN ANIMAL AGRICULTURE: OPPORTUNITIES AND
[illegible]

they are likely to become practices that will gain wide acceptance.

SUMMARY

Veterinarians serve both animals and society in unique ways, including empathy for animals and

science-based knowledge of animal health and husbandry.

They have an inherent responsibility to help animal owners, the public, and other stakehold

ers understand the complexity and ramifications of animal care decisions. In addition to weighing

effects on the animals involved, establishing and implementing good care for agricultural animals

is a balancing act involving human needs (including occupational health and safety), environmental

concerns, and economics.

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FIFTH VIEWPOINT: INDUSTRY PERSPECTIVE ON ANIMAL WELFARE

Charles Arnot

Virtually every sector of society has undergone significant change over the past 40 years and animal agriculture is no exception. Advancements in technology and structural changes in agriculture over the past two generations have radically altered how food animals are raised today. These changes have allowed Americans to enjoy a safe, nutritious, and remarkably affordable supply of meat, milk, and eggs. They have also raised questions about animal care on today's farms and animal agriculture needs to address those questions in a transparent and forthright manner.

Brent Sandidge is a third-generation central Missouri farmer specializing in pork production. His farm dates back to the 27 acres of land his family purchased in 1927. His father decided to get into the pig business in the mid-1950s.

"My father probably had 20 sows when he started," said Sandidge. "Almost everybody had some pigs, some cows, row crops, etc. Farmers were extremely diversified back then."

By the early 1960s, the Sandidge hog operation had grown to
around [illegible] sows.

"That was considered big," said Sandidge. "We were
probably known as one of the largest pork

producers in the state of Missouri."

Because animal agriculture is a low margin business,
farmers have focused on reducing costs

and increasing productivity to remain economically viable.
According to USDA/AMS, from 1960

to [illegible], the deflated average farm price of cattle declined
by [illegible], milk by 30%, hogs by 56%, eggs

by [illegible], chickens by 60%, and turkeys by 73% (Plain, 2010).
Because the prices paid to farmers for

those commodities did not keep up with inflation, farmers
had four basic options: Increase the size

of the operation to maintain the same basic income with
more animals, live on less money year after

year, find a specialty market to capture additional margin,
or leave farming.

Sandidge recalls that when he returned to the farm after
graduating from college in 1978, his

county's pork producer association mailing list contained
around [illegible] names. Today, only a handful

would be considered traditional farrow to finish hog
operations.

"What happened was, people who adopted the new technology
continued to grow and thrive. For

others, maybe the pig business wasn't their first love—they
probably just didn't enjoy the pig busi

ness so they tended to leave it. They decided to
concentrate on other things—corn and soybeans,

for example."

pigs exactly what they need for healthy growth. That has dramatically improved the health and

productivity of our herd."

When the sows roamed freely, Sandidge recalls that a 70% piglet survivability rate was consid

ered good. Today, 90% is not unusual.

Efficiencies and increased productivity allow U.S. consumers to enjoy more affordable meat,

milk, and eggs than consumers in other countries. From 1960 to 2005, the average de*ated retail

price of beef decreased by 27%, pork by 31%, chicken by [illegible] and turkey by 65% (Plain, 2010).

As a result, consumers can afford more meat and poultry. According to the Livestock Marketing

Information Center, in 1970, average Americans spent 4.2% of their income to buy 194 lb of meat

and poultry. In 2005, average Americans spent 2.1% of their income to buy 221 lb of meat and

poultry (Plain, 2010).

Many farmers have chosen contract production to minimize capital requirements and manage

the extreme volatility of commodity markets. In contract production, the contractor or integrator

owns the animals, and provides the feed, health supplies, and transportation. The grower or farmer

is paid to care for the animals and generally gets to keep the manure to use as fertilizer. Today, 46%

of U.S. hogs, 90% of chickens, and 75% of turkeys are raised on contract according to the University

of Missouri (Plain, 2010).

The overwhelming majority of men and women involved in providing meat, milk, and eggs are committed to doing what's right, and while the size of today's farms and the use of technology have changed dramatically, the integrity and commitment of those in food production has not.

While the Sandidge farm has grown from 20 sows in the mid-1950s to 3000 sows today, Brent says he shares his father's commitment to do the right thing.

“If you're in the pig business, you've got to love pigs because it's a lot of hard work. I love raising pigs. I'm doing everything I can to improve their environment so they have less stress and they're more productive.”

Less than 1% of the U.S. population listed their occupation as farming, forestry, or fishing in the 2000 Census (BLS, 2010). The remaining 99% of Americans are generationally and geographically removed from production agriculture. Many have a romanticized notion of what farming “should be” based on outdated information and a lack of education about today's production practices. While research proves that raising animals indoors protects them from weather extremes and predators and reduces disease (University of Missouri Extension, 2009), the integrated model of production is inconsistent with the nostalgic image of farming held by many. In qualitative consumer research conducted on behalf of the Center for Food Integrity, consumers indicated they have a high degree of trust and admiration for farmers, but they are not sure today's production methods should still be considered farming.

Consumers have a right to expect farmers, processors, restaurants, and food retailers to act responsibly and to hold accountable those who do not.

The change in size and structure of animal agriculture, the
lack of public understanding of today's

farming practices, and cultural confusion about the role
and function of animals in developed coun

tries requires those involved in animal agriculture not
only to continue to produce safe, nutritious,

and affordable meat, milk, and eggs, but also they must
demonstrate their commitment to do so in

a socially responsible manner to build and maintain public
trust.

Historically, agriculture was perceived to be committed to
the shared values of compassion,

responsibility, respect, fairness, and truth. Farmers were
granted a broad social license to operate

because it was assumed they would "do the right thing."
Today, some sectors of society are question

ing that assumption.

Industry critics argue that today's systems put profits
above principles. That is a primary tenet of

the argument against today's animal agriculture and it is
expressed in concerns about animal care,

environmental practices, contribution to local communities,
and employment practices.

When public trust is lost or violated, the social license
to operate is replaced with social con

trol in the form of legislation, regulation, market
mandates, and litigation. If the public no longer

believes those in animal agriculture will "do the right
thing," they support laws and regulations

to control what happens on the farm. Animal agriculture has
seen an increase in social control

related to animal care in the form of state legislation and ballot initiatives sponsored by activist groups.

Historically, those involved in animal agriculture have relied primarily on science to defend the increased use of technology and enhanced production systems. Research from Iowa State University (Sapp et al., 2009) shows that effectively communicating shared values is three to five times more important than demonstrating competency through science in building public trust, which protects the social license to operate.

To be successful today and in the future, animal agriculture needs to demonstrate a commitment to operating balanced systems that are ethically grounded, scientifically verified, and economically viable (Figure 5.2).

Those who focus on ethics want food system practices that are consistent with the shared values of compassion, responsibility, respect, fairness, and truth. They want to ensure that the increasingly sophisticated and technologically advanced food system does not put profits ahead of ethical principles and that science is not used as moral justification. When this side of the triangle is out of
Economically Viable ROI Demand Cost Control Productivity Efficiency Profitability Sustainable Systems Ethically Grounded Scientifically Verified Data Driven Repeatable Measurable Specific Objectivity Value Similarity Compassion Responsibility Respect Fairness Truth Ethically Grounded E c o n o m i c a l l y V i a b l e S c i e n t i fi c a l l y V e r i fi e d

FIGURE 5.2 Balanced systems. (From CMA Consulting LLC © .)

balance, critics claim that there is no scientific basis for the claims being made and that the ethical [illegible] will jeopardize the economic viability of the system.

Those with a primary interest in scientific verification are data driven. They want specific, mea

surable, and repeatable observations to provide the basis for their objective decisions. They believe

science can provide the insight and guidance necessary to make reasonable determinations about

how food systems should be managed. When this side of the triangle is out of balance, critics claim

that the organization is relying on science while ignoring ethical considerations and that research

may be done and recommendations made without consideration of the economic impact.

Those responsible for the bottom line are focused on profitability. They work every day to respond

to demand, control costs, and increase efficiency to maximize the return on investment. They have to

manage the increasingly complex demands of competing in a global marketplace with volatile com

modity markets and ruthless competition. When this side of the triangle is out of balance, critics claim

that profits outweigh ethical principles and that business decisions are made without the benefit of

scientific verification, placing those decisions at risk when questioned by those who value validation.

If we cannot operate a balanced system that is ethically grounded, scientifically verified, and

economically viable, it will collapse. That collapse may subject farmers, processors, restaurants,

or retailers to undue pressure that includes consumer protests or boycotts, unfavorable shareholder

resolutions, uninformed supply chain mandates, regulation, legislation, litigation, or bankruptcy.

There are some basic actions farmers and others in animal agriculture can take on the farm to

build and maintain public trust in today's systems.

1. Do the right thing—above all else, make sure your farm meets or exceeds expectations for animal care and environmental stewardship.

2. Set codes of conduct for animal care—if you don't have them, establish animal care standards and ensure the standards are reviewed regularly and are consistently enforced. Require all workers who handle animals to sign the written code of conduct. This is important both for animal care protocol and to verify that all employees understand their shared obligation.

3. Hire the right people and provide ongoing training and consistent supervision—do background checks, establish clear expectations for animal care, and provide ongoing training in animal care and husbandry and consistent support and supervision.

4. Empower your workers—Let them know the critical role they play in providing animal care and assuring your care standards are met consistently throughout the farm. Create clear channels of communication for reporting concerns related to animal care.

Animal agriculture needs to communicate its genuine commitment to principles and shared val

ues, not just because it is the right thing to do, but because it is good business. If animal agriculture

fails to maintain a social license, it will be forced to comply with a more restrictive, higher cost,

more bureaucratic system of social control.

Animal agriculture will be granted the greatest latitude in developing solutions and maintaining

social license when farmers identify those issues that may challenge public trust and con■dence in

today's farming, and propose principle-driven solutions that maintain a sustainable balance of eth ity, science, and profitability.

SUMMARY

Animal agriculture has changed significantly over the last 50 years, as has virtually every sector of society. Technological advances and structural changes in agriculture have allowed Americans to enjoy safe, nutritious, and very affordable food. Those changes have also raised questions about animal care on today's farms.

The economic reality is that prices paid to farmers for what they produce did not keep up with inflation, meaning they had to choose increasing the size of their operations, living on less money each year, finding a specialty market to capture additional margin, or leaving farming. The result is that there are fewer but larger farms in the United States today and new technology has allowed them to increase efficiency, productivity, and volume.

Research shows that modern production methods, such as raising animals indoors, is better for the animals in a number of ways but they are not consistent with the nostalgic image of farming held by many. Consumers have traditionally granted farmers a broad social license to operate because it was assumed they would "do the right thing." Since the public has little understanding of today's farming practices, farmers must demonstrate their commitment to produce food in a socially responsible manner to maintain the social license.

Historically, those involved in animal agriculture have relied on science to defend the increased use of technology. Research shows that effectively communicating shared values is three to five

times more important than demonstrating competency through science in building public trust. To

be successful, animal agriculture must demonstrate a commitment to operating balanced systems

that are ethically grounded, scientifically verified, and economically viable. Failure to maintain this

balance could subject the food system to undue pressure that includes consumer protests or boy

cotts, unfavorable shareholder relations, uninformed supply chain mandates, regulation, legislation,

litigation, or bankruptcy.

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SIXTH VIEWPOINT: AN ACTIVIST'S PERSPECTIVE ON ANIMAL WELFARE

Paul Shapiro

America's animal agribusiness industry is being confronted with a new reality in the twenty-first

century. For many decades, it cloaked itself in the protective mythology of Old MacDonald's Farm

with images of contented cows and pampered pigs. However, that veneer is fading, as more and

more Americans are learning how farm animals are really raised today.

When thinking about how farm animals are raised, it can be tempting to envision those young beef cattle we still see grazing in the countryside. The bucolic image is a powerful one, and one that even many involved in today's farming system seem to believe is the norm.

However, the beef industry, generally speaking, is the exception—not the norm—in animal agribusiness. Approximately 33 million beef cattle (USDA, [illegible]) are slaughtered in the United States annually. Compare that to the nine billion chickens, turkeys, and pigs we consume (USDA, 2010b) and it becomes clear that if we are serious about discussing farm animal welfare, we need to be serious about conditions in the poultry and pig industries. Moreover, that is where a majority of the most pressing welfare concerns are found.

To put the disparity of scale in context, in just 36 hours the U.S. poultry industry slaughters more animals than the U.S. beef industry slaughters in an entire year.

Despite the U.S. animal protection movement's recent success in encouraging agribusiness to start moving away from some of its most extreme abuses, most of the billions of animals raised and killed each year still endure conditions that the majority of Americans would find simply appalling were they to actually witness them.

Animal science professor Peter Cheeke aptly describes this in his textbook, Contemporary Issues in Animal Agriculture, when he writes:

One of the best things modern animal agriculture has going

> for it is that most people . . . haven't a clue how animals are raised and processed. . . . In my opinion, if most urban meat eaters were to visit an industrial broiler house, to see how the birds are raised, and could see the birds being "harvested" and then being "processed" in a poultry processing plant, they would not be impressed and some, perhaps many of them, would swear off eating chicken and perhaps all meat. For modern animal agriculture, the less the consumer knows about what's happening before the meat hits the plate, the better. (Cheeke, 1999)

Events in recent years give the impression that we are reaching a societal tipping point when it comes to establishing a better, more humane relationship with other animals. However, we need to balance that well-founded optimism with reality: In many ways, the treatment of the astronomical numbers of animals we raise and kill for food has grown steadily harsher in recent decades.

I don't anticipate that we'll soon reach societal agreement regarding the ethical permissibility (or lack thereof) of exploiting these animals. As interesting and worthwhile as that debate may be, it is a separate issue. We don't need to wait for such a broad discussion to conclude (or even to begin) before we can start making important animal welfare improvements that society already agrees on and that science and economics demonstrate are feasible. In short, it is incumbent upon us all to move forward on phasing out some standard practices that most of us already agree are simply unacceptable.

That is to say that there really is no excuse for failing to enact policies prohibiting many of the more egregious abuses animals face, and there are certainly plenty to go around. Such an effort would both reduce an enormous amount of unnecessary animal suffering and demonstrate that we are indeed capable of restraining ourselves when it comes to the virtually unlimited power we hold over farm animals.

Such progress is not intended to end the discussion about broader ethical questions, nor is its purpose to end all animal cruelty. The intent, simply put, is to allow our society to move in a positive direction by closing the gap between what Americans want for farm animals and what agribusiness is giving them.

WHERE DOES THE AMERICAN PUBLIC STAND?

The polling and the statewide votes regarding farm animal welfare are all fairly consistent.

A 2008 Gallup poll found that 64% percent of Americans support "passing strict laws concerning the treatment of farm animals" (Gallop, 2008). As well, a 2003 Zogby poll found that while a majority of Americans identify themselves as concerned about "the treatment of farm animals raised for food consumption," 82% agree that "there should be effective laws that protect farm animals against cruelty and abuse." The same poll found that [illegible] percent of Americans believe that "farms should be inspected by government inspectors to ensure that laws to protect animals from cruelty are being followed" (Zogby, 2003).

Even industry-funded polls show virtually identical results.

In 2007, the American Farm Bureau Federation paid Oklahoma

State University to conduct a nationwide survey (Lusk, Norwood, and Prickett, 2007) on American attitudes toward farm animal protection. The results were revealing:

- 81% agree: Farm animals have roughly the same ability to feel pain and discomfort as humans.
- 75% agree: Would vote for a law in their state that would require farmers to treat their animals more humanely.
- 95% agree: It is important to me that animals on farms are well cared for.
- 68% agree: The government should take an active role in promoting farm animal welfare.
- 18% agree: Housing pregnant sows in crates is humane.

It could not be clearer: Americans believe farm animals have interests that matter (for example, not being confined in a virtually immobile state for months on end), and they believe those interests ought to be legally protected.

HOW MUCH LEGAL PROTECTION DO FARM ANIMALS HAVE NOW?

If you spend any amount of time in agricultural circles, you would be hard-pressed to go for long without hearing complaints about a sea of regulation producers must endure. In reality, when it comes to how animals are actually treated, almost anything goes. It may be reassuring to pretend that animals on farms have significant legal protection from abuse, but that simply is untrue in most cases.

Animals used for food production have no federal legal protection whatsoever while they are on the farm. The federal Animal Welfare Act completely exempts animals used for food, and the

Humane Methods of Slaughter Act (HMSA) only sets standards for the animals' final minutes—

while they are at slaughter. Even worse, the U.S. Department of Agriculture (USDA) interprets the

HMSA to exempt nearly all slaughtered animals (chickens, turkeys, rabbits, and several other species,

which represent approximately 95% of the land animals who go through slaughter plants). Moreover,

no person or company has ever been prosecuted under the HMSA for humane handling violations

because USDA has no authority to do so; even in cases where the USDA has found repeated, blatant

violations of the Act—such as an Iowa kosher cattle slaughterhouse that was documented repeatedly

ripping the tracheas out of cows' throats while the animals were fully conscious (Eby, 2004)—vio

lations go unprosecuted. Lastly, there is the federal 28-Hour Law, which regulates the transport of

some farm animals, but which the USDA does not interpret to cover birds and is irrelevant as far as

on-farm treatment is concerned (which is where the vast majority of farm animals' lives are spent).

At the state level, all 50 states have criminal anti-cruelty statutes, but most of them broadly

exempt standard agricultural practices (which are often vaguely defined), essentially allowing any

practice the industry chooses to widely utilize. Not surprisingly, a 2003 Zogby poll found that 66%

percent of Americans find it "unacceptable" to exempt common agricultural practices from state

cruelty laws (Zogby, 2003). However, even in states that do not exempt standard practices from their

cruelty codes, animal abuse prosecutions against agribusiness operations are extremely rare.

The result of such regulatory laissez faire is that animals are left with very little protection,

legally speaking, especially while they are on farms.

As American attitudes toward farm animals have grown increasingly sympathetic over the past

few decades, some standard industry practices have gone in the opposite direction, especially in the

poultry and pig industries. Poor farm animal welfare is not just a matter of a “few rotten eggs,” but

rather it is a case of some standard industry practices that most Americans find simply rotten.

This widening chasm between what Americans want for farm animals and what farm animals actu

ally get is one of the most indefensible realities of our current animal agribusiness system. What many

animal advocates are now proposing is simply that we narrow this gap by translating existing public

support for animal welfare improvements into new policies that offer some semblance of protection to

these animals. The following sections offer a few very brief concrete suggestions for such policies.

CAGE CONFINEMENT OF LAYING HENS

More than 250 million U.S. egg-laying hens live in barren wire cages so restrictive that the animals

can barely move for more than a year before they are slaughtered. With no opportunity to engage in

many natural behaviors, including nesting, dust bathing, perching, and walking, these birds endure

severe, chronic frustration. This near-immobilization takes a substantial toll on the animal’s physi

cal health. Deprived of exercise, the birds suffer from a weak skeletal system (Shipov et al., 2010), and combined with the commonly fed high-energy diet, they can suffer from "fatty liver hemorrhagic syndrome," a major cause of mortality in commercial flocks (Leeson, 2007).

If any system is emblematic of where the industry has gone far beyond what most Americans find acceptable, it is the cage confinement of laying hens. Even some in the meat industry seem uncomfortable with what happens in the egg industry. For example, consider what industry journalist and executive director of the Meat Industry Hall of Fame, Dan Murphy, has to say on the topic:

Now, I don't know how many meat industry executives have spent any amount of time inside an egg production facility, but it's not a pleasant experience. In fact, I would argue that the egg industry is probably the sole exception to my conviction that producers and processors generally treat their live stock with care, if only to protect their investment. Egg producers operate from the principle of planned obsolescence. Since the hens are expendable, the goal is maximum production in the short time they are confined to their "living quarters"—if you can call the battery cage set-up anything that euphemistic.

(Murphy, 2000)

Today's battery cage proponents frequently assert that the cages were invented for the welfare of the bird, an argument unsupported by much evidence. In fact, in 1971—long before animal welfare was a major topic in the industry—one poultry industry representative admitted:

They can tell you all kinds of reasons why cages are good, but what they really did was to organize the

> hens in a production line where you can use more machinery, cut way down on labor, and allow just a few people to take care of a tremendous number of birds. (Sawyer, 1971, p. 216)

In other words, battery cages became popular because they made producing eggs cheaper, not because they were better for the birds.

Dr. Bernard Rollin of the Department of Animal Science at Colorado State University states that

> [v]irtually all aspects of hen behavior are thwarted by battery cages….The most obvious problem is lack of exercise and natural movement....Research has confirmed what common sense already knew—animals built to move must move. (Rollin, 1995, p. 120)

However, common sense does not always prevail, and basic movement is not an option for these animals.

When dealing with single facilities that confine hundreds of thousands—millions in many cases—of birds, individual inspection and veterinary care for each bird is impossible. The most that workers typically do for the birds is walk the aisles to remove the hundreds of newly-dead birds they find in cages each day (often, as numerous exposés have documented, the staff miss dead birds so frequently that carcasses become mummified in the cages).

The United Egg Producers (UEP) recommends that in a cage with multiple chickens, each laying hen get only 67 in. 2 of cage space (UEP, 2010). To put this in perspective, think about a letter-sized

(8.5 × 11 in.) sheet of paper. That sheet of paper takes up 93.5 in.2 of space. Now imagine folding the paper so that you hide almost a third of it, and then picture confining a 4-lb animal in that space for months on end. That is the plight of the modern egg-laying hen.

The extraordinarily restrictive amount of space is not the only major welfare assault for caged laying hens. Konrad Lorenz, the Nobel Prize-winning father of modern ethology, wrote that

> the worst torture to which a battery hen is exposed is the inability to retire somewhere for the laying act. For the person who knows something about animals it is truly heart-rending to watch how a chicken tries again and again to crawl beneath her fellow cagemates to search there in vain for cover. (Lorenz, 1980)

In fact, research has shown that laying hens will work as hard to gain access to an enclosed nesting area as they will to gain access to food after they have been starved for 27 hours (Follensbee, [illegible]). Such evidence makes it clear just how strongly these birds are motivated to nest.

The good news is that there is growing public opposition to the confinement of hens in cages, as evidenced by a flood of legislation, media attention, and corporate policies favoring cage-free production in recent years. For example:

- Several countries, such as Germany, Austria, and Switzerland, have already legislated against cages for laying hens and are presently phasing them out. Indeed, the entire European Union is phasing out barren battery cages (the kind that are standard in the United States) by 2012.
- California and Michigan—two large egg-producing

states—have passed de facto bans (with phase-out periods) on cage confinement of hens.

• At the start of 2005, no major restaurant chains used any cage-free eggs; now, most do.

There is no question about the intersection of values that is driving change for laying hens. In the above-referenced American Farm Bureau poll, a majority of Americans thinks caging hens is inhumane, and a UEP-funded poll found that a plurality of Americans believe that caging hens is “not healthier nor safer.” 1

Animal scientist Dr. Michael Appleby sums it up well:

> Battery cages present inherent animal welfare problems, most notably by their small size and barren conditions. Hens are unable to engage in many of their natural behaviors and endure high levels of stress and frustration. Cage-free egg production, while not perfect, does not entail such inherent animal welfare disadvantages and is a very good step in the right direction for the egg industry. (Appleby, 2006)

Commercial U.S. cage-free operations—which allow hens to walk, spread their wings, nest, perch, and more—are already raising millions of laying hens, and this number will likely increase as concerns about farm animal welfare grow stronger. The industry has a chance to embrace cage free systems that better-accommodate both animal welfare and consumer desires.

GESTATION CRATE CONFINEMENT OF BREEDING PIGS

In 1968, after witnessing the economic results already achieved by the egg industry through confining increasing numbers of animals in small spaces, one pork industry analyst asked, “Why cannot greater efforts be made to introduce some of the economies of scale to hog production that have

made the battery raising of chickens so ef■cient?" (Twedt, [illegible]).

So it began. There was indeed little to stop the pork industry from going in the same direc

tion as the egg producers. This is especially so in the case of the female pigs who are used for

breeding.

While most pigs used for pork production may have bleak lives living on concrete slatted ■oors

with no bedding and little environmental enrichment, breeding sows are abused in ways so terrible,

few people would support such treatment were they to see it firsthand.

Gestation crates are 2-ft-wide barren metal cages that confine impregnated pigs for months on

end. They are unable even to turn around. Pigs con■ned in gestation crates suffer immensely, unable

to exercise or engage in nearly any of their natural behaviors. The forced immobilization takes a

serious physical and psychological toll, leading to both leg and joint problems along with psychosis

resulting from extreme boredom and frustration.

Numerous animal scientists oppose these cruel crates. Colorado State University animal scientist

Dr. Temple Grandin asserts, "Gestation crates for pigs are a real problem...Basically, you're asking a

sow to live in an airline seat...I think it's something that needs to be phased out." 2

Some in the pork industry still defend the use of gestation crates on the grounds that not only is it cheaper to pack pigs into the smallest spaces possible, but crating allegedly helps reduce sow aggression. Animal scientist and farm animal expert Dr. John Webster asserts that this defense "rests on the premise that it is acceptable to prevent an undesirable pattern of behaviour by restricting all forms of behaviour." Webster goes on to explain, "It would be as valid to claim that prisons would be much more manageable if all the inmates were kept permanently in solitary confinement" (Webster, 2005).

As well, the economic argument in favor of gestation crates isn't exactly strong. One need not look further than Iowa State University, where a 2-1/2-year-long study concluded that raising sows in groups in hoop housing rather than individual crates could cut the cost of production by 11% percent per weaned pig (Iowa State University, 2007).

As is the case with battery cages, the science seems to comport with the public's gut reaction against such extreme confinement. After the Scientific Veterinary Committee of the European Commission concluded, "Since overall welfare appears to be better when sows are not confined throughout gestation, sows should preferably be kept in groups" (Scientific Veterinary Committee, 1997), the entire European Union passed legislation phasing out gestation crates.

Seven U.S. states have passed legislation banning gestation crates. Even some parts of the industry, after years of defending such confinement, are beginning to see the light with major pork producers starting to move in the right direction.

In fact, a 2004 National Hog Farmer magazine article profiled Goldsboro Hog Farms, a major U.S. pork producer that has not used gestation crates for years (Miller, 2004). Cargill, a major pork producer, issued a press release in 2009 declaring that 50% of its sows are no longer in gestation crates (Cargill, 2009), and in 2010 the company's director of communications asserted that "our plan is to ultimately move further away from gestation crates" (Forster, 2010). Smithfield Foods—the world's largest pork producer—has stated that its goal is to become gestation crate-free, although at present it doesn't have a timeline for achieving that aim.

The fact that many farms are using alternative systems is living proof of the unnecessary nature of gestation crates.

FORCED RAPID GROWTH OF BIRDS RAISED FOR MEAT

The 9 billion chickens and turkeys slaughtered in the United States each year are far removed in appearance from the wild animals that we originally domesticated. Unlike their fleet-footed ancestors, these animals are the products of intensive genetic selection for maximal weight gain with minimal feed consumption—as though animals could be transformed into meat-producing machines with enough human manipulation. Administration of growth-promoting antibiotics and other additives often help along the way, as do near-permanent lighting schedules that cause the birds to eat more than they would if they had a longer nighttime period of darkness.

In the 1950s, it took 84 days to raise a 5-lb chicken. Today, it takes an average of only 45 days, often

even less (Havenstein, Ferket, and Qureshi, 2003). In 1947, just before this forced rapid growth of

birds took off, the Saturday Evening Post described what the chicken industry was planning to do:

No politician ever promised more than our poultrymen are now about to deliver. They expect to squelch

that dream of two chickens in every pot by providing one bird chunky enough for the whole family—a

chicken with breast meat so thick you can carve it into steaks, with drumsticks that contain a minimum

of bone buried in layers of juicy dark meat, all costing less instead of more. 3

They weren't really that far off.

Moreover, just as being morbidly overweight carries numerous health problems for humans, this

forced rapid growth takes an enormous toll on the welfare of the birds. Poultry welfare expert Dr.

Ian Duncan writes, "Without doubt, the biggest welfare problems for meat birds are those associ

ated with fast growth" (Duncan, 2004).

Dr. Temple Grandin puts it more bluntly: "Today's poultry chicken has been bred to grow so

rapidly that its legs can collapse under the weight of its ballooning body. It's awful" (Grandin and

Johnson, 2005). Consequently, huge numbers of chickens raised for meat suffer from leg deformities

and lameness. Studies consistently show that approximately 26 to 30% of broiler chickens suffer

from gait defects severe enough to impair their walking ability (Knowles et al., 2008), and additional

research strongly suggests that birds at this level of lameness are in pain (Danbury et al., 2000).

Additionally, rapid growth can lead to circulatory and pulmonary problems. "Sudden death syndrome" (SDS) is caused by acute heart failure and is common in broiler chickens (Riddell and Springer, 1985). Young birds die from SDS after sudden convulsions and wing-beating (Julian, [illegible]). Ascites is a condition in which rapidly growing broiler chickens do not have the heart and lung capacity needed to distribute oxygen throughout the body (Duncan, 2001) and is a leading cause of on-farm mortality as the birds reach market weight ([illegible]sma, 2001).

Even though rapid growth increases mortality rates, it is not necessarily in producers' economic interests to improve the situation. Two University of Arkansas poultry industry researchers were straightforward in their assessment when they asked:

> Is it more profitable to grow the biggest bird possible and have increased mortality due to heart attacks, ascites and leg problems or should birds be grown slower so that birds are smaller, but have fewer heart, lung and skeletal problems?...A large portion of growers' pay is based on the pound of saleable meat produced, so simple calculations suggest that it is better to get the weight and ignore the mortality.
>
> (Tabler and Mendenhall, 2003, pp. 8-10)

But better for whom?

On the growth rate issue for meat-producing birds, animal scientist Dr. John Webster observes,

> On the balance of the evidence, we must conclude that approximately one quarter of the heavy strains

of broiler chickens and turkeys are in chronic pain for approximately one third of their lives….This must constitute, in both magnitude and severity, the single most severe, systematic example of man's inhumanity to another sentient animal. (Webster, 1995, p. 156)

While slower-growing strains of birds do exist, they comprise an infinitesimal portion of the U.S. poultry market and are therefore not as easy for consumers to find. The companies that control nearly all poultry production have created the problem through intensive genetic selection for specific traits (mainly rapid growth and higher rates of feed conversion), and those same companies can instead select birds for health and welfare. In fact, nearly one-third of chickens raised for food in France are actually slow-growing, free-ranging birds, marketed as "Label Rouge" (Fanatico and Born, 2002).

Despite the enormity of the suffering forced rapid growth causes these animals, the costs asso ciated with slowing these birds' growth rates are not as high as are those associated with some other important farm animal welfare improvements. The European Union's Scientific Committee on Animal Health and Animal Welfare found that slower growth would increase running costs principally by delaying the slaughter age, but that delaying slaughter age by only 10 days, while having a significant impact on welfare, would only cause approximately 5% higher costs than those of conventional breeds. [4]

Slowing today's astronomical growth rates would of course not address every form of suffering we inflict on the billions of birds we raise for food, but it would help improve their welfare in a meaningful way.

MOVING FORWARD TO A BETTER FUTURE FOR FARM ANIMALS

Concern about animal cruelty is far from the only consideration vying for the American public's attention, but the evidence is clear that our society considers it an important matter that warrants our serious attention. Farm animals are completely at our mercy, yet the abuses we force on them—including, but far from limited to, the three examples given in this chapter—are simply beyond the bounds of what our society considers ethically appropriate.

Some in the industry are consequently moving toward better systems and more realistic husbandry. Unfortunately, some trade groups that represent animal agribusinesses choose not to lead, but to fight the kinds of reforms outlined in this chapter, no matter how popular they may be with the American public.

As Nebraska cattle rancher Kevin Fulton writes,

A lot of farmers I know don't support battery cages and gestation crates, but they fear being ostracized by the Farm Bureau and other trade groups if they speak out. I can't imagine anyone being proud to have to keep their animals locked up in tiny cages for their whole lives. Most farmers would rather use good husbandry than have to rely on such shortcuts, but they don't see a way out. If we had better leadership in our industries though, we could move in the right direction rather than being—correctly—perceived as hostile to any substantial animal welfare changes. 5

The animal agribusiness industry has a chance to stop defending practices many Americans find

indefensible and instead move toward systems that will better accommodate both animal welfare

and consumer desires. Rather than trying to prevent change, these groups can and are beginning to

seek incentives for producers to convert to higher welfare production methods.

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1. "Laying Out the Facts." Presentation by United Egg Producers spokesman Mitch Head, delivered to the American Beef Institute's "Animal Care and Handling Conference," Kansas City, MO, February 18, 2004.

3. Comments Temple Grandin made during a Q&A session on January 4, 2006 at Manhattan Columbus Circle, New York. They can be heard at: http://nycanimalrights.com/Temple%20Grandin%20Animals%20in%20Translation.htm

4. Saturday Evening Post, August 9, 1947. As cited in Sawyer, Gordon. 1971. The Agribusiness Poultry Industry: A History of Its Development. Hicksville, NY: Exposition Press, p. 116.

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6. Personal email communication between Kevin Fulton and the author on September 29, 2010. Used with permission.

6 Chapter 6: Contemporary Animal Agriculture : Rural Community Concerns in the United States

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DAIRY CATTLE

Judith L. Capper

INTRODUCTION

Animal welfare concerns usually center around three areas of focus—productivity, ability to express "natural" behaviors, and the absence of pain or suffering (Fraser et al., 1997). Nonetheless, it can be argued that dairy cattle welfare is a function of the three aforementioned criteria, with notable inter connections between each issue. The degree to which husbandry systems satisfy the mental and physical needs of dairy cattle is somewhat difficult to assess. Traditionally, animal productivity has been accepted as an indicator of animal welfare—with higher productivity (milk yield, fertility, growth rate) implying that the animal's needs are met to a satisfactory degree. There can be no doubt that in the case of the lactating dairy cow, sustained high productivity cannot be achieved in the absence of good welfare. Nonetheless, other parameters such as physiological data (circulating hormone and enzyme concentrations, heart rate, immunosuppression), measures of morbidity and mortality, and behavioral adaptations that suggest compromised welfare or adoption of coping strategies provide indicators by which we can benchmark the effects of differing management practices or husbandry systems.

UNIQUE ASPECTS OF DAIRY PRODUCTION IN ANIMAL WELFARE ISSUES

Animal welfare is often related to the animal's ability to
express natural behaviors (von Keyserlingk

et al., 2009). Concern exists that animals kept under
conditions considered abnormal may suffer,

although abnormality is dif■cult to de■ne in modern
livestock. The issue of natural behavior

expression may be overtaken by emotive language propagated
by those who are opposed to ani

mal agriculture and wish, for example, for "pigs to express
their pigginess." Such groups neglect

to acknowledge the role of animal agriculture in providing
high-quality protein to the growing

population, and fail to acknowledge animals' contributions
to human life in terms of clothing,

land maintenance and diversity, by-products for industrial
manufacture, etc. When directed at the

dairy industry, emotive language serves to further promote
the popular consumer perception that

the small-scale production systems present in the 1940s and
1950s had considerably higher wel

fare standards than current production systems. This is an
entirely disingenuous suggestion—few

people would suggest that standards of human welfare
(health, nutrition, behavior) were signi■

cantly better in the 1940s, where the average life
expectancy was 62.9 years (compared to 77.8 for

2005; National Center for Health Statistics, 2006). The
U.S. industrial revolution demonstrated

the short-term improvements in productivity gained by
running factories for 24 hours per day.

However, this short-term increase in productivity was at a
considerable cost to human welfare—

poorly ventilated, cramped working conditions without adequate time allowances for breaks or meals and no health care provision led to increased disease, reduced morale, and a long-term productivity decline (Brezina, 2005). To take this example further, factories still run on a 24-hour cycle in many industries; however, with considerably improved working conditions, scheduled breaks and vacation, and provision of health care and benefits, productivity has improved considerably. It has become clear that maximum short- and long-term productivity is gained through improving worker health and welfare, allowing the human components of the system to perform at the optimum level. The same approach may be applied to animal production—turning the "high productivity = high welfare" suggestion on its head, one can suggest that "high welfare = high productivity." There is no doubt that early innovations demonstrated to improve dairy productivity had undesirable consequences when taken to extremes. However, improved knowledge and understanding of dairy cow nutrition and metabolism has led to a system, which allows for improved animal welfare and productivity when applied appropriately.

The bucolic image of small-scale, extensive dairy systems often leads to the characterization of modern large-scale agriculture as "factory farms," thereby implying that these systems have an extremely low level of concern for animal welfare. Nonetheless, examination of the characteristics of mid-1940s dairy farms shows that the agrarian idyll may not be an appropriate image. Dairy production in 1944 was characterized by extensive pasture-based systems with an average herd size of approximately six cows (Capper, Cady, and Bauman, 2009). Dairy cow nutrition was reliant on homegrown forages with few purchased concentrate feeds (Woodward, 1939) and with only a basic understanding of the nutritional and metabolic interactions between animal nutrition and productivity. Perhaps the most striking aspect of this so-called high animal welfare system was the low productivity—the average dairy cow in 1944 yielded only 2074 kg/year. Since this time, the milk yield per cow has increased at an average of 136 kg/year, of which half to two-thirds of the increase has been attributed to improved genetics (Shook, 2006). However, the remaining component can be attributed to improved understanding of nutrition, management, and welfare, thus allowing the modern dairy cow to produce more than 9333 kg of milk per year (USDA/NASS, 2010). Nonetheless, efficiency within modern production systems is sometimes perceived by the consumer as being undesirable or to occur at the expense of optimum animal welfare and well-being.

The sustainability of any dairy system depends upon balancing economic and environmental sustainability while maintaining the social license to operate. Average dairy product consumption has steadily risen over the past 20 years, with a decline in fluid milk consumption more than compensated for by an increase in consumption of cheese and other dairy products. Although milk is still considered a staple food, competition from other beverages and concern over the portrayal of dairy management practices by media and activist groups may threaten social license, particularly when animal welfare is the issue under discussion. This is exacerbated by anthropomorphic views of animal welfare and the perception that the modern dairy cow has been “removed” from its natural environment. In contrast to the dairy population in the 1940s, which comprised a mix of small (Jersey, Guernsey) and large breeds (Holstein, Ayrshire, Shorthorn), the modern U.S. dairy population is distinctly more homogenous, containing near 90% Holsteins, approximately 5% Jerseys, and 5% other breeds (Majeskie, 1993). The modern dairy cow may therefore be considered to be a human creation—selection pressure augmented by the introduction of technologies including artificial insemination, embryo transfer, genetic evaluation, and genome mapping has allowed for animals that have significantly higher milk yields, yet these come with their own management challenges that must be met for productivity and animal welfare to be optimized. It appears that selection for high milk production may confer a higher susceptibility to stress and therefore a greater risk of behavioral, physiological, and immune problems (Rauw et al., 1998) than demonstrated by lower producing cows. It should be noted that milk production per se does not confer an increase in cortisol or stress-related behaviors—it is the very absence of stress that allows dairy cattle to perform to their genetic potential for lactation. Improvements in management practices that result in a system more conducive to dairy cow welfare therefore have demonstrable effects upon perfor

mance. Major contributors to animal welfare and productivity include the physical environment,

disease prevention and treatment, and nutrition, all of which should be considered both as singular

effects and as interacting factors.

Physical Environment

To maximize productivity and animal welfare, dairy management systems should be founded upon

the behavioral routines of the animal. This does not necessarily extend to a situation where animals

are allowed to forage on pastureland and to run in traditional herds containing both female and

male animals, without human intervention, as might be suggested by some of the more extreme

anti-animal agriculture groups. Nonetheless, the behavioral needs and routines of the cow must be

considered when designing a dairy system that is effective in optimizing animal welfare. According

to Grant and Albright (2001), dairy cows spend 3 to 5 h/d eating, thus consuming 9 to 14 meals per

day. In addition, they ruminate for 7 to 10 h/d, spend approximately 30 min/d drinking, and require

approximately 10 h/d of lying or resting time. This only leaves a minor period free for daily manage

ment practices including milking. Compromising the cow's ability to perform these activities has

negative effects on productivity and may increase stress levels.

Groups of dairy cattle quickly establish a dominance hierarchy, which is maintained according to age, body weight, and social status within the population ([illegible]lund and Polan, 1974). Research demonstrates that when maintained in groups containing greater than 100 animals, dairy cattle may lose the ability to recognize individuals and assess their relative position within the hierarchy (Albright, [illegible]). This would appear to favor small-scale dairy production systems; however, it can easily be achieved within larger dairies, which, for ease of management, group cows according to stage of lactation or parity. However, significant stress behaviors are often exhibited as a result of moving animals between established groups, for example, from a "far-off" (60 to 30 days pre-partum) to a "close-up" (30 days pre-partum to parturition) dry cow group. Abnormal feeding behaviors and an increased incidence of metabolic disorders have been exhibited by cows subjected to abrupt environmental or social changes during the peri-parturient period (Bazeley and Pinsent, 1984) with consequent effects on productivity. This may be alleviated by moving large numbers of cows at a time, in order to minimize individual animal stress from handling and to reduce social disruption (Grant and Albright, 2001) but this practice is again better suited to a large facility.

Grant and Albright (2001) note that optimal grouping strategies minimize negative social interactions and encourage positive interactions, with an overall aim of maximizing cow comfort and productivity. Fighting within the group is an obvious stressor and may reduce productivity—although conflict is thought to be reduced by the maintenance of a stable dominance hierarchy, it is not eliminated and can only be minimized. Competition for feed is an inevitable consequence of modern dairy production systems unless animals are confined to tie-stalls (which are associated with a different group of welfare issues). For example, the increase in dry matter intake during the first few weeks of lactation occurs at a faster rate in older cows than in heifers (Kertz, Reutzel, and Thomas, 1991) and may lead to negative interactions at the feed bunk. This provides a rationale for grouping cows according to parity during early lactation. Fox (1983) suggests that the welfare of cows within small- and medium-scale production systems is higher than in other farm animal species. However, it is interesting to note that grouping cows is more suited to a medium- or large-scale dairy than a small-scale dairy, despite their generally negative image with consumers.

Anecdotal evidence from the U.S. dairy industry suggests that when herd sizes were reduced in California in an attempt to decrease milk supply, milk production per facility increased because of improved dry matter intake (DMI) and extra feeding space per cow. Despite the potential for hierarchal conflicts within large groups, it appears that these may be mediated though the provision of adequate feeding space and supplies of fresh feed (Grant and Albright, 2001). The ideal group size is difficult to define, but is a function of competition for feed and water, space in the lot and holding area, stall use, and time diverted from productive behaviors (eating, drinking, resting, and ruminating).

Over time, greater knowledge of cow behavioral requirements has led to the understanding that provision of comfortable stalls has a direct effect upon productivity. Tremendous evolution has occurred from original wooden stalls that did not allow adequate forward or side space for animals to lunge forward in a natural manner but facilitated free movement within the pen, to modern free stalls with sand bedding and ample space to extend their front legs and lunge forward or sideways, while still allowing for natural herd behavior within the pen. Poorly designed stalls that are too short or that have inadequate bedding material reduce occupancy of free-stalls, thus reducing the proportion of time spent lying or resting and increasing the chance of injury and lameness.

The debate as to whether cattle should be confined, grazed on pasture, or kept within a system that makes use of both practices continues to rage. Critics of confinement systems claim that they stifle natural behaviors, yet given the increase in human population size that is predicted to occur within the next 40 years, the intensity of competition for land use is likely to increase. Assuming that dairy consumption per capita stays stable, an industry-scale move to grazing systems is not a feasible alternative simply based upon the lower productivity in grazing herds (USDA, 2007) and thus the increase in land requirements per unit of milk (Capper et al., 2008). Grazing systems are often perceived to be more welfare-friendly than are confinement systems; nonetheless, the welfare issues associated with grazing may have different symptoms, but are equally detrimental to dairy productivity and well-being. There is little evidence that cows within these grazing systems have higher overall welfare than animals in a well-managed confinement system, especially given the relative lack of control over environmental factors such as temperature, humidity, and ventilation. Indeed, over time, conventional dairy systems have progressed from extensive pasture-based systems, through completely enclosed tie-stall and stanchion barns to modern open side-walled barns with ventilation fans or cross-ventilated barns, which create an environment that allows animals to remain within their thermo-neutral zone without expending excess energy on heat generation or dispersion. Where a market or sufficient resources are present to allow for grazing systems to prosper, it is essential to match the animal characteristics to the system. This is exemplified by the results observed when U.S. Holstein genetics were imported into New Zealand: Initially milk production was increased compared to the New Zealand Holstein, but the grass-based system is nutritionally insufficient to support high milk production and leads to lower survival rates as cows fail to cycle or become pregnant and are culled as a result of the demands of the seasonal antipodean calving system (Lucy, 2001).

Arguably, one of the most significant advances in both dairy and beef cattle has been the development of handling systems that minimize stress and maximize productivity. Researchers such as Dr. Temple Grandin at Colorado State University have designed and implemented movement

systems that allow the animal's natural flight zone to be manipulated to facilitate handling with

reduced animal stress and thus greater ease and efficiency of management (Grandin, 2007). Cattle

that have a positive relationship with their handlers tend to move more smoothly, are less nervous

within the milking parlor or handling systems, and acclimatize more easily to changes in routine,

for example, when moving groups or during initial introduction to the milking process. Fox (1983)

states that maximum biological efficiency is achieved through a close human-cow bond, lack of

fear, zero flight distance, and selection for docility; nonetheless, these characteristics do not com

pensate for low genetic merit for milk yield or poor management within the herd.

Disease Prevention and Treatment

The introduction of antibiotics for animal use was a major step forward in improving dairy welfare

and productivity. Modern animal production is often criticized for the extent to which antibiotics

are used, with ongoing debate as to whether antibiotic use within agriculture has contributed to the

rise of antibiotic resistance and related human health issues. Given that one of the cornerstones of

animal welfare according to the "five freedoms" first originated by Brambell (1965) is the ability

to be "free from pain, injury, and disease," promotion of a dairy system whereby antibiotic use is

prohibited seems counter to the suggestion that animal welfare and productivity should be maxi

mized. If it is accepted that animal welfare is paramount within production systems, the increasing popularity of extensive or low-input systems that make marketing claims based upon non-use of therapeutic antibiotics should be questioned. Groups opposed to animal agriculture often suggest that modern-day conventional dairy producers are motivated simply by profit, with little regard for animal welfare or well-being (Sustainable Table, 2009). However, this suggestion is inappropriate as productivity is negatively affected by suboptimal animal welfare or increased morbidity and mortality. Any management practice or system that negatively affects morbidity or mortality rates is neither economically viable nor practicable.

Within any system analysis, it is vital to consider the scientific basis behind the livestock production practices rather than allowing decisions to be made based on emotional or philosophic arguments (Pretty, 2007). This is exemplified by animal welfare legislation that is coming into play across the United States and the rest of the world. For example, restricting the use of individual housing for calves after eight weeks of age in Europe facilitates social interactions and allows the development of natural herd behaviors (von Keyserlingk et al., 2009), but also increases the potential for disease transmission through direct contact, with a concomitant risk of increased morbidity and mortality. The conflict between public perception, scientific evidence, and traditional production methods is perhaps best exemplified by the current discussion relating to tail docking in dairy cattle.

Proponents of tail docking suggest that it promotes cleanliness within the herd, reduces tail-related injuries (predominantly eye infections) in workers, and reduces the incidence of mastitis. There is little scientific evidence to support these claims either from an animal or human welfare perspective and as the practice is not supported by the major animal welfare or wellness organizations, nor the general public as a whole, it appears that it may soon be legislated against. It is impossible to justify production practices for which no scientific data exist to demonstrate either a lack of negative effects or an improvement in welfare—this underlines the importance of devoting further resources to welfare issues in future research protocols.

Dr. Temple Grandin, a pioneer in the field of animal behavior and movement, often refers to the concept of “bad becoming normal,” which may be defined as a situation that is detrimental, yet is seen so often that it becomes commonplace (Grandin and Johnson, 2006). Dr. Grandin applies this principle to the relatively high incidence of lameness within the dairy industry—an issue that is cited by consumers as a particular welfare issue. There is some debate as to whether an increased incidence of lameness is an inevitable consequence of industrialization within the dairy industry: Certainly lameness reduces productivity (Green et al., 2002) and is undesirable both from an economic and welfare perspective. However, milk yield itself has not been shown to be a contributing factor (Haskell et al., 2006). In addition, there was no association between herd size and lameness incidence in the study of Espejo and Endres (2007), although the authors noted that studies in England had found differing results. The frequency of hoof-trimming, time spent away from the pen (without access to stalls, food, or water), and cow-comfort quotient were reported to have significant effects upon lameness (Espejo and Endres, 2007). Matching stall size and design to cow size and weight was also cited as a major factor in lameness incidence by both Haskell et al. (2006) and Espejo and Endres (2007). This is often seen in older facilities where average cow size has increased over time, without a corresponding increase in stall size or change in design. It is somewhat comforting to know that these management factors can be controlled or changed in most farm situations; therefore, significant potential exists to reduce lameness and improve overall animal welfare, provided that the producer has sufficient incentive to do so. The increasing number of certification schemes that include animal welfare as a major component and provide a market advantage may achieve this.

Mastitis is arguably one of the most significant issues within the dairy industry, with potential production losses of 135 kg milk in the first lactation or 270 kg milk in the second lactation per unit increase in average log somatic cell count (Raubertas and Shook, 1982). Mastitis's nature as an inflammatory condition causing pain and loss of production is by definition a welfare issue. The severity of this issue is highlighted by the fact that producers report 16.5% of animals suffering from the condition, and udder or mastitis problems rank second in the list of producer-reported reasons for culling (USDA, 2007). There appears to be an association between milk yield and mastitis incidence (Phipps, 1989), yet there is some discussion as to whether this is a direct cause-effect relationship, for which there seems to be little biological foundation, or whether it results from greater time spent in the milking parlor with associated potential for infectious transfer, as a consequence of increased yield. For example, the biotechnological tool recombinant bovine somatotropin (rbST) increases milk yield by approximately 4.5 kg/d if sufficient feed is supplied to support milk yield (Capper et al., 2008). The FDA-approved label for rbST includes a warning that cows injected with the product are at an increased risk for mastitis, which groups opposed to biotechnology have taken as evidence that rbST use causes mastitis. However, a 1100-cow study undertaken by Poulet (1992) demonstrated no correlation between the relative incidence of mastitis and the use of rbST.

As demonstrated by the U.S. dairy industry over the past century, greater intensification, including an increase in herd size, is an inevitable consequence of the need to produce more milk to feed the increasing population using fewer animals and non-renewable resources. However, mastitis incidence is not linked to herd size (USDA, 2007) and its control is dependent upon the implementation of best management practices including milking parlor hygiene, use of teat disinfectants, and clean bedding materials. It is worth noting that there are few studies relating to mastitis incidence in organic herds in which antibiotic use is not permitted (Hamilton et al., 2006; Ruegg, 2009).

Anecdotal evidence suggests that many large organic herds also maintain a conventional herd into which animals may be moved if antibiotic treatment becomes necessary, or these animals may simply be sold. Given that milk yields in organic dairy herds are generally 20 to 40% lower (Zwald et al., 2004; Rotz et al., 2007) than those of conventional herds, any demonstrable reduction in mastitis may simply result from lower productivity. It appears that there is little to be gained from adopting management practices characteristic of organic or extensive production in preventing and controlling mastitis, but implementing best management practices as exhibited by the most productive and efficient farms currently within the industry paves the pathway to improving animal welfare.

Increases in milk production over the past 30 years have been associated with a reduction in fertility (Lucy, 2002). It is debatable as to whether this is an animal welfare issue per se. Reduced fertility may be taken as an indicator of underlying health issues, but it may also be argued that achieving pregnancy after milk production peaks and the cow is able to attain a positive energy balance is more desirable for the animal and is more likely to result in a successful pregnancy.

Drying-off high-yielding cows that continue to yield 30 or 35 kg of milk per day at 365 days into lactation is undesirable and may lead to problems in the subsequent lactation (Church et al., 2008).

Nonetheless, infertility is a major reason for culling with a producer-reported 26.3% of animals being removed from the herd due to reproductive problems (USDA, 2007). A recent report from the Farm Animal Welfare Council (2009) suggested that the average lifespan of 3.3 lactations for U.K. herd cows is an indicator of suboptimal welfare given that cattle can live to 12 years or older. If we set aside the previously discussed effects of genetic merit upon productivity and the market forces in place that favor replacing older cattle with heifers within the current dairy herd, improving fertility would be expected to have positive effects upon lifespan and welfare. It should be noted that dairy cow fertility is not an objective measure—pregnancy rate defined as the proportions of cows that become pregnant divided by the total number of cows eligible to become pregnant within a specific time frame) is significantly affected by the ability of herders to detect heat. Indeed, Coleman (1993) reported that 90% of low estrus detection rates could be attributed to herders versus 10% to the cow herself. This does not necessarily account for the increase in non-behavioral estrus ("silent" heats) exhibited by high-producing animals under thermal or other stresses (Her et al., 1988), but demonstrates the value of heat detection methods such as tail chalking in improving fertility. The current average U.S. pregnancy rate ranges from 16% to 20%. Nonetheless, the author is personally aware of more than one U.S. dairy herd averaging over 41 kg of milk per day with a pregnancy rate of 29%—an example of a production facility whose management practices should be emulated both now and in future.

The relatively high incidence of culling within the U.S. dairy herd is often cited as evidence of poor animal welfare compared to less intensive systems. Holstein cows spend an average of 2.54 lactations within the herd (DairyMetrics™ database, Dairy Records Management Systems, Raleigh, NC; accessed November 13, 2009) before being sold or diverted to the beef market (culling). Just as any dairy production system has to function as a fiscally efficient business to be economically sustainable, it can be argued that the concept of "involuntary culling," that is, culling that is not under the producer's control, can be restricted to only two occasions—animal death or theft. Other incidences of culling due to low yields, poor fertility, or disease are an economic decision—if the cost invested in rectifying the issue or the return gained by keeping the animal in the herd outweighs the cost of replacing the animal with a freshly calved heifer, and providing such a heifer is available, it is inherently logical to replace the cow. It should be noted that the movement of cows from the dairy herd to the beef supply should not be considered "wastage"—approximately 7% of animals slaughtered for beef production in 2009 originated from the dairy herd, allowing sufficient beef to be produced without having to increase the size of the national beef herd. Although the majority of dairy bulls are diverted into beef and veal production systems, dairy heifers comprise only 1.4% of animals within beef feedlots (USDA, 2000), reflecting their relative value as dairy versus beef animals. On an idealistic basis, it is tempting to suggest that cattle would perform to their genetic merit and only leave the herd when they have completed their natural lifespan; however, this situation may not be best-placed to fulfill the needs and constraints of the modern dairy industry, especially given that a cow necessitates the production of a calf in order to lactate, and approximately half of the calves born are heifers. Discussion is occurring as to the potential effects of increasing sexed semen use within the dairy industry—it is possible that the future U.S. dairy industry will only use female-sexed semen upon the highest genetic merit cows, with the remainder being bred to a beef bull, or inseminated with male-bearing sperm.

Nutrition

Nutrition is the foundation upon which dairy cow productivity and welfare is built. Multifaceted links exist between the three pillars of animal welfare, yet without an adequate high-quality feed provision to supply the nutrients required to support maintenance, lactation, pregnancy over the long-term, productivity, efficiency, and health and welfare suffer. As previously discussed, adoption of the credo that high productivity goes hand-in-hand with optimal animal welfare carries the inherent assumption that nutritional strategies that encourage high production also ensure that animal welfare is maintained. Provision of sufficient time and physical space for feeding behavior to occur is a key to maintaining productivity—Grant and Albright (2001) suggest that feeding is the predominant behavior in dairy cattle until requirements are satisfied, with rumination taking precedence only when its feed has been abnormally restricted. From a physiological aspect, distur

bances in rumen function or nutrient digestion lead to reduced productivity; for example, the early

discovery that supplementing ruminants with highly fermentable grain (e.g., corn) also led to a

considerable increase in mortality until correct feeding levels were established. Once these were in

place, the next issue to become known was the ﬂuctuations in ruminal pH and subsequent acidosis

conferred by feeding forage separately from concentrate feeds. Over time, the adoption of total

mixed rations (TMRs) within conventional dairy production has increased from 35.6% in 1996 to

51.5% in 2007, with 70.1% of herds with a rolling herd average of over 9072 kg/y (slightly below

the average annual milk yield for the United States in 2007) feeding a TMR. Feeding a diet that

is balanced to maintain energy and protein supply and that reduces adverse changes in ruminal or

intestinal digestion has demonstrably improved digestibility, productivity, and welfare. These are

only two brief examples of the interaction between nutrition, health, and physical environment, but

there are many more. An in-depth discussion of the effects of inadequate or inappropriate nutrition

upon welfare is beyond the scope of this review, yet the subject should be considered in any welfare

discussion.

CONCLUSION

Animal welfare, productivity, and efﬁciency are keys to the continued sustainability of the dairy industry. Rather than focusing on individual practices from conventional or alternative production systems, best progress can be made by highlighting the management principles that maximize all three components of animal welfare, thus indicating that productivity and welfare are intrinsically linked. Within the current industry, this means examining the systems employed by the top 20% of producers, shifting the bell-shaped curve from the current average to a better average, and gaining momentum for future change in the process. Early adopters of innovation within any industry make the fastest progress, with the difference between early and late adopters being demonstrated by product quality—in this case milk production and indicators of animal welfare. Ideally, proactive adoption of best management practices will improve productivity and welfare—if adoption is so low that regulation or legislation is required to bring the lowest performers up to average performance, it should be questioned as to whether those producers will remain competitive within an industry that is increasingly reliant on social license to operate. Ultimately, one of the biggest threats the dairy industry faces concerning animal welfare is the presence of producers who fail to value the interaction between animal welfare and productivity and who are inevitably the subject of exposes by anti-animal agriculture groups. The importance of animal welfare and productivity in maintaining the socioeconomic sustainability of the dairy industry cannot and should not be underestimated.

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POULTRY

Kenneth Anderson

POULTRY AND POULTRY PRODUCTION SYSTEMS

Over the last 100 years, the poultry industry has developed into three highly efficient systems

made up of the commercial egg, broiler, and turkey segments. Back in the early 1900s when small

self-sustaining farms were everywhere in the United States, free-range chickens for eggs as well

as meat were a standard commodity on most every farm (Dryden, 1918). By the 1930s, free range

was the main form of egg production being utilized, but farmers needed a more economical way to

produce eggs year round for market and to get away from diseases caused by having the chickens

on the floor. Thus, a battery system of caging chickens began to be developed in the early 1950s

(Jull, 1951). Cages resulted in farmers being able to decrease the cost of production and increase

the bird-to-space ratio, which made egg and meat production more profitable. Battery systems for eggs and litter systems for meat have been the standard now for decades, but entering into the twenty-first century there is a huge push from animal rights activists as well as a segment of the consumer market to get birds out of cages, back on the floor, and provide outdoor access. It is ironic how the industry is making a huge circle right back to where it all began. Today, hens on many of the poultry farms produce 489 eggs in 110 weeks (Anderson, 2007), 6.4-lb broilers in 42 days with 1.58 lb of feed per pound of gain (Havenstein, Ferket, and Qureshi, 2003), and 50-lb turkey males in 22 weeks with a feed conversion of 2.7 lb of feed per pound of gain (Krueger, 2008). These performance numbers were undreamed of 60 years ago, and even 20 years ago, layers were only producing 380 eggs in 110 weeks (Anderson, 1991). These advances in performance are the result of genetic selection, better understanding of disease and vaccines, nutrition, and environmental management. Within each of these sectors, there are subsectors made up of the breeders, hatcheries, broiler growers, egg production, transport, and processing. Currently, broilers and turkeys are predominantly reared on litter floor operations where the birds are contained in a large building with deep litter. Commercial layers are predominantly housed in some type of cage environment, with approximately 80% of the U.S. laying flock housed in cages, 10% housed in environmentally enriched production environments, and approximately 9% in a cage-free range system. Because of the extensive use of cages, the layer industry has been a primary target of organizations to end

the use of battery cages in the United States. This criticism and activism is coming primarily

from external coalitions of animal rights organizations, environmentalists, vegetarians, individu

als within the animal research community, and the consumer (Anderson, 2009c). As a result, state

ballot initiatives and state agreements targeting the layer industry have emerged, resulting in the

affected industries rapidly changing to meet the imposed requirements. The organizations sponsor

ing these initiatives have become very astute at manipulating the public perception and influencing

regulations.

The poultry industry is being criticized from all sides for its management of facilities, hus

bandry practices, disease prevention, and environmental management. There are a number of prac

tices within the poultry industry that can be misconstrued as deleterious to the welfare of animals.

However, these practices have been researched and are constantly being examined by the industry

for their benefit to welfare and quality of the product produced. In a number of instances, practices

have been abandoned in commercial operations because of their potential negative impact on the

bird and lack of benefit to the commercial producer or product quality. Part of this may be a result

of the efforts of poultry breeders to select for behavior traits that benefit the birds in a more inten

sive setting (Craig and Muir, 1996). Issues in the poultry industry that have been noted as affecting animal well-being are discussed in the following sections.

HATCHERY

The handling of newly hatched chicks, poults, or ducklings has been associated with a number of

animal welfare concerns regarding hatcheries and the movement of hatchlings through the hatchery

system (Agriculture Canada, 1989). Growing concerns are focused on the way the neonatal chick or

poult is handled once it is removed from the incubator. The keys to humane handling of these young

animals are related to gentle handling of chicks from the hatching tray, separating them from hatch

residue and piped embryos, and ensuring that they are not dropped from high places. Chicks expe

rience short drops of a few inches during processing and have no changes in their livability in the

growing house. Hatchery processes begin with the chicks, broken shells, and unhatched embryos in

the hatching trays being gently tipped onto the chick and eggshell separator, which allows the chicks

to fall through the rollers onto a rod conveyor. This separates the chicks from the large shell compo

nents and the small shell particles. The chicks then slide into a chick-go-round. From this carousel,

the chicks can easily be handled for sorting, sexing, and vaccinating (Bell and Weaver, 2002). The

chicks are then placed in chick boxes for transport to the rearing facilities.

Cull or non-salable hatchlings that do not enter production such as males (layers) and chicks

with defects or injuries are humanely euthanized immediately after hatch. Three methods are used

for euthanasia in hatcheries. They include immediate mechanical destruction (maceration), vacuum

with impact plate, and modified atmospheric gas (asphyxiation). The Humane Slaughter Association

(2002) recommended the use of two methods: maceration and modified atmosphere gas euthanasia

(Raj and Whittington, 1995). The key to each of these methods is the immediate death of the chick

with no excessive pain or struggling. All of these methods of euthanasia are acceptable if they are

done according to standard operating procedure and the equipment is maintained and functioning

properly. The result of this process should be evaluated rigorously because the animal welfare con

cerns are very high. The same can be said for methods for the disposal of unhatched embryos. Live

pips and the embryos that have not hatched are now treated in the same manner as cull chicks. As

such, they should be disposed of in a similar manner with constant checking of the results to ensure

that no live embryos survive. Two additional methods, rapid cooling and freezing, are also accept

able means of euthanizing unhatched embryos. Most hatcheries utilize some form of maceration

as their primary euthanasia method, which results in immediate death (Beckman, 2010). In other

circumstances or in an emergency, euthanasia may be accomplished using CO_2 for large groups and,

for individual chicks, cervical dislocation can be used by properly trained individuals.

BEAK TRIMMING, DUBBING/DE-SNOODING, AND TOE TRIMMING

These are morphological alterations in a number of different ways, including elective surgery, ampu

tations, or mutilations. These descriptors vary depending upon who is describing them. If these procedures are utilized, one must ensure that the equipment used to carry out these procedures is working properly, and that the personnel involved in carrying out these procedures are adequately trained. If these procedures are not needed, they should be eliminated from chick processing practices. Breeders are selecting for behavioral patterns that diminish the need for these practices (Craig and Muir, 1996).

Beak trimming was developed to curtail the development of abnormal behaviors such as cannibalism or excessive feather pecking. In these cases, the hen's welfare was enhanced with beak trimming.

Beak trimming continues to be the method of choice worldwide for the control of cannibalism and general improvements in performance and livability. When performed at the proper age using the hot blade (HB), infrared (IR), or scalable continuous wave lasers (SL), there are few long-term negative effects. There are advantages and disadvantages with each method. Some of the advantages of all methods are reduced mortality (Craig and Lee, 1989, 1990), lower feed consumption, improved feed efficiency (Lee, 1980), and improved egg production (Kuo, Craig, and Muir, 1991). Some disadvantages associated with beak trimming of older birds or severe trimming are delayed sexual maturity (Carey, 1990), potential neuroma formation, and chronic stress in the trimmed pullets. Indications are that beak trimming likely results in pain to the bird due to the mechanoreceptor and thermoreceptor cells present in the beak (Gentle and Breward, 1985;

unttschaldt et al., 1982). However, the length of time that the pain may endure appears to be related to quality of the trim (Gentle, 1986a, 1986b), trimming age, and severity of the trim (Davis, Anderson, and Jones, 2004). Davis showed that corticosterone levels in birds trimmed at 6 days returned to the same as non-trimmed flock mates within 24 h, while hens trimmed at 11 weeks of age had elevated corticosterone levels at 5 weeks after the trim. Regardless of the methods, the negative aspects of beak trimming that may occur in the pullet phase appear to be offset by the positive aspects in the layer phase with enhanced performance and improved livability of the flock. These changes are in part due to changes in behavioral patterns, which result from beak trimming (Craig and Lee, 1989) that includes increased feeding activity, increased resting pattern, and a reduction in pecking by cage mates. The chickens adapt quickly to the beak alteration and there does not seem to be a long-term negative effect on the birds.

Dubbing is a procedure to remove the comb from the head of the bird at hatch in an attempt to limit later damage by injury, freezing, or cannibalism. Dubbing roosters and hens is a practice that has not persisted in the layer industry due to increased climate control of the production houses (Hester, 2005). Dubbing is still used for special cases that include research facilities where the combs of roosters may become caught or injured due to caging for selective artificial insemination practices; however, hens are no longer dubbed. The comb of breeding males in cages can become so large they become a potential entrapment component or may restrict access to the feed trough.

Dubbing eliminates this impediment and, when done properly at hatching, results in a reduction in comb size of 50 to 75%. This is only used in strains with large combs such as egg-type strains. The second reason is to minimize the comb's exposure to cold temperatures. Full-size combs have a greater potential of freezing in cold climates and dubbed hens perform better than their non-dubbed counterparts do in cold weather (Cole and Hutt, 1954). However, as the poultry industry is forced to revert to extensive production systems in cooler climates, the use of dubbing may be revived to help the birds cope with cold or freezing temperatures in the winter. In this case, the producers are balancing one husbandry practice with another. Whether the practice is dubbing or housing chickens in a confined space, each has welfare considerations, which will improve the overall welfare of the bird in one instance, but may not improve welfare of birds in another. If necessary, dubbing is best completed at hatching due to the lack of vascularization of the comb at that age (Cole and Hutt, 1954) although it can be done through 8 weeks of age with special care to prevent bleeding. The comb is removed at its base using surgical scissors.

De-snooding is the removal of the snood (dewbill) to prevent head injuries from picking or fighting in a growing flock (TNAU, 2010). The snood is removed at hatch by pinching the snood off between the thumbnail and forefinger or using a small clipper. It can also be removed with scissors at 3 weeks of age. As with many practices in poultry, this practice has alternative names and mean

ings especially in the way they are presented to the public. One case in point is the Wales Statutory

Instruments 2007 No. 1029 (W.96) regulation entitled "The Mutilations (Permitted Procedures)

(Wales) Regulations 2007." With this type of title, de-snooding would not be a very welcomed pro

cedure even if the benefits to the bird were significant. However, recent research has shown that the

snood may enhance heat loss in males (Buchholz, 1996) and that, behaviorally, de-snooding does

not appear to result in overt aggression in the rearing environment. In support of discontinuing de

snooding, growers have found that there is no advantage to the male turkey and that the snood may

help the turkey dissipate body heat. Therefore, in discussions with experts, it was concluded that

de-snooding be abandoned as unnecessary for the welfare of birds in the turkey industry.

Toe clipping is only used in the turkey industry for females grown for roasting and in the broiler

industry for male breeders to reduce the incidence of injuries to the other birds in the flock from

scratches to the back, breast, and legs. This practice was shown to diminish the nervousness of the

flock and to reduce body injury to flock mates from moving and fighting as the birds reach maturity

(McEwen and Barbut, 1992). However, advances in genetic selection, husbandry, and nutrition have

minimized the need to use this practice. Toe trimming is typically done at the hatchery using a hot

blade, infrared, or microwave (Honaker and Ruszler, 2004). Broiler breeder females are no longer trimmed and the males typically only have the dewclaw removed (Bell and Weaver, 2002). Quart, Russell, and Wilson (1989) indicated that trimming of multiple toes might contribute to decreased mating efficiency and fertility. When toe trimming is done in the hatcheries, the infrared method is preferred to minimize pain and stress (Wang et al., 2008) associated with older methods. This practice does reduce the incidence of injuries to other birds; however, the question of whether the procedure results in long-term pain or discomfort to the animal has not been resolved. One report indicated that removal of one toe in breeder chicks did not appear to cause chronic pain (Gentle and Hunter, 1988). Esthetically the procedure is not pleasant to observe, but neither turkeys nor broilers appear to suffer any long-term negative consequences.

Chick transport from the hatchery is another area of concern for animal welfare groups. Items that need to be monitored include the cleanliness of the chick boxes and pads, handling of the chick boxes, temperature of the transport truck, ventilation in the transport truck, exposure to exces sive stress and noise, and the duration of the delivery trip. If these components are monitored and maintained, then both good chick quality and bird welfare are ensured. Mitchell and Kettlewell (2004) indicated that a transport time of 12 h is acceptable if conditions such as temperature, humid ity, and ventilation within the transport vehicle are well controlled and monitored to ensure chick well-being.

Poultry housing issues have focused on space and housing for laying hens in cages and it is prob

ably the most controversial issue facing the poultry industry today. It is by far the most pressing

issue in the commercial egg industry, but less pressing in other sectors of the poultry industry in

which birds are reared on the floor in litter facilities (Bell and Weaver, 2002; Hester 2005). Housing

density, the amount of space provided to the hens, is a combination of two factors—the amount

of floor space allocated to each bird and group size. In a cage-house setting, both of these fac

tors can have a negative impact on production and behavior of the flock (Adams and Craig, 1985;

Anderson, 1996; Anderson, 2009b). As space per hen is diminished and as group size increases,

productivity declines and mortality increases. These impacts are present even when the population

is held constant with decreasing space and when the population is increased with a constant den

sity (Anderson, 1996). However, is it correct to interpret this response as being due to diminished

well-being? Bogner et al. (1979) determined that Leghorns need between 450 and 581 cm 2 in order

to accommodate behaviors of preening and comfort movements. Lagadic and Faure (1987) taught

hens that if they performed a task, pecked a specific button, a portion of the cage would move to

increase the determined floor space available. With this type of testing, they determined that hens

selected floor space of between 400 to 619 cm 2 . Currently, the egg industry is providing 432 cm 2 (67 in. 2) for white egg strains and 490 cm 2 (76 in. 2) for brown egg layers (United Egg Producers, 2010).

These amounts of ªoor space for the hen, as well as the physical structures within the environment,

promote the display of comfort movements from a more natural behavioral repertoire. There is a

transition within the egg industry toward housing birds in more extensive systems that include envi

ronmentally enriched housing systems (Tauson, 2000), cage-free space or aviaries (Gibson et al.,

1989) and free-range facilities (Hughes and Dunn, 1986; Appleby and Hughes, 1991). Spaces within

these facilities range from 929 cm 2 (1 ft 2) for slat/litter houses and aviaries to 1393 cm 2 (1.5 ft 2) in

all litter and free-range operations (United Egg Producers, 2010; Anderson, 2009a). These systems

provide roosts, nest boxes, litter areas, and, in the case of free-range operations, the opportunity for

hens to access the outdoors (Anderson, 2009a). In these environments, adequate space for roost

ing (13 to 15 cm per bird), nesting (1 nest per 5 to 8 hens), feeding (3.8 to 5.1 cm per bird and the

hen should not have to move more than 7.9 m), and watering (1 to 2.54 cm per hen depending on

device con■guration or 1 nipple per 10 hens) are important. These extensive systems provide a more

enriched and stimulating environment that allows hens to exhibit a complete behavioral repertoire.

However, there are negative aspects associated with extensive systems such as sternum deformities,

bone fractures from falls, exposure to inclement weather, increased risk of disease and parasitism,

and increased risk of predation.

broilers, broiler breeders, turkeys, and turkey breeders are housed in floor facilities that contain

litter areas, feeders, waterers, and nest boxes; therefore, these segments of the poultry industry have

not had the level of scrutiny focused on the layer segment of the poultry industry. However, as with

all commercial poultry operations, the primary concerns are related to the housing and maintenance

of such flocks. These concerns are associated with bird density and adequate space allocations for

the resources of feed and water.

Broiler breeder density allocations recommended for litter and slat/litter houses are 3 and 2 ft 2 per

bird, respectively, and for commercial broilers the desired density is 0.8 to 1.0 ft 2 per bird depending

on the final body weight desired (Bell and Weaver, 2002). Bird density, whether excessive or not,

can and will affect growth, feed conversion, and behavior of birds, which can negatively affect their

welfare. The undesirable behaviors in breeder flocks are cannibalism, excessive feather pecking,

and fear-related behaviors such as avoidance and escape responses or flock hysteria. Many of these

behaviors are readily observable by producers and, if noted, measures should be taken to rectify

them. Space at the feeder should be adequate for all birds in a pen to eat at once, as this is especially

important in breeder flocks. In skip-a-day feed restriction programs, this may be especially impor

tant. If space is not adequate, there may be observable increases in aggressive behaviors. Inadequate

feeder space will not necessarily result in injury to the subordinate animals, but will influence the subordinate bird's ability to obtain adequate nutrition, and will result in non-uniform body weights

and poor productivity. In many instances, it may only be a single bird dominating a feeder. The

birds in a ªock utilize water space differently and aggressive behaviors associated with water con

sumption are not an issue in facilities with adequate space. As long as watering space does not limit

water consumption, watering space is not an area that needs to be controlled. Hens will typically

stand around a cup or nipple drinker and take turns drinking. Nesting space is important in breeder

operations and should provide 1 nest per 4 to 5 hens or 1 m of community nest per 35 to 40 hens.

If this space is inadequate, there will be an increased number of eggs laid on the ªoor. Inadequate

nesting space can also lead to increases in breakage and eating of eggs. The height of the nests from

the ªoor (>20 in.) is also thought to increase the potential for the development of hysteria. In ªoor

production systems, hens should be kept out of nests at night and early morning, and then the rests

should be opened for egg laying in the morning. This keeps the nests cleaner and allows free access

to the nests when eggs are being laid.

Feed and water restriction programs are used to control body weight in fast-growing, high-feed

consuming breeder birds and water restriction keeps them from over-drinking after the feed has

been consumed (Bell and Weaver, 2002). Such programs go hand in hand, one to restrict feed

intake, and the other to limit growth rate. Water restriction is also used to prevent birds from con suming excessive amounts of water in an attempt to satisfy their desire for more food. Water restric

tion also helps maintain better litter conditions. Thus, monitoring of behavior with regard to feed

and water consumption can provide insight into the well-being of hens.

Commercial turkey breeder hens are maintained in facilities separate from the breeding toms.

Due to the size of the males, natural mating is no longer used, and lighting and feeding programs

are different for the two populations. The recommended space is 0.3 m 2 per hen and 0.4 m 2 per

tom. If the space is not adequate, feather picking, cannibalism, and other health problems can ensue

(Spratt, 1993).

Molting is used extensively in the layer industry to extend the productive life of laying hens (Bell

and Weaver, 2002; Anderson and Havenstein, 2007). It is also used in the broiler breeder, turkey

(Lilburn et al., 1993), and duck segments of the poultry industry to extend egg production (Rolon,

Buhr, and Cunningham, 1993; Hurwitz et al., 1995, 1998). The molting procedures result in the

initiation of a natural process in which the hen enters into a phase of reproductive quiescence that

allows her to replace her feather coat and replenish her body systems before entering into another

reproductive cycle. The stimulus for entering into this phase consists of environmental stimuli, such

as reducing lighting, temperature, and some level of anorexia. In the avian species, molt inducement

has been accomplished by limiting the nutrient intake of all or selected nutrients as a commercial husbandry practice. The methods used to induce molt in laying hens are stressful and have been

condemned as inhumane husbandry practices. There are times when wild birds do not eat in spite of

having food readily available, for example, during molting, breeding, and egg incubation.

Stevens (1996) indicates the importance birds place upon seasonal breeding and other activities.

He indicated that fasting is especially pronounced in geese that may be anorexic for 2.5 months and

king penguins that fast for 4 to 6 months. It must be remembered that stress is not something that can

be avoided throughout the course of life and there is stress that is actually bene■cial to the animal.

By de■nition, the absence of stress is death (Selye, 1973). Fasting can also be the result of an altera

tion in the endocrinology of the hen (Swanson and Bell, 1974a). In wild birds, hormonal changes

are typically associated with molting and broodiness, and seasonal changes result in limited food

supply, so the husbandry practice of molting in the commercial egg and breeder industries is based

on those principles. The hen is capable of coping with and compensating for changing conditions in

its environment to maintain physiological homeostasis (Clarenburg, 1986; Freeman, 1987). The hen

responds by using physical, chemical, anatomical, and physiological mechanisms to maintain this

homeostasis. The hen has functions that are constitutive or always functioning, and others that are

adaptive, that is, they are used as the need arises to maintain the homeostatic state.

The following are some of the physiological mechanisms, both constitutive and adaptive, that are used to respond to limited or total restriction of food that occurs postprandial, between meals, and during a fast, as determining when one mechanism starts and another begins is arbitrary (Clarenburg, 1986). The metabolism of chickens readily evokes these physiological processes throughout the course of a regular day. Upon prolonged absence of food, other essential nutrients are depleted (for example, vitamins, minerals, essential amino and fatty acids, lipotropic factors, and carbohydrates), which can be life threatening. Starvation triggers a collapse of homeostasis as basal metabolic rate declines and the hen minimizes all energy expenditures in order to survive. This response does not occur in anorexia associated with animal husbandry practices. Rice (1905) and Rice, Nixon, and Rogers (1908) were the first to report on fasting in laying chickens to induce molting of hens in commercial layer flocks. However, during eras of depressed financial returns on egg production, research on molting experienced renewed interest as a means of extending the productive life of the hen (King and Trollope, 1934; Frasier, 1948; Swanson and Bell, 1974a). Modified photoperiods combined with withdrawal of feed and water were used in the 1940s and research interest in induced molting has continued. Several types of induced anorexia and durations of anorexia have been widely examined in chickens based on total feed restriction (Frasier, 1948; Marble, 1963; Bierer and Eleazer, 1966; Noles, 1966; Bell, 1970, 1984; Swanson and Bell, 1970, 1974a, 1974b, 1974c, 1974d;

Summers and Leeson, 1977; Brake, Thaxton, and Benton, 1979; Brake and Thaxton, 1979a, 1979b; Washburn, Peavey, and Renwick, 1980; Lee, 1982, 1984; Rowland and Brake, 1982; van Kempen, 1983; Brake and Carey, 1983; Garlich et al., 1984; Zimmerman, Andrews, and McGinnis, 1987; Kuney and Bell, 1987; Carey and Brake, 1989; Savage, 1992; Koelkebeck, Parsons, and Leeper, 1993; Brake, 1994; Bell et al., 1995; Hurwitz et al., 1995; Anderson, 1998, 2000; Davis, Anderson, and Carrol, 2000). Other areas of research have included limited feeding, altering the mineral content of the diet, such as excessive dietary magnesium (Shippee et al., 1979), excessive dietary iodide (Arrington et al., 1967), excessive dietary zinc (Shippee et al., 1979; Bell, Swanson, and Kuney, 1980; Berry and Brake, 1985; Goodman, Norton, and Diambra, 1986; Berry, Gildersleeve, and Brake, 1987; Breeding, 1991), dietary calcium restriction (Douglas, Harms, and Wilson, 1972), and dietary sodium restriction (Whitehead and Shannon, 1974; Hughes and Whitehead, 1974; Whitehead and Sharp, 1976; Nesbeth, Douglas, and Harms, 1976a, 1976b; Wakeling, 1978; Said et al., 1984; Berry and Brake, 1985). However, all of these methods resulted in a forced anorexic state and a significant loss in body weight. Water deprivation was also employed, but Palafox (1976) and Swanson, Bell, and Kuney (1978) reported no beneficial effects and, in fact, found undesired post-molt effects on performance of laying hens. Thus, water deprivation during the molt was abandoned. New molting methods have been reviewed and developed as non-anorexic methods have been adopted by the layer hen industry (Anderson and Havenstein, 2007; Biggs et al., 2003, 2004; Anderson, 2002). All

concurred that the birds produce an equivalent total number of eggs and a greater egg income. They

further suggested that economically feasible alternatives to the more traditional molting methods

resulted in better performance of hens compared to that for hens not induced to molt.

EUTHANASIA

Euthanasia is the act of inducing humane death in an animal. Ultimately, this means that the ani

mal should be exposed to minimal stress and anxiety brought on by the pain that the animal might

perceive before unconsciousness and death. The poultry industries are faced with two needs in this

area. There is a need for euthanasia of individual birds that become sick or injured during the course

of the production period and a need for mass euthanasia of whole houses of birds in instances such

as infectious disease outbreaks (Benson et al., 2009). The use of gas (CO_2) and cervical dislocation

are two methods that work well for immediate euthanasia of sick or injured birds.

The Canadian Council on Animal Care (2010) defines the use of CO_2 as conditionally acceptable

with emphasis on proper methods if used. Carbon dioxide would normally be used as emergency

backup on small populations of poultry. A proper chamber must be used, and proper precautions

must be taken to protect workers involved. Compressed CO_2 gas in cylinders should be used to

allow inflow into the chamber to be regulated precisely. With an animal in the chamber, an optimal flow rate should displace at least 20% of the chamber volume per minute. It is important to verify that an animal is dead before removing it from the chamber. Chambers for exposing poultry to CO_2 must have a view port to allow verification that the birds are down for at least 2 min before being removed from the chamber. A clear plastic bag is suitable for administering CO_2 to very young poultry, generally less than 10 days of age, or for live piped embryos, which are still in the shell. A sealed box with the ability to maintain a 60 to 70% concentration of CO_2 gas as it is gradually increased at a rate of 20 to 30% per minute, exhaust, and view ports is acceptable for older birds as long as the CO_2 atmosphere within the chamber is sufficient to euthanize the bird (AVMA, 2007). Loss of consciousness is caused within 10 to 15 sec and death is typically induced within 5 min of exposure. Death should be verified by extending the exposure time of the bird to the CO_2 atmosphere for an additional 10 min.

Cervical dislocation by hand is a second method that can be used for smaller birds, but the Burdizzo Emasculator Apparatus is used for larger birds. The procedures for cervical dislocation by hand begin by restraining the bird by both legs at the hock joint. Then the head is grasped by placing the index finger or thumb at the occipital crest just above the neck at the junction of the atlas and caudal vertebra and the other finger being placed under the lower mandible (Chamberlin, 1943). Then with one quick motion, the neck is stretched and the head rotated backward, simultane ously by pinching it between the thumb and fore■nger. The vertebrae between the atlas and caudal

vertebra are dislocated simultaneously, which severs the spinal cord and tears the jugular vein and

carotid artery. The procedures for cervical dislocation using the Burdizzo Emasculator Apparatus

begin with restraining the bird's legs and/or wings (depending on body size) using an appropriate

device or having one person hold the bird by both legs at the shanks, resting the bird with its breast

on a table or on the ªoor. The neck of the bird is placed between the jaws of the Burdizzo Apparatus

at the junction of the atlas and caudal vertebra and the jaws are closed quickly by pulling the handles

together until the handles of the Burdizzo Apparatus lock together. The bird is released after all

re*exes cease.

Govrin-Lippmann and Devor (1978) and Jensen et al. (1985) indicated that injury resulting from

discharges of peripheral nerves subside within seconds and that all afferent activity ceases. This

response causes activity of the muscles in poultry immediately after the severing of the spinal cord.

Hughes and Gentle (1995) and Gentle (1991) provided physiological evidence that there is no periph

eral neural input immediately after severing of the nerves of the spinal cord, indicating a pain-free

period immediately after the severing of the spinal cord. This indicates, in the case of cervical dislo

cation and decapitation, that when the burst of nerve discharge occurs, there is no cerebral receptor

site functioning to perceive the nerve impulses sent to the brain. Therefore, the brain of the animal does not sense the burst of neural activity through cervical dislocation or decapitation. The EEG recordings made from severed heads are merely recording the random firing of neurons that are not indicative of pain (Scadding, 1981). Chapman et al. (1985) indicated that animals have responses to neural stimulation that differ from humans. This makes it difficult to draw strong, clinically relevant conclusions from experimental observations on animals. Cervical dislocation is one of the primary and easiest methods of euthanasia. Mass euthanasia because of diseases or natural disasters is relatively new to the industry, but the need became apparent because of diseases such as avian influenza in Southeast Asia and natural disasters like Hurricane Floyd in North Carolina. Methods using water-based foams, used in fire suppression, have been developed for emergencies where large numbers of birds must be euthanized at once. These methods were conditionally approved by USDA-APHIS in 2006 for meat-type chickens. This process has been verified as effective in a number of other species (Benson et al., 2009). Stunning prior to euthanasia for processing is now done by two methods: electrical and modified atmosphere (Raj, 1998). The issue associated with electrical stunning is that birds may not be stunned properly and may recover their somatosensory evoked potentials in the brain, which is a significant welfare concern. New electrical stunning methods appear to have minimized this problem (Prinz et al., 2010). Modified atmosphere stunning has been developed and used successfully in the European community (Poole and Fletcher, 1998). Both methods are acceptable and, depending

on the gasses used and timing of the euthanasia sequence in the processing plant, have a similar

disadvantage of somatosensory recovery if euthanasia is not done promptly.

TRANSPORT AND CATCHING

The transport of older birds requires catching them for transport, which is followed by movement

of the birds on trucks from the rearing facilities to the production unit and later to the processing

plant (Lacy and Czarick, 1998; Scott, Connell, and Lambe, 1998; Kannan et al., 1997). Catching

and transport are novel experiences for birds and they are equally stressful regardless of rearing

environment. The key in all of these processes is gentle handling of the birds to minimize injuries.

This means that individuals must be properly trained in handling procedures, operation of loading

equipment, and methods for transport of birds (Nijdam et al., 2004). In addition, the transport truck

must be capable of providing protection for the birds from extremes in temperature during transport

by using side panels or curtains and to ensure adequate air movement in the center of the loads dur

ing warm and cold weather.

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BEEF CATTLE

Terry Engle

Animal agriculture is one of the fundamental cornerstones that have helped shape the development

of the United States. Over the last 100 years, animal agriculture has changed in dramatic ways.

Consolidation of livestock production facilities has increased production efficiency while maintain

ing low costs of meat, milk, and eggs to the consumer. However, consolidation has yielded fewer people working directly in animal agriculture and has shifted the focus of animal care from animal husbandry to animal productivity. This disconnect has caused societal concerns for animal well being and lack of citizen understanding of, and support for, animal agriculture. This section will discuss ways in which animal comfort can be practically vectored into beef cattle production.

Beef cattle production has drastically changed over the past 50 years. The implementation of new technologies and production techniques has enhanced the efficiency of production of meat products. The increase in production efficiency has enabled producers to produce more products with fewer animals, while maintaining a high-quality product at a low cost for the consumer. Enhanced beef cattle production efficiency is primarily a result of improvements in feed technologies, genetic selection, animal health, and management.

With the increased focus on enhancing production efficiency, the individual animal itself cannot be forgotten. The basic beef cattle husbandry principles still apply to modern beef cattle production today: Provide the basic needs for cattle (feed, protection, medical assistance, etc.) and the animal will provide product for human consumption. Thus, it is in the producers' best interest to maintain an environment wherein beef cattle can thrive—where disease is kept to a minimum, moribund animals are expeditiously treated or humanely euthanized, and feed, water, and shelter are in adequate supply.

Several food animal production systems have evolved into systems where environmental condi tions, feeding regimes, and animal activities are tightly controlled in order to increase production efficiency. Beef cattle production has taken a different approach to increase production efficiency. Typically, a cow-calf operator confines cattle in open pastures and allows the animals to harvest native forage. When indigenous feedstuffs become incapable of supporting proper cattle nutrition, the rancher supplies stockpiled feedstuffs to compensate for the nutrient void until the indigenous forages are replenished. Stockpiled feedstuffs can be items such as hay, by-products from other industries such as cull vegetables, fermentation by-products, bakery waste, etc. The ability of these animals to harvest their own feed as well as their ability to utilize by-products from other industries has been instrumental in enhancing cow-calf production efficiency.

In a commercial cow-calf operation, a certain percentage of the female calves born each year are retained in the cow herd as replacement females. At weaning, females not retained as replacement animals, cows being removed from the production herd, and the majority of male calves (typically castrated at or shortly after birth), enter the cattle-feeding sector of beef production. In general, these animals can be marketed through an auction system, transported directly to a feedlot setting, or allowed to graze crop residues throughout the winter to increase body weight and, therefore, enter the feedlot at a heavier weight at some time in the future. Nevertheless, calves entering the feedlot sector are transported from pasture-based production settings to feedlot settings where cattle are housed in group pens, cared for daily, sometimes comingled with cattle from other geographic locations, and a total mixed ration containing all the appropriate nutrients is delivered daily, thus eliminating the need for the animal to harvest feed on its own via grazing. Cattle typically spend approximately 140 to 200 days (depending on the weight at which they enter the feedlot) in a feedlot setting until slaughtered at approximately 14 to 16 months of age (heifers and steers).

Due to the length of time that it takes to produce beef for human consumption (from breeding to slaughter), proper nutrition and abatement of animal stressors are fundamental animal husbandry components essential for optimizing animal health and productivity. Environmental and management stressors can increase disease outbreaks and decrease efficiency of food producing animals, thus increasing the cost of production and ultimately affecting animal welfare. Adverse weather conditions, including both the effects of hot and cold climatic conditions, are particularly difficult for grazing animals as well as confinement-fed animals housed in outdoor facilities. Prolonged hot or cold environmental conditions can decrease nutrient quality of feedstuffs as well as alter the nutrient utilization of feed by the animal. Decreased nutrient quality and the need to metabolically repartition nutrients to cope with extreme climatic conditions diminish the ability of the animal to immunologically protect itself from environmental pathogens, ultimately compromising animal health and overall productivity. Therefore, the subsequent sections in this chapter are devoted to discussing practical ways to enhance animal comfort in beef cattle production systems by minimizing animal stress.

Stress and its relationship to the occurrence of disease have long been recognized. Stress is the nonspecific response of the body to any demand made upon it (Selye, 1973). Stressors relative to animal production include infection, environmental factors, parturition, lactation, weaning, transport, and handling. Stress has been reported to decrease animal production (growth, reproduction, efficiency, etc.) and overall animal welfare.

SOCIAL BEHAVIOR

Beef cattle are social, gregarious animals that can thrive in various environmental conditions.

Since cattle are social animals that develop hierarchies within the herd, introducing new animals to an established herd or pen of cattle can be stressful to both resident animals and new arrivals.

Numerous dominance-subordination experiments from the late 1950s and 1970s (Wieckert, 1970) indicate that a hierarchy is established within a few days of animals being comingled and that dominant animals do stake out a “territory.” New animals introduced into an established group will spend time and energy learning the established hierarchy. This can be accomplished within a few days, but noticeable agitation across the group will be observed until the new animal learns the hierarchy and is accepted into the group. Therefore, introducing new animals to established groups of animals as infrequently as possible can help minimize stress.

ENVIRONMENTAL STRESSORS

As indicated earlier, beef cattle production takes place outdoors in pastures or large feedlot pens.

Therefore, beef cattle are exposed to various environmental conditions throughout the course of a

year. Depending on the geographical location, cattle can be exposed to ambient temperatures below

freezing or in excess of 38°C for prolonged periods of time. When climatic conditions exceed upper

and lower critical temperatures for cattle, the animal needs to compensate metabolically for such

a deviation. Any time an animal has to expend energy to heat or cool itself, the overall production

efficiency of that animal is decreased.

COLD STRESS

Cattle are typically cold-hardy animals (Young, 1981). However, the ability of cattle to tolerate cold

temperatures requires that they remain well insulated from the environment. Maintaining effective

insulation requires protection from the wind, maintenance of a dry hair coat, and protection from

cold and frozen or wet and muddy conditions (Wagner, Grubb, and Engle, 2008). Providing shelter

during times of inclement weather will improve animal efficiency (Young, 1981) and well-being.

However, building extensive structures for beef cattle in cow-calf operations is not economically

feasible. Allowing range cows and calves access to natural structures such as trees, rocks, etc.,

and utilizing existing structures such as stockpiled hay and buildings as windbreaks can be very effective at minimizing the impact of cold weather. Furthermore, providing bedding, such as straw,

can help keep cattle dry during times of wet, muddy conditions.

Feedlot operators may be reluctant to provide bedding and windbreaks for cattle during the win

ter months because, although windbreaks can effectively alleviate the negative impact of wind on

winter performance, air*ow in the summer months can be compromised and performance reduced

(Mader et al., 1999). Therefore, unless portable, windbreaks will not likely become common in

areas that experience cold climates in the winter months and hot climates in the summer months.

Providing bedding to cattle can effectively combat cold stress in northern climates (Birkelo and

Lounsbery, 1992). However, feedlot operations may be reluctant to use bedding due to the cost of

removing bedding plus manure from the pens. Furthermore, bedding may retain moisture in pens

and delay drying of the pen surface. Providing bedding as a routine management strategy will

likely not become common during times of typical inclement weather. However, the economics of

providing bedding in the aftermath of a catastrophic winter storm should be evaluated. Wagner et

al. (2008) reported net energy requirements for maintenance of feedlot cattle exposed to a storm

in southeast Colorado in December 2006 and January 2007. Average high and low temperatures

from December 26, 2006, through February 22, 2007, were -2.16°C and -14.69°C, respectively.

Furthermore, snowfalls of 25.4 and 5.08 cm were recorded on

December 20 and 21, 2006. An

additional 25.4, 30.48, and 30.48 cm of snow fell on December 29, 30, and 31, 2006, respectively.

Additional snow events occurred on January 13 and 14, January 21, and February 14 and 15, 2007.

The snow pack peaked at 91.44 cm on December 31, 2006, and averaged 32.33 cm ± 0.26 from

December 26, 2006, through February 22, 2007. Net energy required for maintenance (NEm) was

approximately 21.92 Mcal/hd/d or 0.21 Mcal per kg EBW 0.75 . These data indicate that NEm required

during and in the aftermath of a major winter weather event may be 2.7-fold higher than NEm

required (0.077 × EBW 0.75) under thermal neutral conditions. Calculations of lower critical tem

perature and external insulation indicate that the insulation value of the hair coat of these cattle may

have been inhibited by the moisture, mud, and snow following the storm. Table 8.1 describes the

effect of corn and feeder cattle prices on economic losses ($ per head) associated with a catastrophic

winter storm. These data indicate that applying bedding to feedlot pens after an extensive cold/

snowfall event needs to be considered.

HEAT STRESS

Cattle raised in most portions of the United States can be exposed to heat stress during certain

times throughout the year. Typically cattle in cow-calf operations have access to shade provided by

natural (trees, berms, etc.) or constructed (buildings, stockpiled feed, etc.) structures and during the

summer months are exposed to moderate wind speeds that help with cooling. Furthermore, genetic selection has helped to reduce the impact of heat stress on beef cattle. In general, *Bos indicus* cattle are more heat tolerant and parasite resistant than are *Bos taurus* cattle. Typically, cattle raised in hot and dry desert climates or hot and humid semi-tropical climates have a certain percentage of *Bos indicus* genetics to assist with minimizing heat stress. Feedlot cattle are typically finished in the high plains of the western United States due to the dry climate (low precipitation—rain and snow and low humidity). However, periodically cattle finished in the high plains are exposed to ambient temperatures at or above the thermal neutral zone for cattle for prolonged periods of time. Feedlot cattle performance can be adversely affected during prolonged periods of elevated ambient temperatures, especially if the elevated ambient temperature is coupled with low wind speeds and high humidity (Hahn and Mader, 1997; Mader et al., 1999). Enhancing an animal's ability to dissipate heat or reduce solar radiation load can help to diminish the impact of heat stress on overall animal performance and well-being. Several management strategies have been implemented by feedlot producers to reduce the effect of heat stress on feedlot cattle. Providing shade to decrease solar load, but not airflow (i.e., overhead structures), sprinkling pen surfaces and cattle with water, and restricted or managed feeding programs (Mader et al., 2002; Davis et al., 2003) are common techniques used to help mitigate heat stress in feedlot cattle. For an in-depth review of the aforementioned strategies to mitigate heat stress in cattle, see Mader (2003).

PEN DESIGN

Three very effective methods commonly utilized by feedlot operators to help keep cattle dry during

times of wet, muddy conditions are mounding within pens, pen slope, and concrete pads adjacent

to the feed bunk. Constructing mounds of dirt and dried manure in pens coupled with the appropri

ate slope of a feedlot pen surface where water can be diverted out of the pen, minimizing standing

water and maximizing pen surface drying, allows cattle to avoid muddy pen surfaces. Furthermore,

it is common practice to have a concrete apron adjacent to the feed bunk, which allows cattle a solid

foundation to stand on while consuming feed.

MANAGEMENT STRESSORS

Castration, dehorning, branding, handling, and transportation are common management practices

used in the beef cattle industry. Pain and distress associated with these management techniques are

difficult to quantify and have been the center of much debate regarding animal welfare. Castration

induces physiological stress and alters several physiological and behavioral responses indicative

of pain (Melony, Kent, and Robertson, 1995; Fisher et al., 1996, 1997a,b). However, attempting to

alleviate the stress of castration with local anesthesia or analgesics pre- and post-castration has been

challenging and results have been variable. Ting et al. (2003a,b) reported that systemic analgesia TABLE 8.1 The Effect of Corn and Feeder Cattle Prices on Economic Losses ($ Per Head) Associated with a Catastrophic Winter Storm Item Cattle Price a Corn b Price ($ per 25.41 kg) $ per 45.45 kg 2.50 3.50 4.50 5.50 6.50 Feed costs c — 91.08 111.79 132.51 153.22 173.94 Yardage d — 20.30 20.30 20.30

20.30 20.30 Interest e 80.00 9.05 9.05 9.05 9.05 9.05 100.00 11.31 11.31 11.31 11.31 11.31 120.00 13.58 13.58 13.58 13.58 13.58 140.00 15.84 15.84 15.84 15.84 15.84 Death loss f 80.00 65.27 67.69 70.12 72.54 74.97 100.00 77.99 80.41 82.84 85.26 87.69 120.00 90.71 93.13 95.56 97.98 100.40 140.00 103.42 105.85 108.27 110.70 113.12 Total costs g 80.00 185.69 208.83 231.98 255.12 278.26 100.00 200.68 223.82 246.96 270.10 293.24 120.00 215.66 238.80 261.94 285.08 308.22 140.00 230.64 253.78 276.92 300.06 323.20 Source: Adapted from Wagner et al., 2008. Professional Animal Scientist. 24: 494-499. a 403.8 kg pay weight. b 15% moisture. c 9.67 kg per day dry matter intake for the 58-day study period and diet dry matter concentration was 70%. d $0.35 per head daily for the 58-day study period. e 8% on initial calf value. f 7% of the steer value at the start of the study period calculated from initial calf value and production costs up to the start of the study. g Feed plus yardage, interest, and death loss costs.

with ketoprofen, a nonsteroidal anti-inﬂammatory drug, was an effective method for alleviating

acute inﬂammatory stress associated with castration. Earlier research by Earley and Crowe (2002)

indicated that ketoprofen was superior to local anesthesia with lidocaine in suppressing increases in

plasma cortisol (an acute stress indicator) and decreasing abnormal standing post-castration. Other

researchers have reported similar results (Gonzalez et al., 2010; Stafford et al., 2002). Furthermore,

plasma cortisol response to castration increases as the age of the animal at castration increases

(King et al., 1991). This is most likely due to an increase in soft tissue damage (greater tissue inner

vation and blood ﬂow) at the time of castration in older compared to younger animals (Ting et al.,

2003a,b; Weissman, 1990; Fisher et al., 1996). It is evident that castration is painful to cattle based

on physiological and behavioral observations reported in the literature. Utilization of analgesics should be implemented to minimize the pain experienced by castration. Furthermore, if castration is going to be used as a management tool, it should be performed at the earliest age possible. Future research should focus on determining the method and duration of analgesics in order to minimize pain in castrated animals. Possible means of chemical or immunological castration should also be investigated.

Removing horns from cattle (dehorning) is a management practice to help prevent bruising of cattle when they are transported together in close quarters, as well as to reduce the risk of injury to other animals and employees. In general, horns can be removed by disbudding (destroying the horn-producing cells) at 6 to 8 weeks of age, or by removing established horns. Hot iron and chemical forms of disbudding are common methods of preventing horns from growing. Once horns are mature, horn removal is more challenging. Horn buds and the base of mature horns are highly vascularized and innervated and mature horns are linked to the frontal sinuses. Due to the innervation, vascularization, and relationship to the sinus, dehorning can be painful and increase the risk of infection and excessive bleeding. Results of numerous experiments indicate that dehorning causes an increase in plasma cortisol (Wohlt et al., 1994; McMeekan et al., 1997; McMeekan et al., 1998; Mellor et al., 2002; Sylvester, et al., 1998; AVMA, 2011). Local anesthesia, analgesics, cauterization, and a combination thereof, have been reported to assist with pain management in cattle that have been disbudded or dehorned. Due to the labor costs and reduced production efficiency, genetic selection for cattle with no horns (polled) is becoming popular. Hot iron and freeze branding are common management practices for permanently identifying cattle. However, as discussed with castration and dehorning, both forms of branding can be painful as indicated by increased heart rates and plasma epinephrine and cortisol concentrations, which are indicative of pain (Lay et al., 1992 a,b). Therefore, similar pain abatement strategies as describe previously should be utilized when branding cattle. Alternatively, other less painful permanent identification systems could be utilized such as genetic or digital technologies. Animal handling and transportation can also induce stress in beef cattle. For an extensive review of this topic, see Grandin (1997). If possible, habituating animals to handling equipment, people, and routine handling events can help decrease animal fear, which in turn helps to decrease animal stress. Regardless of acclimatization status to handling, it is imperative that all equipment be functioning appropriately when animals are being handled. Slipping or falling in a squeeze chute or on a cattle trailer can be extremely stressful to cattle (Grandin, 1993, 1997, 2001). Removing or minimizing objects that cattle may find frightening (swinging ropes, shadows, etc.) will also help decrease animal stress during handling. Furthermore, people handling animals need to be appropriately trained in cattle handling techniques, and remain calm and quiet. This will decrease the

likelihood of animals having a negative experience during
the handling or transportation event.

Cattle that have a negative experience during handling and
transportation (i.e., falling, slipping,

rough handling, etc.) will remember the event and become
more stressed during subsequent han

dling events. If cattle are extensively managed and not
handled as frequently as intensively managed

cattle are, it is important that the above-mentioned
strategies for minimizing stress be implemented

in conjunction with understanding the fear response
described by Grandin (1997).

THE CHALLENGE

It is apparent that beef producers understand the
importance of minimizing stress on beef cattle.

By doing so, production efficiency is enhanced. However,
over the last 10 years societal/consumer

concerns for animal well-being and lack of understanding of
animal agriculture have increased

exponentially (Rollin, 1990, 2004). Society as a whole has
begun to question how food animals are

raised. In doing so, animal welfare has been moved to the
forefront of topics that the beef industry

must address. It is no longer satisfactory to consumers to
justify beef production practices based

on animal performance–the welfare of each individual animal
needs to be vectored into produc

tion practices. Humane treatment of animals has always been
an ingrained social ethic among beef

producers. However, more attention needs to be given to
pain management and abatement of envi

ronmental stressors as they relate to beef cattle
production. By implementing these strategies into

production practices and communicating them to the consumer, animal welfare will be improved

and consumer confidence will be enhanced.

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Section III

Sustainable Plant and Animal

Agriculture for Animal Welfare

9 Chapter 9: Symbiosis of Plants, Animals, and Microbes

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10 Chapter 10: Food Safety Issues in Animal Source Foods Related to Animal Health and Welfare

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CHEMICAL FOOD SAFETY

Steve L. Taylor and Joseph L. Baumert

INTRODUCTION

While the preceding section of this chapter focused on the very important issues surrounding

microbial food safety of animal-based food products, chemical hazards are also important. Unlike

microbiological hazards, chemical agents do not multiply in foods unless they are associated

with microbial growth. With chemical hazards, the focus is on hazard identification and assess

ment with control efforts focused on the prevention of their entry into the food with various raw

materials. However, a few potentially hazardous chemical substances are produced by microorgan

isms sometimes associated with animal-based foods including botulinum toxin from growth of

Clostridium botulinum. This section focuses on the nature of various potential chemical hazards

and their monitoring and control including a focus on food allergens, which have emerged in recent

years as a chemical safety issue that must be controlled through the development and application of

allergen control plans.

CHEMICAL HAZARDS ASSOCIATED WITH ANIMAL-BASED FOOD PRODUCTS

Foods can be viewed as complex mixtures of chemicals with many being nutrients essential to sus

tain life. Nevertheless, non-nutrient chemicals can and do exist in foods. Some of these chemicals

can be toxic and hazardous under certain circumstances of exposure, although, fortunately, most

are not hazardous under typical circumstances of exposure. Even some nutrients can be toxic under

certain circumstances of exposure. The central axiom of toxicology is that the dose makes the poi

son so the amount of exposure to a given chemical is related to the potential hazard. The focus here

is on chemical substances in foods that may pose a risk in animal-based food products under some

reasonably expected circumstances of exposure. Chemicals in foods arise from two principal sources—naturally occurring substances and manu

factured chemicals. The naturally occurring substances in foods include the nutrients that have

limited toxicological properties when consumed as part of the diet. However, some naturally occur

ring substances are potentially hazardous including both naturally occurring constituents of certain

foodstuffs and naturally occurring contaminants. Fortunately, very few such chemicals exist in

animal-based food products beyond the naturally occurring contaminants found in seafood such

as ciguatera toxins in fish and various shellfish toxins, all arising from algae consumed as part of

the food chain in ocean environments. These toxic contaminants will not be extensively discussed

because seafood is not a principal focus of this book. The major categories of manufactured chemicals that can occur in animal-based food products are feed additives and veterinary drugs, although food additives, chemicals migrating from packaging materials, and inadvertent or accidental contaminants occurring as industrial and environmental pollutants can also be a concern on occasion. Chemicals produced by reactions occurring during the processing, preparation, storage, and handling of foods could also be considered artificial because these processes occur through human intervention.

NATURALLY OCCURRING TOXICANTS IN ANIMAL-BASED FOODS

Few naturally occurring constituents occur in animal-based foods with the exception of certain hazardous species of marine organisms (Table 10.1). The only known exceptions are certain naturally occurring plant toxicants that can be ingested by animals feeding on certain noxious weeds; the toxicants can then be passed through to meat, milk, and eggs (Beier and Nigg, 1994). Such situations happen very rarely but are more likely to occur with livestock grazing on open range in regions where certain noxious weeds are endemic. The levels of alkaloid toxins that pass through to meat, milk, and eggs, and the hazards associated with the intake of these animal-based food products have not been studied extensively. Thus, these situations with a couple of rare exceptions would best be described as concerns rather than known hazards. The so-called milk sickness from the ingestion of milk from cows that grazed on white snakeroot is probably the most noteworthy example of such a situation. Tremetone is the identified toxicant present in white snakeroot. Notably, Abraham Lincoln's mother died of milk sickness in Illinois

in 1818, but this illness has not been reported in recent years in the United States (Beier and

Nigg, 1994). Naturally occurring contaminants can also enter the food supply from natural sources. With ani

mal-based food products, the principal concerns are bacterial toxins and mycotoxins from molds.

Bacterial foodborne diseases are typically caused by viable pathogenic bacteria that invade cells

and tissues, multiply, and thereby cause inflammation and injury. However, a few bacteria are toxi

genic and produce exogenous toxins in foods before the food is eaten. In these cases, the ingestion

of the toxins causes the illness even if the bacteria are destroyed in processing or preparation. The

staphylococcal enterotoxins and botulinal toxins are the best examples. Staphylococcal food poisoning is one of the most common forms of foodborne disease and

is caused by ingestion of staphylococcal enterotoxins. The staphylococcal enterotoxins are pro

duced in foods by certain strains of Staphylococcus aureus, which grow on foods, including

animal-based food products, under certain conditions such as temperatures between 10°C and

45°C (Wong and Bergdoll, 2002). Upon ingestion, the enterotoxins cause nausea and vomiting

within 1 to 6 hours. Low microgram amounts of the enterotoxins are sufficient to elicit symptoms

(Wong and Bergdoll, 2002). The enterotoxins are small proteins with molecular weights of 25,000

to 29,000 daltons, and nine distinct, but structurally related, enterotoxins have been identified

as being produced by various strains of Staphylococcal aureus (Wong and Bergdoll, 2002). The enterotoxins are relatively stable to digestion and are quite heat resistant. For this reason, staphy

lococcal food poisoning is often associated with foods that were cooked after improper storage

at elevated temperatures that allowed the proliferation of S. aureus. Staphylococcal food poison

ing is prevented by food storage conditions that do not allow S. aureus to grow and produce the

enterotoxin. TABLE 10.1 Naturally Occurring Toxicants in Animal-Based Food Products Naturally Occurring Constituents Poisonous animals (puffer ■sh) Plant toxicants passed through to meat, milk, and eggs Constituents causing allergies or intolerances Milk allergens Egg allergens Fish allergens Crustacean shell■sh allergens Molluscan shell■sh allergens Meat allergens Lactose for lactose intolerance Naturally Occurring Contaminants Bacterial toxins (botulinum toxin) Mycotoxins (a■atoxins) Algal toxins (saxitoxins in paralytic shell■sh poisoning) Another toxigenic bacterium is Clostridium botulinum, which can produce potent neurotoxic

botulinal toxins under anaerobic conditions (Parkinson and Ito, 2002). Because of the requirement

for anaerobic growth conditions, botulinal toxin formation occurs most frequently in improperly

processed (canned), low-acid foods, including meat products. The vegetative cell of C. botulinum

and the botulinal toxins are easily destroyed by heat. However, the spores of C. botulinum are

heat-resistant, survive improper thermal processing, and germinate and grow under suitable anaero

bic conditions (Parkinson and Ito, 2002). The commercial canning process is predicated on the

destruction of spores of C. botulinum so that the spores will not germinate, grow, and produce toxin

during storage of the canned product. The botulinal toxins are proteins with a molecular mass of approximately 150 kDa. Seven toxin types have been identified as being produced by various strains of C. botulinum (Parkinson and Ito, 2002) with types A, B, and E most commonly associated with foodborne illness. The botulinal toxins are extremely potent. Clinical symptoms develop within 12 to 48 hours after ingestion of the implicated food. Symptoms include serious neurological manifes tations including blurred vision, inability to swallow, aphasia, and weakness of the skeletal muscles progressing to respiratory paralysis and death. Proper operation of canning equipment is the key to industrial control points to prevent introduction of botulism into canned food. Mycotoxins are naturally occurring contaminants produced when certain species of molds grow on certain foods (Chu, 2002). Typically, the toxin-producing molds grow on cereal grains and oil seeds. However, in the case of aflatoxin, ingestion of moldy feed by cows can result in the appear ance of an aflatoxin metabolite in the milk. The aflatoxins are produced primarily by fungi of the Aspergillus genus, namely, A. flavus and A. parasiticus, which are molds that can contaminate peanuts and corn (Chu, 2002). Aflatoxins B and G are the forms of aflatoxin that have been identi fied in legumes and cereals. Dairy cows fed aflatoxin-contaminated grains or oilseeds are known to release a related form of aflatoxin, aflatoxin M, into their milk. The aflatoxins are potent hepatocar cinogens. The control of mycotoxin formation in foods is predicated on the control of mold growth in stored grains, oilseeds, and other foods. Regarding aflatoxin M in milk, the most critical measure is to avoid feeding moldy grains to dairy cows.

POTENTIALLY TOXIC MANUFACTURED CHEMICALS IN ANIMAL-BASED FOOD PRODUCTS

Foods may contain a variety of manufactured chemical substances that are either intentionally or

unintentionally added (Table 10.2). With the intentionally added chemicals, these substances should

be safe under normal circumstances of exposure. However, overuse or inappropriate uses can lead to TABLE 10.2 Potentially Toxic Manufactured Chemicals in Animal-Based Food Products Food Additives (with overuse) Sodium nitrite Agricultural Chemicals Feed additives Veterinary drugs and antibiotics Industrial Chemicals Polychlorinated biphenyls Polybrominated biphenyls Intentional Adulterants Melamine and cyanuric acid

hazardous situations. With unintentional manufactured chemicals, the exposure dose is also impor

tant, but the mere presence of the substance can be considered as a source of concern.

Food Additives

Food additives are intentionally added to foods to provide a wide variety of technical bene■ts.

Several thousand food additives exist, although many of these chemicals are used in rather small

amounts. The degree of hazard associated with the food additives used in animal-based food products is

quite low primarily because the safety of food additives is well established (Taylor, 2005). In many

cases, food additives have been subjected to safety evaluations in laboratory animals and use levels

are maintained at exposure doses far below any dose that would be hazardous. Furthermore, many

food additives have long histories of safe use even if classical toxicological evaluations in labora

tory animals have not always been exhaustively performed.

Many of these substances are generally

recognized as safe (GRAS). Finally, the use of food additives is deliberately controlled in manufac

turing operations. As long as additives are used in accordance with good manufacturing practices,

hazardous situations can be avoided. The primary hazard associated with food additives is their misuse. An example relating to the

popular processed meat additive, sodium nitrite, will illustrate the consequences of misuse. Sodium

nitrite is a white granular substance easily confused with other salts, including sodium chloride,

which are much less toxic. In the illustrative incident, a small grocery store was repackaging addi

tives such as sodium chloride, sodium nitrite, and monosodium glutamate (MSG) from bulk con

tainers into home-use packets (Taylor and He[illegible]e, 2002). Somehow, sodium nitrite was erroneously

labeled as MSG. The mislabeled product was used in hazardous amounts by consumers, resulting in

acute methemoglobinemia and at least one death.

Agricultural Chemicals

An array of various chemicals is used in modern animal agriculture. Residues of these chemi

cals can sometimes be found in the raw and processed animal-based food products. Public health

authorities evaluate the safety of such chemicals and regulate and monitor their use in food-pro

ducing animals (Taylor, 2002). Feed ingredients and veterinary drugs, including antibiotics, are the

primary concerns with food-producing animals. When properly used, minimal hazards are posed

by the residues of these chemicals remaining in foods.

Thus, the primary approach to lessen this particular hazard is to use such materials only as recommended.

Feed Additives

Like food additives, substances added to feed do not often cause health-related concerns among consumers of meat, milk, and eggs. Some years ago, concerns were raised when diethylstilbesterol (DES) was allowed and used as a growth promoter in beef cattle. Subsequently, DES was shown to be carcinogenic, and its use as a feed additive was banned. DES is definitely carcinogenic to humans; its use as a drug to prevent miscarriages in pregnant women was linked to certain types of cancer in their offspring. However, there is no evidence that the very low levels of DES in edible beef occurring after the use of DES as a growth promoter pose any carcinogenic risk to humans.

Veterinary Drugs and Antibiotics

A variety of veterinary drugs and antibiotics can be used on food-producing animals. If properly used, residues in foods are typically low and hazards are small. Some concerns have arisen especially when these chemicals are used inappropriately. As an example, penicillin is a common antibiotic used in animal as well as human health. Some consumers are allergic to penicillin primarily because of its use in human medicine. The likelihood of allergic reactions to the very low levels of penicillin residues found in foods is quite remote (Dewdney and Edwards, 1984), but improper use could lead to higher levels of consumer exposure.

Industrial Chemicals

Industrial chemicals enter the food supply principally as environmental pollutants. Typically, the residue levels of industrial chemicals found in foods is rather low, resulting in inconsequential hazards. However, on the rare occasions where hazardous levels of industrial chemicals enter the food supply, devastating consequences can occur from both a health and economic perspective because of the potential magnitude of the contamination.

Polychlorinated Biphenyls (PCBs) and Polybrominated Biphenyls (PBBs)

Animal food products have become contaminated with environmentally persistent chemicals, PCBs and PBBs, on several past occasions (Taylor, 2002). PCBs and PBBs are primarily industrial chemicals with PBBs commonly used as fire retardants and PCBs frequently used in transformer fluid. Residues exist in the food chain as toxic pollutants from industrial practices. PCBs and PBBs are not particularly worrisome as acute toxicants in foods. However, since they are fat-soluble, elimination from the body is slow and the chronic effects of exposure to these contaminants in foods are a concern. Many years ago in Michigan, an incident occurred involving the accidental contamination of dairy feed with PBBs. This episode resulted in the destruction of many cows and their milk. While the health consequences remain uncertain, the economic impact was considerable (Reich, 1983). Leaking heat exchangers or transformers are the principal sources of PCBs. The most famous incident of PCB contamination occurred in Japan when PCBs leaked from a heat exchanger used

in the deodorization process for rice bran oil. Ingestion of the oil was responsible for many cases

of "yusho" (meaning oil disease) in Japan (Miyata, Murakami, and Kashimoto, 1978). The toxic

effects were chronic with symptoms persisting in many of the victims for 8 years or more after

exposure. Such incidents continue to occur periodically although fortunately without the large num

ber of human illnesses experienced in the yusho incident. Leaking transformers have contributed

to the contamination of feeds with PCBs, which led to the destruction of chickens, eggs, and egg

containing food products (Taylor, 2002). Clearly, this type of environmental pollution with indus

trial chemicals can and should be prevented.

Intentional Adulterants

Of course, the intentional adulteration of foods can also result in potentially hazardous chemicals

entering the food supply. The classic example is melamine, which perhaps together with cyanuric

acid was intentionally added to milk and wheat gluten in China to increase apparent protein levels.

These chemicals elicit misleading results in some protein assays based upon nitrogen content.

However, melamine together with cyanuric acid is a rather potent toxic combination of chemicals

that resulted in adverse reactions in infants exposed to the adulterated milk and pets ingesting the

contaminated pet foods (Hau, Kwan, and Li, 2009). Of course, in most countries, it is illegal to add

intentional adulterants to foods although catching the perpetrators can be problematic unless some knowledge exists to suggest possible analytes for testing.

FOOD ALLERGENS FROM ANIMAL-BASED FOOD PRODUCTS

Certain naturally occurring constituents of animal-based food products are capable of causing food

allergies or intolerances. Over the past decade, food allergies and intolerances have been increasingly

recognized as serious food safety issues. Food allergies involve abnormal responses of the human

immune system usually to naturally occurring substances, primarily certain specific proteins, in

foods (Taylor and Hefle, 2001). Food allergies occur only in certain individuals in the population

with an overall estimated prevalence of 3.5 to 4.0% in the United States. These individuals have

immune systems that respond abnormally to specific naturally occurring proteins in foods that most

consumers can ingest with no adverse consequences. Both humoral (antibody- or IgE-mediated)

and cell-mediated allergies occur with foods. Food allergies can involve both animal- and plant

based foods. The most common foods involved in IgE-mediated allergic reactions are peanuts, tree

nuts, soybeans, and wheat from the plant kingdom and cow's milk, egg, crustacean shellfish, and

fish from the animal kingdom. Many other foods can cause allergic reactions on a more infrequent

basis. The symptoms of IgE-mediated food allergies are individually variable ranging from very

mild skin rashes and itching to life-threatening asthma and anaphylactic shock. Rather low levels of

exposure to residues of allergenic foods are sufficient to elicit an allergic reaction in some affected individuals. Thus, food-allergic individuals must follow rather strict avoidance diets in an attempt to eliminate all exposure to those foods that trigger their allergic responses (Taylor, He[illegible]e, and Munoz Furlong, 1999). In addition to IgE-mediated food allergies, abnormal cell-mediated immunological reactions can also occur with foods. However, allergic reactions of this type have not been well studied especially with respect to animal-based food products. Milk and eggs will serve as the primary examples of commonly allergenic foods of animal origin. All types of mammalian milks (cow, goat, sheep, etc.) are allergenic and cross-reactions frequently occur between milk from different species (Sicherer, 2001). Eggs from all species of domestic birds (chicken, turkey, duck, goose, etc.) are allergenic and cross-reactions are frequent among eggs from different species (Sicherer, 2001). Despite serving as excellent sources of protein, meats such as beef, pork, chicken, and turkey are not considered as commonly allergenic foods. Milk and eggs are the most common allergenic foods among infants, affecting as many as 2 to 3% of infants and young children under the age of 3 years (Taylor, 2005). Most milk- and egg-allergic infants outgrow these particular food allergies. However, milk and egg allergies persist in some individuals so the development of oral tolerance is not universal (Skripak et al., 2007; Savage et al., 2007). Recent evidence has indicated that young children may become tolerant to heated forms (baked) of milk and egg before becoming tolerant of less well-cooked forms of egg or milk (Lemon-Mule et al., 2008; Nowak-Wegrzyn et al., 2008). The primary

allergens in milk and eggs are naturally occurring
proteins. In milk, the major aller

genic proteins are casein, β-lactoglobulin, and
α-lactalbumin (Besler, Eigenmann, and Schwartz,

2000). These proteins also happen to be the most prominent
proteins in milk. For eggs, the major

allergenic proteins are ovomucoid, ovalbumin,
ovotransferrin, and lysozyme (Besler, 1999). These

egg proteins are the most prominent proteins in egg white.
Egg yolk also contains known allergens,

but they do not appear to be allergenic as frequently.
Bovine serum albumin (BSA), a blood protein,

is a minor allergen also found in cow's milk. However, BSA
appears to be the major allergen in

beef. BSA is more heat-labile than other milk allergens, so
most allergic reactions to beef can be

prevented by eating well-done beef (Nowak-Wegrzyn and
Fiocchi, 2009). A similar protein, chicken

serum albumin (CSA), is the major allergen present in
chicken meat. CSA can also be found in egg

yolks and is responsible for bird-egg syndrome, a condition
where individuals are allergic to pet or

domestic birds and are reactive to some egg products
(Quirce et al., 2001). Some food-allergic subjects react to
rather low doses of their offending foods. For these
individu

als, the implementation of a safe and effective avoidance
diet is a major obstacle. Because of these

low thresholds, allergen control has become a key concern
in food manufacturing facilities where

multiple formulations are made on shared equipment and in
shared facilities. Food intolerances are also
individualistic adverse reactions to foods or food
components but, in

this case, they occur through mechanisms that do not involve the immune system (Taylor and He*e,

2001). Several types of food intolerances are known to occur. However, the metabolic food disor

ders are the category most frequently associated with animal-based food products. Metabolic food

disorders occur either when individuals respond abnormally to a food component because they have

a de*ciency in an enzyme needed to metabolize that substance or because the substance affects

their metabolic processes in an unusual manner. With animal-based foods, lactose intolerance is the

best example of a metabolic food disorder (Suarez and Savaiano, 1997). Lactose is a disaccharide

found in cow's milk. Lactose-intolerant individuals have low levels of the enzyme, β-galactosidase

(lactase), in their small intestine. As a result, the disaccharide cannot be hydrolyzed into its con

stituent monosaccharides, glucose and galactose. While glucose and galactose can be absorbed and

used for energy, lactose is not absorbed from the intestine unless it is hydrolyzed. The undigested,

unabsorbed lactose then enters the colon where resident colonic bacteria convert it to CO_2, H_2, and

H_2O creating *atulence and frothy diarrhea. A very large number of consumers are affected by

lactose intolerance because it is common among Asians, Hispanics, and African-Americans. While

these individuals must follow dairy product avoidance diets, most of them can safely ingest some

lactose in their diets without experiencing adverse reactions. In this case, the threshold dose is much

higher than for IgE-mediated milk allergy.

SUMMARY

Animal-based food products do not frequently present chemical hazards to consumers. The chemi

cals that are intentionally used in the production of animals or the processing of animal-based

products are generally well evaluated for safety and are of limited concern when used according to

good agricultural or good manufacturing practices. The most signiﬁcant hazards involve naturally

occurring toxicants, industrial environmental contaminants, and intentional adulterants. Control

measures can be implemented to lessen the risks posed by any of the known chemical hazards. Food

allergies and intolerances represent a well-known risk to the sensitized segment of the consuming

public. However, food-allergic individuals can lessen their risk simply by avoiding products made

with certain animal-based components such as milk, egg, or lactose.

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COLOR FIGURE 11.1 Farm production balance in the United States, 1929-2007. (From USDA/ERS. Chart

by Ken Meter, 2009.) Ag Area US Pastures US Arable US Forests US Ag Area World Pastures World Arable World Forests World A r a b l e , F o r e s t , & P a s t u r e p e r c a p i t a , a c r e s 7 6 5 4 3 2 1 0 1960 1970 1980

1990 2000 2010

COLOR FIGURE 12.1 Per capita availability of arable, pasture, and forestland in the United States and the

world during the past century. (From Food and Agriculture Organization, 2010.) Barley Rice Wheat Corn Sorghum Oats Soybeans 1980 1985 1990 1995 2000 2005 2010 Y i e l d , M c a l D i g e s t e d E n e r g y / H e c t a r e 40,000 35,000 30,000 25,000 20,000 15,000 10,000 5,000 0

COLOR FIGURE 12.3 Capture of digestible energy per hectare in crops harvested from various cereal

grains and soybeans in the United States from 1980 to 2009. Rainfed Arable Cropped Worldwide, 38% of arable land is cropped! H e c t a r e s , m i l l i o n s 1200 1000 800 600 400 200 0 S u b S a h a r a n A f r i c a N A f r i c a ; N e a r E a s t N A s i a , E o f U r a l s A s i a P a c i f i c S o u t h a n d C e n t r a l A m e r i c a N o r t h A m e r i c a E u r o p e 15% 15% 160% 64% 64% 54% 63%

COLOR FIGURE 12.2 Arable and crop land worldwide and by region. (From Food and Agriculture

Organization, 2000. World Soil Resources Report 90.) Barley Rice Wheat Corn Sorghum Oats Soybeans Y i e l d , k g p r o t e i n / H e c t a r e 1,200 1,000 800 600 400 200 0 1980 1985 1990 1995 2000 2005 2010

COLOR FIGURE 12.4 Protein yields per hectare from various crops in the United States from 1980 to 2009. 40,000 35,000 30,000 25,000 20,000 15,000 10,000 5,000 0 1985 1990 1995 2000 2005 Y i e l d , M c a l / h e c t a r e Corn grain Potato Onion Carrot Sweet potato Tomato Pepper Cabbage Watermelon Lettuce Cantaloupe Sweet corn Broccoli Blueberry Asparagus

COLOR FIGURE 12.5 Energy capture in edible megacalories per hectare by corn grain, various fruits and

vegetables, and berries from 1985 to 2008. (From USDA/ERS, 2010; USDA/ARS, 2010.) Feedlot cattle Feedlot pigs Lifetime cattle Lifetime pigs Broilers T i s s u e / G r a i n C a l o r i e s , % Grain in Finishing Diet, % of DM 0 5 10 15 20 25 30 30 50 70 90 110

COLOR FIGURE 12.7 Feedlot phase versus lifecycle caloric efficiencies for various animal products.

(Based on data from Whitney et al. (2006), J. Anim. Sci. 84: 3356-3363; Bremer et al. (2007), 2008 Nebraska

Feeders Report, pp. 39-40; Dozier et al. (2007), J. Appl. Poult. Res. 16: 206-218; and Klopfenstein et al.

(2008), J. Anim. Sci. 86: 1223-1231. 1,200 1,000 800 600 400 200 0 1985 1990 1995 2000 2005 Y i e l d , k g p r o t e i n / h e c t a r e Soybean Potato Tomato Onion Cabbage Lettuce Carrot Broccoli Pepper Sweet potato Sweet corn Cantaloupe Watermelon Blueberry Asparagus

COLOR FIGURE 12.6 Protein yields per hectare for food crops and soybeans from 1985 to 2008. (From

USDA/ERS, 2010; USDA/ARS, 2010.)