Animal Well-Being

A Report of the Pew Commission on Industrial Farm Animal Production

The Pew Commission on Industrial Farm Animal Production was established by a grant from The Pew Charitable Trusts to the Johns Hopkins Bloomberg School of Public Health. The two-year charge to the Commission was to study the public health, environmental, animal welfare, and rural community problems created by concentrated animal feeding operations and to recommend solutions.

Since man began raising animals for food, production methods have varied tremendously. When most people raised their own animals for meat, milk, and eggs, the welfare of those animals depended very largely on the individuals in charge of their care. However, from a production-scale view, it is probable that past and present production systems utilizing mainly "extensive" systems, where animals are raised mostly outdoors and fed mainly on forage, face similar animal welfare issues in general: exposure to heat and cold, exposure to disease and predators, and possible nutritional deficits. Logic would suggest that livestock producers wishing to either eat or sell their animal products would do their best to minimize any situation that could lead to a detriment to their product. In an extensive system, this might include providing protection animals, such as dogs or llamas, fences, nutritional supplements (when available), a barn or shelter, a water source or shade for cooling, and proper veterinary care and vaccination (when available). Regional differences due to weather and/or topography certainly led to adjustments in both the manner of husbandry and, particularly in the past, the species and breed of animal raised. Historically, in many communities, farmers who excelled at animal husbandry practices were respected for their abilities.

In the past 50 years, food-animal production has changed significantly, particularly in the United States. This change has come mainly for economic reasons, as vertical integration of animal agriculture has become the norm. Subsidies on grain production made feeding animals grain produced elsewhere cheaper than feeding them grains produced on-farm. This situation influenced the movement of animal production to areas concentrated near railheads, where cheap grain could be delivered. In addition, integration in the retail sector has resulted in large companies, such as Wal-Mart and McDonald's, emerging as the main buyers of animal products. As these companies market their products, meat consumption has grown, as has demand for animal products. The result is the need for more and more consistent animal products. These factors have resulted in the current system of industrial farm animal production (ifap). In this system, animals are raised in confined conditions, where the animal welfare concerns of the past (temperature, predators, nutrition, disease) are highly regulated. However, this system may raise other, perhaps more difficult, problems related to animal welfare.

An evaluation of animal well-being must address not only the health and physiological normality of the animal, but also the animal's behavior and affective state. It is in these areas that ifap systems may be lacking. A primary concern about ifap is the restriction of the animals' behavior due to limited space or lack of access to the resources (such as bedding materials, etc.) needed to perform particular behaviors. In some cases, the animal may be so severely confined as to eliminate even normal movement, as in the cases of gestation and restrictive farrowing crates for sows and wire cages for layer hens. In addition, extreme concentration can lead to stress and abnormal behaviors. The use of particular breeds of animals that are high-producing has resulted in genetic problems, such as Porcine Stress Syndrome (PSS). Issues with facility design (air quality, waste treatment, physical materials present) may cause problems ranging from respiratory distress to lameness. Finally, some animal management practices (tail-docking, dehorning, and beak trimming) are both acutely and chronically painful and are performed without pain relief. This report provides an overview of these and other welfare issues, as well as a discussion of the trade-offs involved in making changes to the current system, the economics of animal welfare, recent actions taken by retailers and producers to establish animal welfare standards, and a discussion of how the well-being of animals in any system is measured.

By releasing this technical report, the Commission acknowledges that the author(s) fulfilled the request of the Commission on the topics reviewed. This report does not reflect the position of the Commission on these, or any other, issues. The final report, and the recommendations included in it, represents the consensus position of the Commission.

During the last 50 years animal agriculture has become increasingly concentrated, with animals being raised on fewer and larger farms. The small farms characteristic of the 19th and 20th centuries, which produced a mixture of crops and animals with the animals being managed under extensive conditions, have largely given way to large monocultural production systems in which the animals are confined indoors for all of, or at least a large part of, the year. During the same time, public concerns about the ways in which farm animals are housed and cared for have accelerated. This report addresses some of the animal welfare issues that have arisen related to rearing dairy cattle, poultry, and swine in these concentrated animal feeding operations (cafos), and also discusses the effects of regulation, animal producer and retailer initiatives and standards, and market forces on the welfare of these animals both on-farm and during transit.

Animal welfare is both a scientific and a social issue. Different individuals in our society have different views about what factors are important to ensure that animals are in a good state of welfare. The scientific assessment of welfare involves evaluating the welfare of both individual animals and groups of animals by measuring various aspects of their behavior (e.g., natural behaviors, abnormal behaviors, animal preferences), physiology (e.g., hormonal changes characteristic of stress), health (pain, injury, and disease), and productivity (e.g., growth rates, reproduction). Each of these measures has strengths and limitations, and it is generally agreed that there is no single indicator of good welfare and that multiple measures should therefore be evaluated. The interpretation of the importance of these measures, however, is ultimately based on values and attitudes toward animals rather than on science.

There are a number of animal welfare concerns in cafos. A primary concern is the restriction of the animals' behavior due either to limited space or the lack of access to the resources (such as bedding materials) needed to perform particular behaviors. Inappropriate human–animal interactions during handling of animals for routine procedures, or loading and unloading during transit, can cause fear and injury. Health concerns include the increased potential for disease spread when animals are concentrated, although large concentrated operations also have the potential to better limit disease through biosecurity measures. Health problems also occur due to selection and management of animals for high production, such as rapid growth or high milk yield. Additional concerns arise due to indoor air quality, facility design, restriction or withdrawal of food and/or water for management reasons, the performance of physical alterations (e.g., dehorning, castration) without pain relief, and stress and mortality during transport.

There is little federal regulation of animal production in the United States. Instead, animal care standards, and auditing or purchasing programs to ensure that those standards are followed, have recently been developed by the producer groups and retailers. All of the major animal commodity groups now have animal welfare standards. Several of the commodity groups, and many larger retailers, have also implemented third-party auditing programs. This process has been facilitated by consolidation along the whole supply chain for animals and their products, including related to animal breeding, processing, and retailing. These standards have resulted in some striking improvements in animal welfare, although by and large they have been developed to address issues in existing intensive husbandry systems. They have, however, been complemented by the development of niche marketing and labeling programs for "humanely produced" products that do provide standards for more extensive systems, including "free-range" systems.

What approaches should be taken to improving and ensuring the welfare of farm animals in the future? Although the market has been very successful in driving change, it cannot be presumed to be a perfect driver. Niche marketing programs tend to appeal to only a relatively small percentage of consumers, and at present there is a great deal of variation among retailers and commodities with respect to the level of detail, the enforcement, and the transparency to consumers of their animal welfare standards. Legislation, on the other hand, has the benefit of ensuring that standards are consistent

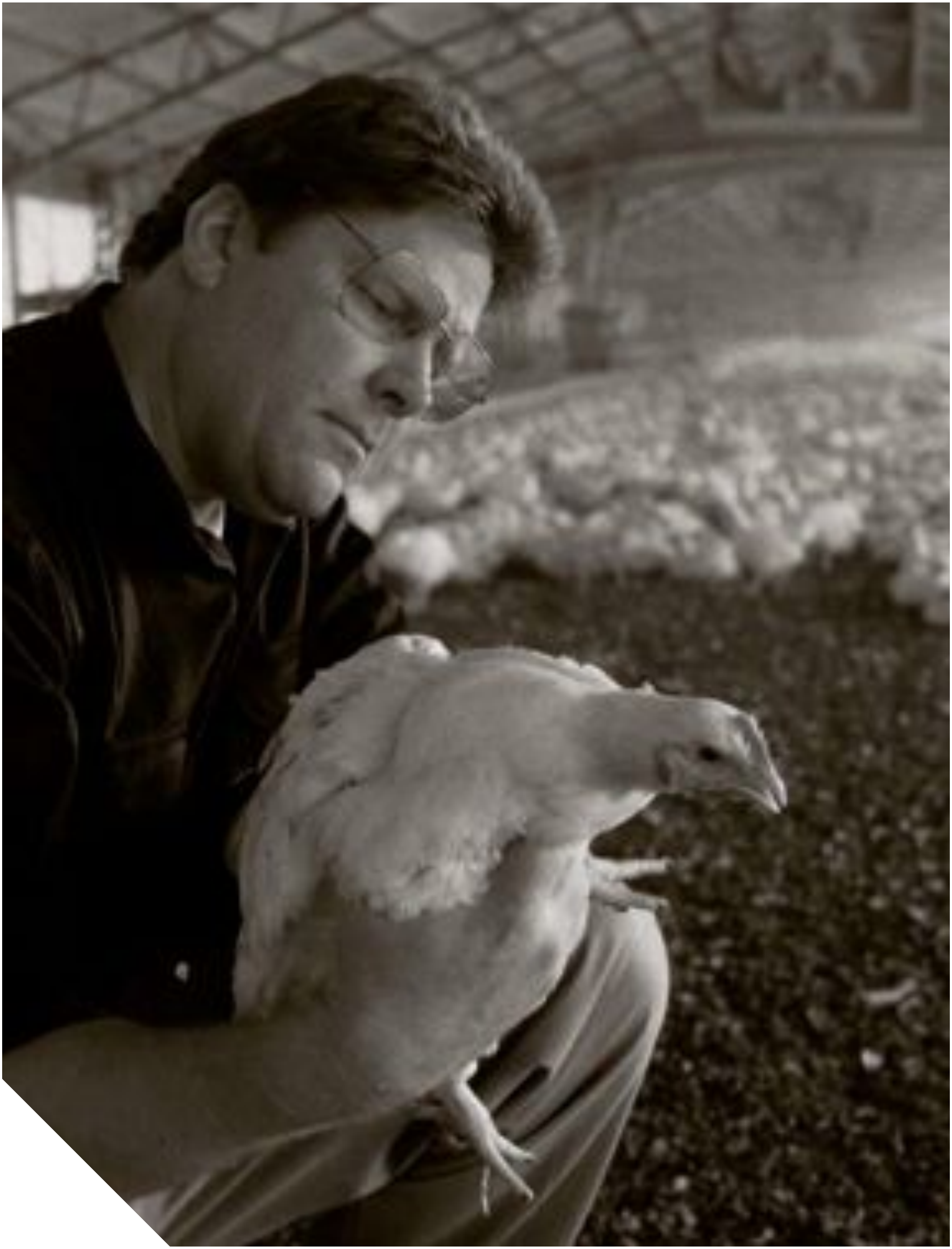
and transparent. In some situations where other types of oversight are difficult or impossible to achieve, legislation is probably the only adequate mechanism for dealing with welfare problems. However, legislation often lacks the consultative and flexible approach necessary to ensure that the standards are sufficiently dynamic and performance-oriented to truly improve animal welfare on farms. Such legislation would also be almost impossible to enforce, given the scale of animal production in the United States, and lack of enforcement could also lead to a lack of consumer confidence in that legislation.

Other approaches to improving welfare are focusing genetic selection programs on welfare traits rather than primarily on production traits, and better applying knowledge derived from animal welfare research to animal management and facility design. Although small-scale experimental studies of animal welfare have added immensely to our knowledge base, there is a critical shortage of on-farm studies, and there are also barriers to on-farm implementation. Investment in the infrastructure of land-grant universities, additional investments in both fundamental and applied animal welfare research, and improvements in university outreach capabilities will be necessary to bridge this gap.

Changing husbandry practices or production systems poses many challenges. First, it should not be assumed that animal welfare problems are exclusive to CAFOs—they also exist in small-scale and extensive production systems, although they may differ in degree or kind from those found in CAFOs. Second, we know very little about consumers' expectations or purchasing patterns with respect to animal welfare, and this is a high-priority area for research. Third, the economic impacts of such changes are uncertain. There are few US studies that assess the comparative economic effects of changing husbandry practices in an attempt to improve animal welfare, although overall these suggest that costs to producers will generally rise, with the increase being small to moderate. However, a full economic analysis must involve an assessment of all impacts of all changes to production practices, including indirect costs such as those to human health, food safety and security, rural communities, and the environment.

The time has come for a national dialogue about what to do about farm animal welfare. This dialogue needs to result in a consultative process that ensures transparency, accountability, and economic security for producers and consumers of animal products. The outcome of this process should be to set performance-based standards for improving animal welfare that leave flexibility for producers to be innovative, and also to develop mechanisms, including incentives, to ensure that the standards are followed. A critical component will be workforce assessment, to ensure that workers are (or can be) adequately skilled and trained to manage more complex husbandry systems in a manner that will not have negative impacts on animal welfare. Without such a process, we risk making changes that absolve the conscience of consumers at the expense of the animals themselves.

In this paper, we provide an overview of issues relevant to the welfare of livestock kept in concentrated animal feeding operations (cafos), as we were requested to do by the Pew Commission on Industrial Farm Animal Production (pcifap). This does not mean that animal welfare issues are restricted to cafos. For example, concerns have been raised related to the use of ducks for foie gras production and the raising of dairy bull calves for special-fed (white) veal production. However, these are small-scale enterprises in the United States that do not meet the epa size definitions for cafos (see Section iii). In addition, animal health and well-being problems also occur in small-scale and extensive systems (Hemsworth et al., 1995; Petherick, 2005; Green et al., 2000; Turner and Dwyer, 2007). These problems may differ in type or extent from those found in cafos, but they can still have profound effects on the welfare of the animals. cafos, in fact, have the potential to improve animal welfare in ways that smaller farms may not. For example, large operations can designate specific employees with specialized training for one area of production, and may also have the resources to establish specialized training programs in animal welfare for their employees. The writers strongly believe that many different production systems have both advantages and disadvantages for animal welfare, and that in most cases welfare is more likely to be affected by how well a particular system is operated than by the type of system per se.

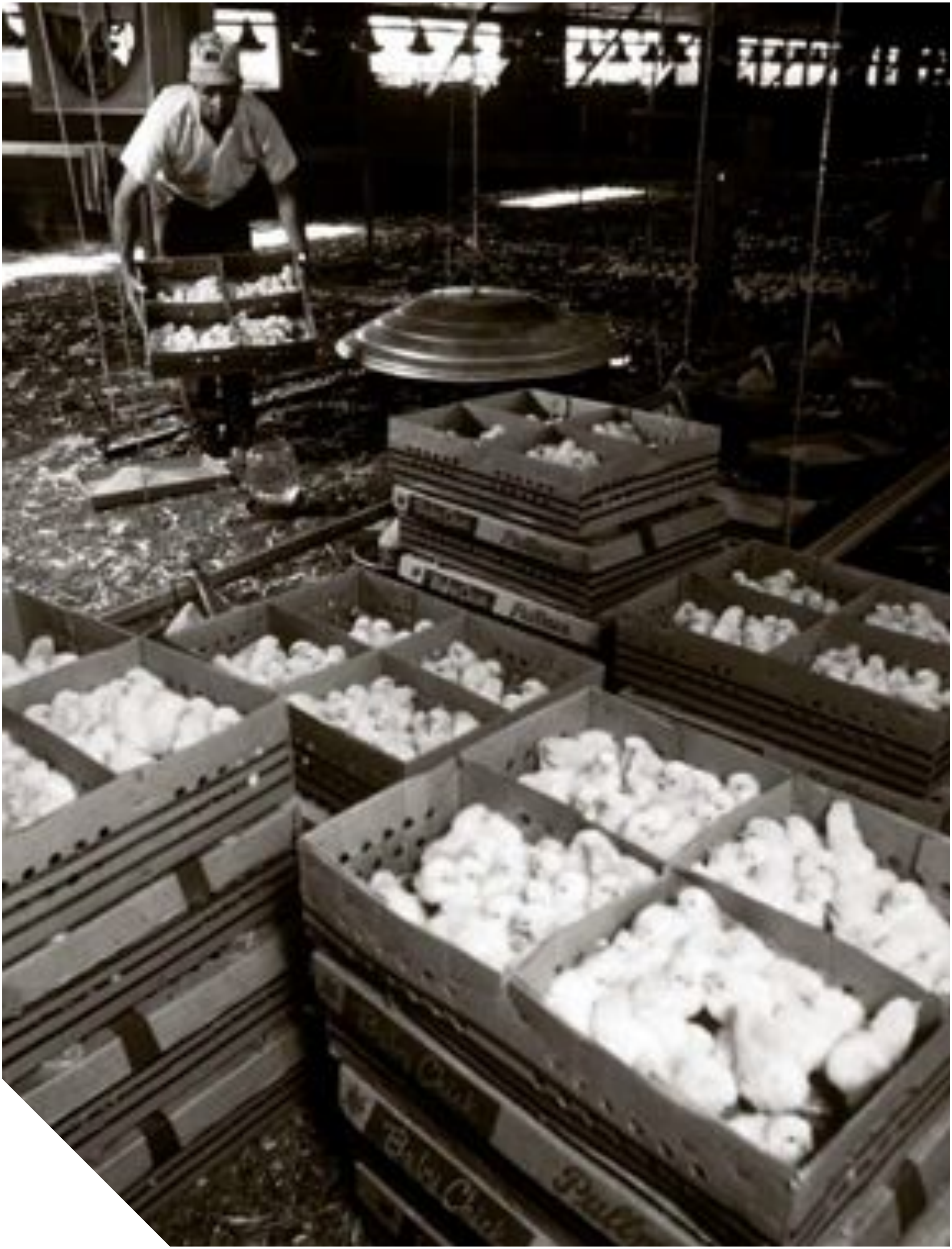


Because of the breadth of this topic, our overview cannot be considered to be a comprehensive overview of on-farm animal welfare issues in cafos. It is also worth noting that animal welfare problems do not end at the farm gate. Readers are referred to the papers and books provided in the reference section for coverage of particular topics related to farm animal welfare that is more in-depth than we are able to provide here. In this paper, after providing background information relevant to the definition of a cafo, we discuss the following topics identified as areas of interest by the pcifap:

While there is not a consensus as to what constitutes a cafo, two factors seem relevant—how the animals are housed and the number of animals in the operation. The Environmental Protection Agency (epa) designates a production system as a cafo if "the animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period" (Gollehon et al., 2001, p. 2), and if there is no grass or other vegetation in the confinement area during the normal growing season. The epa also specifies the minimum number of animals in an operation for it to be considered a cafo (Table 1). However, because the size of a beef, dairy, swine, or poultry animal differs, the United States Department of Agriculture (usda) uses the concept of an "animal unit" (au), equivalent to 1,000 pounds of live weight, to specify the relative size of an operation. According to Gollehon et al. (2001), size categories are as follows:

< 50 au = very small ;
50–300 au = small;
300–1,000 au = medium; and
> 1,000 au = large.

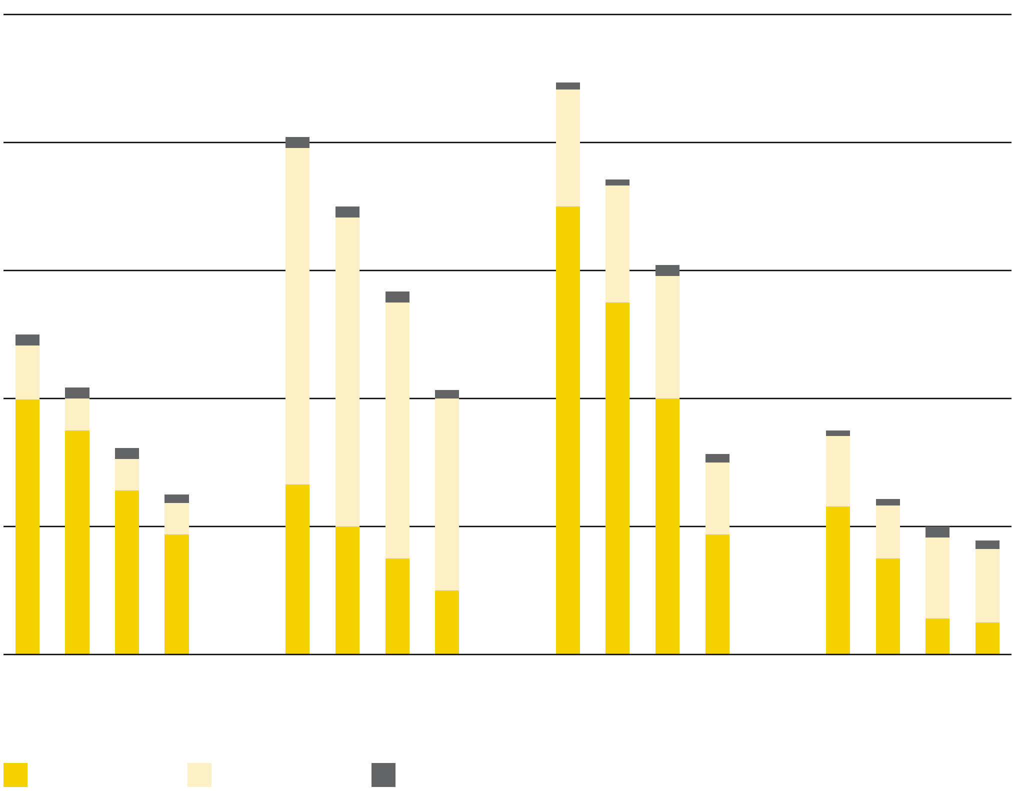
Table 1 shows the number of animals per au, the minimum number of animals in an operation to be designated by the epa as a cafo, and, for purposes of comparison, the equivalent number of animals for very small and large size designations by the usda.



According to usda data, very small and small farms dominate in terms of the total number of animal feeding operations. More than 90 percent of operations in the United States are either very small or small, although their numbers have been declining. Between 1982 and 1997, the total number of animal production facilities declined by more than 50 percent, from 435,000 to 213,000, with the decline occurring primarily in the very small and small size categories; in contrast, the number of medium and large operations increased (Gollehon et al., 2001).

These figures suggest that, consistent with trends in all of agriculture, the number of livestock farms is decreasing while the average size of operations is increasing.

Consistent with the epa definition, in this paper we discuss welfare issues associated with the housing and management of meat-type poultry (broilers, turkeys, ducks), egg-laying hens, swine, dairy cattle, and beef cattle during the finishing phase in feedlots, since these are the types of production that would typically be characterized as cafos.



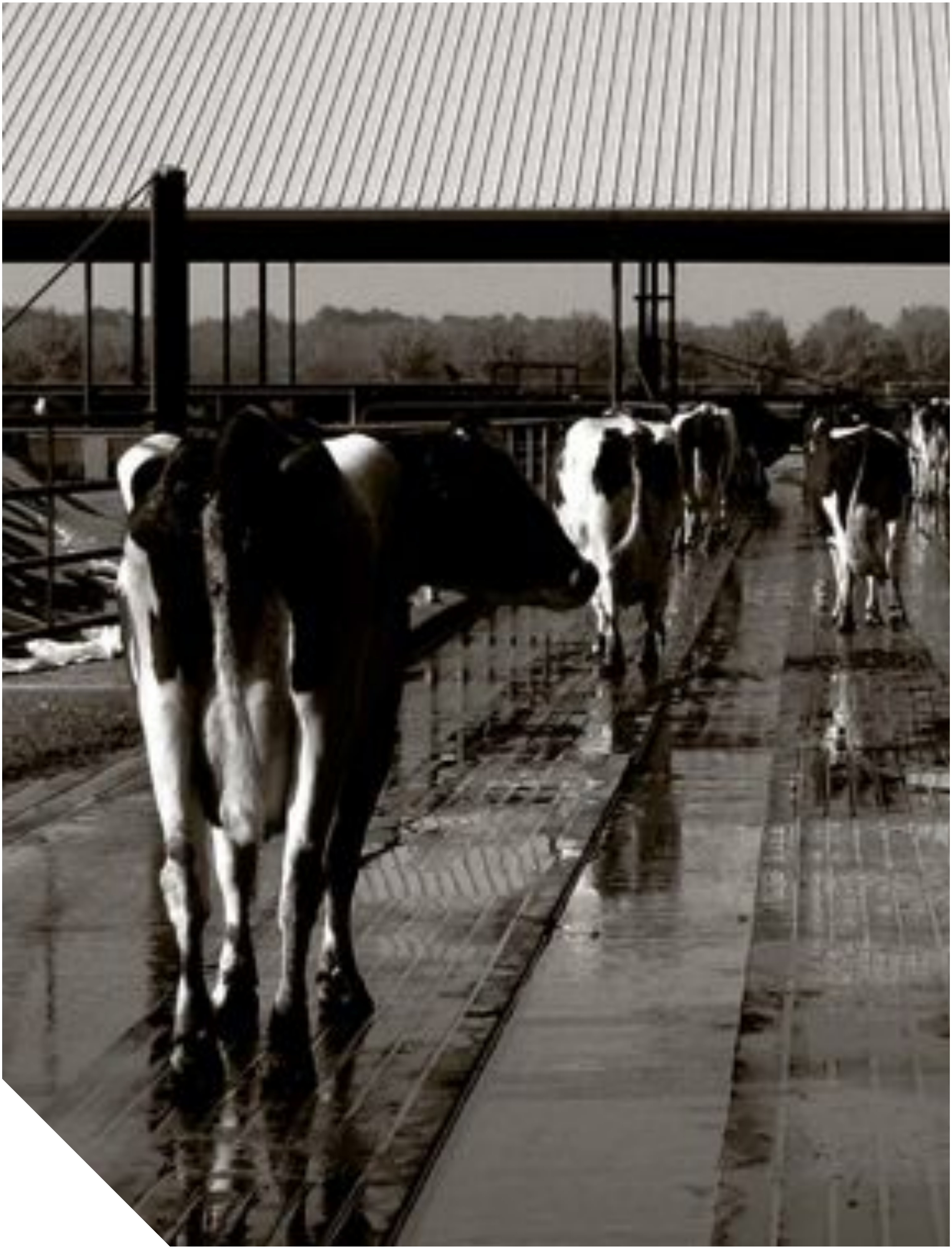
When Singer wrote the first edition of his influential book *Animal Liberation* in 1975, he led off his discussion of livestock production by claiming that farmers and ranchers deny that the animals under their care have any moral standing but are, in fact, "machines" incapable of experiencing pain. Subsequent editions (e.g., Singer, 1990) of the book omitted this claim without comment. As Rollin (1995a) has argued, livestock producers have never doubted that they owed moral responsibilities of good husbandry to the animals under their care, nor could they have managed these animals successfully had they doubted that the animals were capable of experiencing pain, discomfort, or distress. However, producer attitudes toward animals in the past must be largely inferred from anecdotal sources, since it unsurprisingly did not occur to social scientists to survey them about their views on their moral responsibilities regarding animal welfare. Any attempt to characterize historical changes in both animal husbandry practices and especially in producer attitudes must thus proceed in the face of enormous gaps in our data.

In addition, any attempt to discuss producer attitudes and general animal husbandry problems also of necessity operates at a very high level of generality because there has been a tremendous diversity of approaches and methods in animal production at all times and in all places. Thus, while 19th-century animal production typically occurred on family farms producing a fairly complex mix of field crops, garden crops, and animal products, this does not preclude the fact that very large operations, some with large crop monocultures but others with large herds of livestock, were in existence at the same time on plantations or in other proto-industrial models. There have also always been very significant differences in the ways humans manage, market, and regard different species, and so generalizations about husbandry blur important differences between pigs, cattle, and poultry. The husbandry and the timing and nature of change in each of these industries are far from uniform. There are also regional differences that may owe much to climate and landscape, but that may derive equally from the influence of regional cultures.

One way to summarize changes in livestock production is to focus on the supply chain that extends between primary animal producers—farmers and ranchers—and consumers. There was a time in American history when this chain was very short indeed, extending perhaps 40 or 50 feet from the barnyard to the kitchen. We will pick the year 1800 as an arbitrary anchor point for our history. At that point, approximately 80% of European settlers were primarily engaged in farming, and their farm operations, together with hunting and scavenging, would have supplied most of their need for animal products, especially food. Those who did not farm at all would likely have obtained most of their animal products from neighbors who were known to them personally (Horowitz, 2005).

Animals in 1800 were raised primarily in extensive conditions with occasional husbandry, consisting largely of herding them to sources of food and water, and, in some cases, bringing feed to them. There would have been some attention to calving or lambing, but, for the most part, these animals were on their own. They were exposed to the elements and to predators, though certainly owners of livestock would have attempted to limit the latter exposure. They had virtually no veterinary care, and would have been vulnerable to health problems deriving from injury, exposure, and disease from wildlife and other livestock, though relatively low population densities would have shielded them from some mechanisms of disease transmission (Cowan, 1997; Horowitz, 2005).

Can we characterize the mentality of producers and consumers regarding the ethics of animal husbandry circa 1800? The main philosophical positions regarding human duties to animals were certainly in print by this time, although we cannot presume that American farmers would have been aware of them. Farm diaries and agrarian tracts from this period make infrequent references to the welfare of animals, which may either mean that those who



were writing on farm issues did not see animal husbandry as an important ethical practice, or that they did not regard the condition of animals as ethically problematic (Betts, 1953; Fite, 1976). What seems most likely is that the owners of livestock were thought to have an ethical responsibility to provide good husbandry, but that this responsibility was thought to be entirely consistent with human self-interest, since animals that were faring poorly would not be serving the purposes for which they were being kept in the first place.

If we fast-forward 100 years, we would see significant changes in the supply chain for animal products, but much less significant change in on-farm husbandry or attitudes. By 1900, industrialization and growth in urban centers had taken hold on the East Coast. This created a demand for meat, milk, and animal product supply chains that extended far into the interior, serviced first by shipping routes over water and later by railroads. This infrastructure in turn spawned the growth of Midwestern cities that served as hubs for this supply chain, particularly for animal slaughter and processing (Cronon, 1991). Thus, there were now a number of actors inserted between primary producers and consumers of animal products, including those involved with transport, slaughter, processing, and retailing to urban consumers. The greatest concentration and dominance of large-scale enterprise in this supply chain occurred in the middle. Railroads and processors rapidly became very large firms that could exert substantial control over smaller and economically less well organized animal producers and retailers, the latter of whom tended to be small, independently owned markets, butcher shops, and restaurants.

By 1900, many of the key elements for an agricultural supply industry were starting to take shape, not only in terms of agricultural machinery but in connection with the development of milling and feed supply. Railroads and grain elevators were critical to the emergence of a consolidated global grain industry. Unlike the supply chain in 1800, it was now possible to purchase animal feeds from centralized suppliers, and the input side of animal production became increasingly important throughout the 20th century. On-farm production of crops and animals could no longer be regarded as the beginning point in the supply chain, even in 1900, and farmers and ranchers became increasingly dependent on suppliers (Horowitz, 2005).

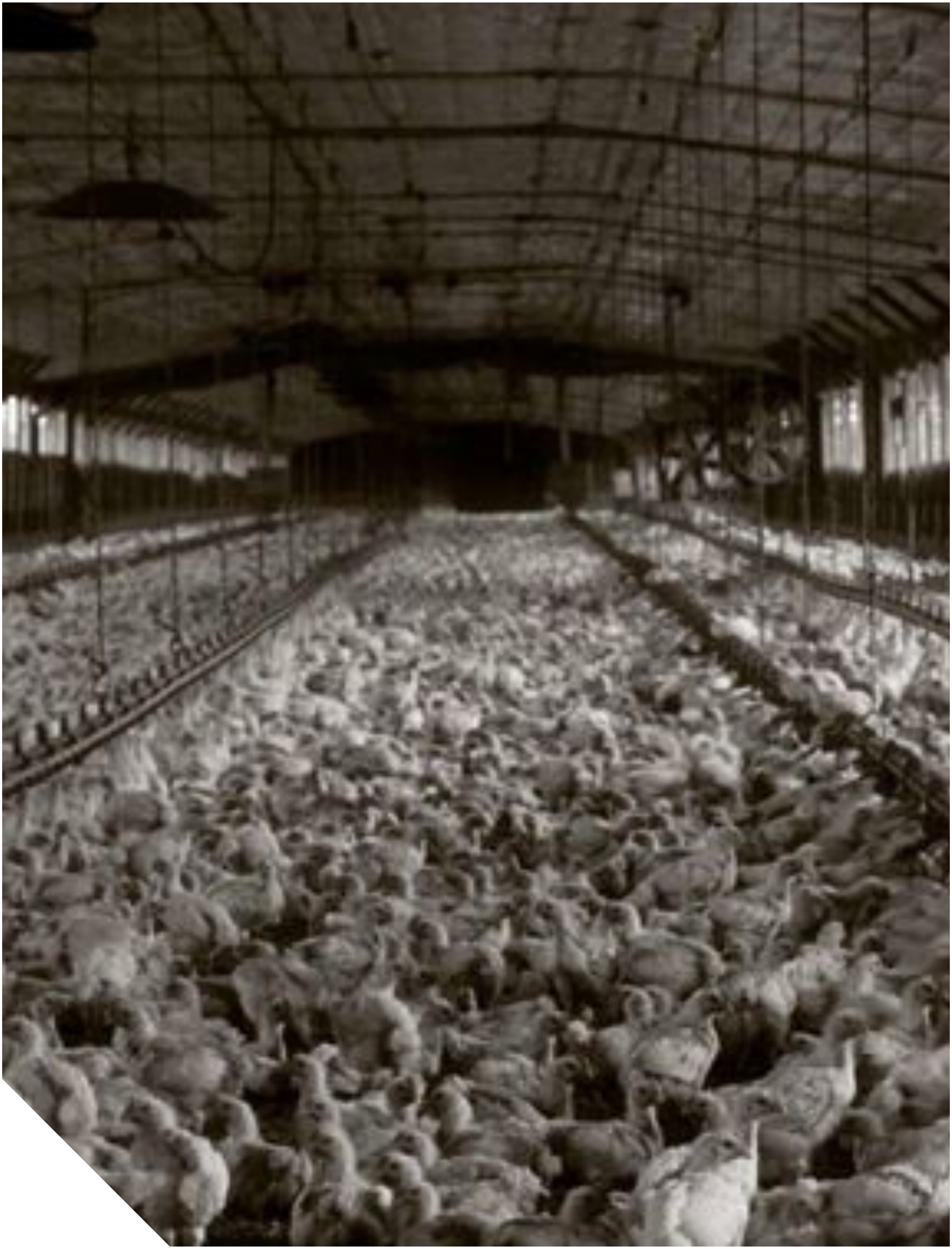
Relative to 1800, animals' lives were changed dramatically with respect to transport and slaughter, those phases of the supply chain that were undergoing the processes of industrialization. Descriptions of early stockyards and slaughterhouses depict conditions that were terrible for both animals and humans, inducing Upton Sinclair to write *The Jungle* (1906). This in turn led to the creation of government regulation for human health and safety in the United States, and the passage of the first federal statute on animal cruelty in 1877, the 28-hour Law dealing with livestock transport (see Section ix-a).

On-farm, however, animal husbandry was relatively unchanged. While the above described changes meant that by 1900 animal production was clearly being thought of as a commercial enterprise rather than a side activity, a great deal of animal production still occurred on diversified farms where several species of animals might be raised alongside extensive crop production activities (Fite, 1984). Whether on specialized or diversified operations, most animals were still kept under extensive conditions with access to pasture or barnyard whenever weather conditions permitted. However, veterinary medical assistance was beginning to become more widely available. Classes in veterinary medicine had been offered since the mid-1800s, and the first dvm degree was awarded by Cornell University in 1876.

Awareness of problems associated with transport and slaughter indicates that for some Americans, at least, livestock animal welfare was coming to be seen as a potential problem. Animal protection groups were beginning to protest the treatment of livestock during transport and while being held for slaughter (Wolfson and Sullivan, 2004). These facts indicate that there were at least some quarters in American agriculture where animal interests were sacrificed for profits. Farmers and ranchers cannot have been wholly ignorant of the conditions that their animals endured upon crossing the farm gate to wind up as a piece of meat. Nevertheless, the on-farm ethic of husbandry would still have held that good care of animals was consistent with the interests of the farmer. Furthermore, although the passage of a law to protect animals in transport acknowledges a role for state action on behalf of animals, husbandry was still regarded as a personal responsibility.

By 2000, changes that were afoot in 1900 had developed in ways that have dramatically altered the supply chain for meat, milk, eggs, and animal byproducts. Overall, farming has been shifted into specialized production systems. Production systems that involve both crops and livestock still exist, but they are no longer the norm. In the main, farmers grow crops that they sell to different farmers who feed livestock. Furthermore, livestock operations are specialized: beef producers are not dairy producers, who are not the people who produce eggs or broilers, and neither beef, dairy, nor poultry producers raise pigs. There is even specialization within production—a dairy producer, for example, may no longer manage their bull calves or raise their own replacement heifers (Fite, 1984; Goldschmidt, 1998; Kunkel, 2000). A supply chain that was once not in any obvious sense a chain at all is now a clear set of distinct production processes coupled in series by economic transactions of one sort or another. Consumers are at one extreme end of this chain and generally have little knowledge of the source or supply organization of the animal products they consume (Huh, 2000).

The consolidation of the processing industry evident in 1900 has continued, creating systems of vertical integration along the value chain, from breeder to grower to processor/packer, with control usually held at the processor level. Vertical integration means that processors typically do not purchase their meat inputs through markets. Rather, stages along the value chain are linked



by production and marketing contracts (most common) or ownership (less common) (Kunkel, 2000).

In a conventional farming system, a farmer owned the cattle, hogs, or chickens until they were sold at market. In production contracting, a processor (called an "integrator") owns the hogs, or chickens and supplies feed and veterinary care, while a farmer (called a "grower") furnishes the housing, management, and waste-removal services. In many cases, the people once known as farmers do not even own the animals, though they do typically own the production facilities and assume a great deal of the financial risk associated with production during the interval when the animals are under their care. Often, the feed, husbandry, and veterinary care made available to animals are specified in these contracts to a level of detail that limits the decision-making of producers considerably. A marketing contract represents a hybrid between production contracts and market exchanges, in which a farmer owns the animals but agrees to sell them to a processor for a pre-determined price. The use of contracts in livestock farming increased from 12% in 1969 to 36% in 2001. In part, this is because they more effectively allocate risks between farmer and seller, and provide incentives for specialization and increased scale of production (MacDonald and USDA-ERS, 2004).

There is, however, considerable variability in the organization of animal production on a commodity basis. In 2003, 47% of all livestock production was governed by contracts. However, the percentage for cattle was 28.9%, for hogs 57.3%, for poultry and eggs 88.2%, and for dairy 50.6% (MacDonald and Korb, 2006). The broiler industry transitioned most rapidly to contract production. In 1950, only 5% of broiler producers were governed by either production or marketing contracts, while the rest were independent. By 1955, however, 88% of poultry producers were governed by contracts. In the case of pork, the transition to contracting did not occur until the 1990s. The percentage of hogs sold under spot markets, where the price is negotiated at the time of purchase (such as at livestock auctions) rather than being pre-determined decreased from 62% in 1994 to only 10% in 2005 (Grimes and Plain, 2006).

There is also regional variation in consolidation, with CAFOs concentrated primarily in the Midwest, northern states, eastern seaboard, and the California–Arizona rim. However, "almost every State has at least 1 county with more than 10,000 animal units" (Gollehon et al., 2001, p. 12). The reason for this is due in part to the economic efficiencies associated with increases in scale (size) of operations and because confinement has the added advantage of providing greater control over the environment. There is a strong correlation between the use of contracting and confinement production in livestock agriculture (James et al., 2007). This is because confinement production requires significant capital outlays for producers, and because broiler, hog, or egg prices are often erratic, thus creating more risk for growers when compared with traditional animal agriculture. In order to encourage producers to take on these added financial risks, large feed companies and processors established production contracts with them (Martinez, 1999).

Two other crucial aspects of the supply chain must be noted. Consolidation in the grain industry combined with decades of subsidy payments to producers of commodity grains such as corn and soybeans has produced a situation where it is very inexpensive to deliver an entire trainload of animal feed to a single location, and even to sell it for an amount that is below the cost of production (Purvis, 1998). The result is that feeding animals in large numbers in proximity to railheads is often cheaper than allowing animals to graze on rangeland or pasture. When coupled to consolidation in processing, this aspect of the contemporary supply chain has proved to be a powerful force toward the "clustering" of CAFOs within specific regions, and the corresponding decline in the number of diversified family-owned farms.

The second change in supply chains is on the consumer end, as very large integrated retailers have emerged during the last 25 years in both the grocery and restaurant sectors. In both cases, between 10 and 15 companies control the majority of sales in animal products, and firms such as Wal-Mart and McDonald's may control significant fractions of retail sales in their sector alone (Hendrickson and Heffernan, 2005). As such, these companies have significant market power to insist on standards from suppliers, including animal welfare standards. The ways in which these standards have developed and are being applied are discussed in more detail later in the paper (Sections IX-D and X).

Contemporary concerns about the welfare of intensively farmed animals are generally considered to originate with the publication of Ruth Harrison's book, *Animal Machines*, in the United Kingdom in 1964. Harrison described what she called a "new type of farming…[with] animals living out their lives in darkness and immobility without the sight of the sun, of a generation of men who see in the animal they rear only its conversion to human food." (p. 1). She coined the term "factory farming" to describe these new production methods.

Harrison's book caused so much public outrage in Britain that the government established a committee to investigate animal farming practices. This committee, which was composed of leading veterinarians, animal scientists, and zoologists, was referred to as the Brambell committee after its chair, Professor Rogers Brambell. The committee laid out its findings in 1965 in an insightful, progressive document (Brambell, 1965). The committee defined animal welfare broadly as including both physical and mental well-being. Their report emphasized that the evaluation of animal welfare must include "scientific evidence available concerning the feelings of the animals that can be derived from their structure and functions and also from their behaviour." The emphasis on behavior and feelings (affective states) was radical for its time and, although most animal welfare scientists now accept that animals do have affective states, this is still a controversial issue for some scientists.

The principles elaborated in the Brambell report were used by the Farm Animal Welfare Council (fawc) of the United Kingdom to develop the so-called "Five Freedoms." These are that the animals should be provided with:

- *Freedom from Hunger and Thirst*—by ready access to fresh water and a diet to maintain full health and vigour.
- *Freedom from Discomfort*—by providing an appropriate environment including shelter and a comfortable resting area.
- *Freedom from Pain, Injury or Disease*—by prevention or rapid diagnosis and treatment.
- *Freedom to Express Normal Behaviour*—by providing sufficient space, proper facilities and company of the animal's own kind.
- *Freedom from Fear and Distress*—by ensuring conditions and treatment which avoid mental suffering.

As fawc notes (2007; http://www.fawc.org.uk), these are not intended to be standards in and of themselves, but instead are a set of ideals that provide a framework for the analysis, development, and improvement of specific practices and housing systems. Translating these into practical improvements in welfare does pose some problems—for example, there is considerable disagreement about the definition, and measurement, of psychological states like fear, discomfort, and distress. The relationships of the principles to one another must also be considered when evaluating and improving animal welfare —for example, although in an ideal world an extensively housed animal would be fully protected from predators, this may not be feasible in the "real" world, so under these circumstances fearfulness of predators may be adaptive for the animal and help to prevent injury and pain. Whatever their limitations, these five principles have now been used as the basis for guidelines and codes of practice for various organizations around the world.

Since the publication of the Brambell Report, various attempts have been made to provide a precise scientific definition of animal welfare (for a comprehensive review, see *Journal of Agricultural and Environmental Ethics*, 1993). These have been unsuccessful for a variety of reasons, but primarily because animal welfare is not just a scientific concept. It is also a social construct (Fraser et al., 1997), and as such different individuals have different ethical views about what factors (e.g., behavioral freedom, health) are important to ensure that animals are in a good state of welfare. Different animal welfare scientists similarly emphasize different aspects of animal welfare or combinations of them when they plan, conduct, and report their research, and ultimately provide an assessment of an animal's welfare. Similarly, because of their background and experience, veterinarians, producers, and consumers may use very different ethical standards when judging the acceptability of particular livestock housing or management practices (e.g., te Velde, 2002).

One schema for illustrating the different approaches to evaluating the welfare of animals represents animal welfare as a function of three overlapping domains (Fraser et al., 1997). The first domain includes standard veterinary health parameters as well as measures of growth and reproductive success developed for improving the efficiency of commercial animal production. Mortality is the most basic indicator of welfare on this dimension. The second includes pain and affective states associated with fear, frustration, and distress, or alternatively with contentment or well-being. The final domain consists of behaviors characteristic or typical of animals of a

given species, often specified with reference to drives or instinctual behavior grounded in the animal's genetic evolution. Appleby (1999) refers to these three domains as animal bodies, animal minds, and animal natures.

The critical point to take from this schema is that welfare is measured along multiple dimensions, each of which involves distinct criteria for improvement or decline. To interpret change in even such a gross measure as mortality is to make an ethical judgment. Saying that being alive is better than being dead may not be a particularly controversial ethical claim, but it is not a claim that can be made on the basis of science alone. Furthermore, it is possible to see improvements in one dimension, say veterinary health criteria or growth and reproduction, while seeing declines in another dimension. As such, there are additional pragmatic factors that must inform any judgment concerning the overall welfare of an animal.

All three domains include a number of distinct measures that could be used to characterize welfare, and in each domain there are both methodological and epistemological difficulties in relating any given measure to acceptable standards for husbandry. One problem arises when so-called anthropomorphisms attribute human states, values, or characteristics to animals that may not have them, for example assuming that an animal is experiencing a particular emotion in response to a situation in the same way that a human would. On the other hand, it would be equally fallacious to deny that animals who exhibit physiology and behavior similar to that of humans experience none of the mental or subjective dimensions of welfare we associate with our own experience (Rollin, 1992; Dawkins, 1998).

To resolve these problems, a great deal of research has been carried out with the goal of identifying reliable, scientifically based indicators of animal welfare (Appleby and Hughes, 1997). The primary focus has been on the theoretical indicators of animal welfare used in experimental studies. In some cases, this approach has been extremely successful in assessing the extent and severity of welfare problems, and in identifying alternatives. An example relates to a practice questioned by the Brambell (1965) committee, beak- or bill-trimming of poultry to prevent the damage associated with feather pecking and cannibalistic behavior. The committee suggested that birds' beaks were probably richly supplied with nerves and that trimming could therefore cause pain. Subsequent behavioral and neuroscientific research indeed revealed that these practices could cause not only acute but also chronic pain (Glatz, 2005). However, research also showed that this pain could be reduced or eliminated by trimming birds when they were younger and by using different trimming technologies (Hester and Shea-Moore, 2003; Gustafson et al., 2007). Some progress has also been made in understanding the genetic and environmental bases of feather pecking and cannibalism, which could result in management and genetic selection programs that reduce or eliminate the need for trimming (Newberry, 2004; Rodenburg and Koene, 2004). Similar strides have been made in understanding and reducing sources of stress during relatively short-term impositions on welfare, for example reducing injury and mortality during handling and transport and improving the humaneness of slaughter (Hemsworth and Coleman, 1998; Grandin, 2000).

Scientific assessment of welfare becomes more difficult when long-term or complex practices, such as housing and management strategies, are being evaluated. Although it would clearly be useful to have a "litmus test" in these situations, most animal welfare scientists agree that there is no single indicator of good or bad welfare, and for this reason attempts to use single indicators such as longevity, animal preference, or the concentration of a stress hormone are no longer accepted as valid. Most animal welfare scientists also recognize that animal welfare is multi-dimensional and that any attempt to assess welfare should ideally combine objective measures of health, physiology, productivity, and behavior. We will now briefly discuss the strengths and limitations of each of these assessment tools.

The stress response is a natural response to physical, psychological, and experiential demands that threaten homeostasis (Moberg, 2000; Lay and Wilson, 2004). Homeostasis refers to the maintenance or balance of a narrow range of vital physiological parameters such as pH, body temperature, and oxygen tension (McEwan 2001). Deviations from homeostasis in characteristics such as heart rate, body temperature, immune response, respiration rate, and hormone concentrations (especially "stress hormones" like cortisol and corticosterone) are the most commonly used physiological indicators of animal welfare.

The key challenge in using physiological indicators is to distinguish "distress," meaning physiological changes that have a negative effect on an animal's welfare (Lay and Wilson, 2004), from those changes that represent normal adaptive responses. Many physiological changes following a stressor are beneficial to the animal, either by helping the animal cope with the stressor or by limiting the damage caused by other defensive mechanisms evoked by the stressor (Sapolsky et al., 2000). In addition, physiological changes associated with the response to a stressor are not specific to unpleasant states. Commonly used stress indicators may increase when the animal is in situations that do not, on the surface, appear to be painful or cause suffering e.g., during sexual behavior, feeding, milking, and nursing (Borg et al., 1991). It is also now clear that there is no response that applies to all stressors (Moberg, 2000), and that treatments known to be stressful do not necessarily result in physiological measures that co-vary. For example, cattle receiving an electric shock showed increased heart rate but no increase in cortisol concentrations (Lefcourt et al., 1986).

Physiological measures of stress have been used with great success to examine the responses of animals to acute challenges, especially practices that cause pain like castration and branding (Lay and Wilson, 2004; Weary et al., 2006). However, the assessment of chronic stress through physiological measures is highly problematic partly because of the difficulty in detecting the changes that occur in physiological systems during prolonged stress, but also because we still lack a good understanding as to how the functioning of relevant physiological systems changes with chronic stress (Lay and Wilson, 2004).

There is widespread consensus that physical health is one of the main components of good animal welfare (Broom and Johnson, 1993; Dawkins, 2005; Fraser et al., 1997). Promoting physical health through the prevention of disease (e.g., by vaccination), treatment of sick and injured animals, and the elimination of pathogens are all examples of improving animal welfare and emphasize the important role of veterinarians. Epidemiological and pathological data have proven to be useful in identifying welfare issues associated with a variety of animal husbandry practices (e.g., Tauson, 1985; Martin, 1983). However, the presence of good physical health is not a guarantee of good animal welfare. Poor animal welfare may also occur if the animal is in poor psychological or mental health, which may occur even when the animal is not in poor physical health. The concepts and measures of mental health and welfare of animals have recently been reviewed in McMillan (2005).

It also should not be assumed that the presence of disease is necessarily an indicator of poor welfare. For example, adenovirus infection of hens leads to decreases in productivity (egg drop syndrome) that can have a major economic impact, but affected birds do not experience pain, suffering, or malaise (Hughes and Curtis, 1997).

Although health measures have figured prominently in assessments of farm animal welfare (e.g., efsa, 2005; Rhodes et al., 2005), their use is not without significant challenges, especially when welfare is assessed in commercial settings. Rushen et al. (2008) have outlined a number of concerns regarding the use of health indicators, including judging the relative impact of different forms of illness or injury on animal welfare, difficulties in accurate and prompt diagnosis, and the difficulty in obtaining reliable and valid information on the occurrence of illness and injury.

Historically, there has been a strong relationship between animal welfare and animal productivity (growth and reproduction). Improvements in husbandry practices, through housing, nutrition, and health management, led to improved productivity and animal welfare. Today, the relationship between measures of agricultural productivity and animal welfare is far more complicated, and measures of productivity can indicate poor welfare when they are both too high and too low.

Increased productivity through genetic selection or other management methods may create a situation where high productivity is an indicator of poor welfare. Numerous studies have reported an increase in health problems associated with high levels of milk production by dairy cows (Fourichon et al., 2001) including mastitis (Ingvartsen et al., 2003). Selection for high production efficiency and increased growth rates has resulted in numerous health problems for swine and poultry (Rauw et al., 1998), including skeletal problems and lameness in fast-growing strains of chickens (Mench, 2004).

Low productivity can indicate a situation where animals are not receiving proper care and are therefore experiencing stress or illness. Immune system activity requires significant metabolic energy (Colditz, 2002), leaving less for growth and reproduction. Furthermore, illness often results in reduced feed intake, further decreasing the amount of energy available for growth and reproduction. In some species, production measures can also indicate a response to an acute stress. For example, a variety of acute stressors such as novel surroundings can cause hormonal changes that lead to blocked milk ejection and reduced milk yield (Bruckmaier and Blum, 1998; Rushen et al., 1999). It is in these examples, where there is some depression of normal productivity, where the relationship with animal welfare is clearest (Fraser and Weary, 2004). However, it is important to recognize that low levels of productivity could also occur for reasons that are completely independent of animal welfare, such as due to poor artificial insemination (ai) techniques or procedures or an inability to detect estrus at the optimum time.

The lack of a consistent relationship between animal productivity and animal welfare means that measures of agricultural productivity can be powerful welfare indicators but only under certain circumstances, such as when low productivity is the direct result of inadequate nutrition, disease, or other stressors that have an adverse effect on the animal.

The science of animal behavior (ethology) has been closely linked to the study of animal welfare (Gonyou, 1994; Millman et al., 2004). A major advantage of using behavior as an indicator of welfare is that it can be measured non-invasively and without disturbing the animal. The Brambell Committee introduced the concept that animals had “behavioral urges” (now referred to as behavioral needs) shaped by their evolutionary history. Many animal welfare scientists believe that frustration of behavioral needs causes animals to suffer and their welfare to be compromised (Dawkins, 2003). Defining which behaviors are “needs” has been one of the major challenges for ethologists (and for the development of alternative practices and husbandry systems). Early studies focused on comparing the behavior of free-ranging (e.g., feral animals or the wild ancestors of domesticated animals) and confined animals, or of animals kept in different production systems (such as hens in cages versus pens versus on free range). Such studies are still of value in gathering general information about the range and variation in behavior of particular species. However, it is also clear that behavior, like physiology, is flexible and is a means by which animals adapt to environmental change. For example, pigs wallow in mud in hot weather to cool themselves. Pigs kept in environmentally controlled facilities where temperatures are maintained within a comfortable range do not need to perform this behavior, and would not do so even if an appropriate wallowing substrate were provided (Fraser, 1989). For this reason, changes in behavior or differences in behavior between free-ranging and confined animals per se do not necessarily indicate anything either positive or negative about the welfare of those animals (Mench and Mason, 1997).

Instead, the major approach that is now being taken to understand the relationships between behavior and welfare is to try to determine how particular behaviors develop, what their function is for the animal, and what causes them to occur (in other words, what motivates them). Behaviors can be important for animals to perform because they have important functional consequences (e.g., they result in cleaner plumage or improvements in physical condition [Mench, 1998]). They can also be important if they are strongly motivated even in the absence of the resources (e.g., space, bedding) necessary to perform the behavior. For example, just prior to farrowing, sows become restless and initiate nest-building behavior even when nesting material is absent. Preventing nest-building behavior is thought to compromise animal welfare (Jensen and Toates, 1993) and has been reported to cause increased heart rates and an increase in abnormal behavior (Damm et al., 2003). Coupling behavior with physiological measures like this is one method for assessing the importance of behaviors.

Another is assessing motivation via preference testing. "Simple" preference testing, where animals are asked to express a preference for certain features such as flooring type or enclosure size, can provide important information about what animals want, but has been criticized on multiple grounds, including that it does not provide information about how important the preference actually is to the animal (Fraser and Matthews, 1997). Dawkins (1990) suggested a modification to preference tests involving an operant component, where the animal has to work (for example by pecking or pressing a key or pushing through a weighted door) to obtain or avoid something. In economic terms, the amount of work that the animal is willing to perform is considered to reflect the "cost" the animal is willing to pay for that resource, and hence the strength of the animal's motivation. Measures of preference have both strengths and limitations (Fraser and Matthews, 1997). The major strength is that well-designed tests can provide useful information about resources that are valuable to animals. An important limitation is that these tests are time-consuming and complex, meaning that only small numbers of animals can be tested, that it is almost impossible to provide the animal with the wide array of competing choices (as well as influences from social companions) that it would have in the "real" world, and that it is very difficult to determine if the animal is making a long-term rather than just a short-term choice. In addition, as with humans, the satisfaction of wants or needs can sometimes result in decreases in other aspects of welfare (e.g., health). However, measures of preference can effectively complement other approaches to the assessment of welfare (Fraser and Matthews, 1997; Dawkins, 2006; Kirkden and Pajor, 2006).

Another focus has been on determining particular behaviors that are indicative of emotional states such as pain, fear, or distress. Vocalizations, for example, have been found to be useful indicators of the pain associated with castration of piglets (Weary et al., 2006), and of distress associated with behavioral restriction in laying hens (Zimmerman and van Hoof, 2000). A significant amount of research has also been conducted on behavioral responses of animals to situations presumed to cause fear (Jones, 1997; Forkman et al., 2007). Much remains to be done, however, to understand and fully validate these types of measures. As Dawkins (1998, 2006) points out, assessment of the mental states of animals involves asking questions about the nature of animal consciousness that are impossible to answer given our current state of knowledge.

Another important research area is the study of the causes of and methods for preventing abnormal behaviors like stereotypy (repetitive behaviors like pacing or bar biting) or injurious behaviors (cannibalism, tail biting). The occurrence of such behaviors in seemingly healthy animals is a cause for concern. Behaviors that cause injury have obvious negative consequences for animal health and welfare. The link between the performance of stereotypies and welfare is more complex, however (Mason and Rushen, 2007). Although stereotypies often arise in poor-quality environments, it is also true that they can sometimes have beneficial consequences for the animal. Mason and Latham (2004) analyzed data from more than 200 published studies of various species of animals and found that high-stereotyping individuals often had better welfare (as assessed by physiological changes, fear responses, or other common measures of welfare) than did low- or non-stereotyping individuals. Furthermore, some stereotypies may become habit-like, or arise from autistic-like changes in the control of behavior, and may thus be unreliable indicators of the animal's current welfare (Mason and Latham, 2004). Therefore, although an animal that performs stereotypies could indeed be suffering, additional research is required before stereotypies can be considered reliable indicators of animal welfare.

There is widespread agreement that each type of measure of welfare has both strengths and limitations, and that multiple measures should therefore be used to assess welfare. However, the challenge of this approach is one

of integration. There is no clear empirical or logically correct method to weight different measures into a single index. Fraser (1995) suggested that animal welfare should be treated as an evaluative concept. Evaluative concepts organize empirical information within a value-based framework. Various attributes can be objectively measured, but their integration and interpretation is value-based. This approach will lead to disagreements, but these are disagreements about values rather than scientific theories. The implications of this approach are substantial, as it implies an inevitable limit to how science can be used to compare and evaluate the welfare of animals in different complex systems.

One more dimension that is also critical in discussions of both human and animal welfare is that measures of welfare may be applied either to individuals or to populations of individuals. Thinking at the population level (i.e., herds groups, breeds, or species) is necessary for characterizing many key elements of welfare. Mortality, for example, becomes a more meaningful measure of welfare when statistics for herds or groups housed in given settings are compared to species averages. But one should also recognize that overall herd health and welfare can be promoted through the sacrifice of ailing individuals. As such, there is one more unavoidable problem in operationalizing measurements of welfare as a norm for husbandry: one must decide how to deal with trade-offs between the welfare of a single animal, on the one hand, and the total benefit–harm ratio of welfare for an entire population, on the other.

Poultry production was already a significant commercial enterprise by 1910 (Smith and Daniel, 1982). Until the 1940s, however, poultry were still largely kept in relatively small backyard flocks, primarily for egg production. Poultry meat was a by-product, available when the unwanted cockerels were killed or when the hens were culled because of seasonal declines in egg production.

The development of the modern poultry industry was highly dependent upon scientific and technical advances (Appleby et al., 2004). Key developments in the late 19th and first half of the 20th centuries were the invention of the artificial incubator, improved understanding of poultry nutritional requirements, and the discovery of methods for synthesizing critical dietary ingredients that allowed formulation of a nutritionally adequate diet without the need for the birds to forage on pasture. A particularly important discovery was that vitamin D3 could be added to the diet so that the birds no longer needed to be exposed to sunlight to synthesize it. This enabled production to be moved indoors and allowed closer control over environmental conditions, particularly lighting. The ability to control lighting had a major impact on the burgeoning egg industry since egg production could be stimulated according to a desired schedule to ensure year-round production. Discoveries that led to the ability to automate feed delivery, watering, environmental control, egg collection, and egg and meat processing were also necessary elements for the intensification of production, as were improvements in the ability to diagnose, treat, and prevent poultry diseases.

Genetic selection also made a major contribution to the economic success and development of modern commercial production. In the late 1940s, the "Chicken of Tomorrow Contest" was launched in response to market demand for a meatier chicken for retail sales (Sunde, 2003). The resulting selection pressure by the breeders led to the development of special-purpose meat breeds of chickens (broiler chickens), which differ dramatically in their physical characteristics from the lighter-bodied laying strains. Modern broiler and egg laying lines have been intensely selected for economically important traits such as rapid growth and high rate of lay (Appleby et al., 2004). The breeding of poultry is now itself a large global industry, with only a handful of companies worldwide maintaining the foundation and grandparent stocks. These companies develop and implement the selection programs for producing desirable phenotypes, and then supply the progeny to poultry companies to be reared as parent stock for the production of broilers, turkeys, and laying hens.

Unlike large animal production, where the numbers of animals raised each year have stayed relatively constant since the 1940s (Price, 2003; Plain, 2006), there has been an explosion in poultry production (Fraser et al., 2001). From the point of view of animal health and well-being, the process of intensification for poultry is one which can generally be considered to have de-emphasized behavioral freedom for the birds. To some extent, this was intentional. For example, hens kept on range are prone to lay their eggs in inaccessible locations, making those eggs difficult or impossible to collect. Eggs laid on the range may also be soiled, posing potential food safety problems. By and large, however, the decrease in behavioral freedom came about because of an increasing focus on minimizing environmental extremes (especially thermal extremes), providing protection from predators, improving nutrition, and facilitating the prevention and treatment of disease. Along the way, new problems arose, which were addressed partially through the development of new technologies but also partially by further intensifying confinement rearing practices.

The extent to which the mortality and morbidity of birds kept in small backyard flocks were affected by the factors described above was undoubtedly influenced by regional variation (e.g.,, climate and predator populations), as well as the skill and knowledge of the individual producer. As the market for poultry products grew in the 1920s, prompting an increase in the size and density of the flocks kept by producers, there was an associated marked increase in a variety of poultry diseases, and consequently an increase in flock mortality rates (Hewson, 1986; Smith and Daniel, 1982). Poultry health programs were established that involved testing followed by culling of affected birds, as well as the selection of disease-resistant lines. Further decreases in these problems were achieved when antibiotics were discovered in the 1950s. Lastly, to deal with the problem of coccidiosis, a soilborne parasite that causes considerable morbidity in flocks, laying hens were moved into cages so that they no longer had contact with feces and soil. Vaccines for other diseases were developed and made available on a commercial scale by the 1970s (Biggs, 1990). These developments, combined with the factors described above, made confinement rearing of poultry on a large scale possible.

There are currently three basic types of commercial poultry production systems in use in the United States—cages, floor housing systems, and range systems (Appleby et al., 2004). Cages are the primary type of housing used for adult egg-laying hens, although the birds may be housed either in cages or on the floor during rearing. Meat-type birds (broilers, turkeys, and ducks) are typically housed on the floor in large buildings that have litter, slats/wire, or a combination of litter and slats/wire as flooring. Attempts to rear meat-type birds in cages have been largely unsuccessful because the birds develop carcass defects (like breast blisters) that lead to carcass downgrades. Floor systems are used for a small (but increasing) percentage of adult laying hens, and also for breeding flocks (all breeding poultry are kept in mixed-sex flocks and are naturally bred except for turkeys, which must be bred using artificial insemination because the males have such large breasts that they can no longer make close enough contact with the females to mate naturally). Range rearing of poultry is now much less common commercially than cage or floor rearing, but floor-housed birds may be given access to an enclosed outdoor area (like a porch) or range (in Certified Organic production, for example) for at least part of the day.

The dairy industry is incredibly diverse, but, in general, dairies have transformed from being small pasture-based systems to indoor systems using tie stalls or free stalls, with or without outdoor access. Although small herds still outnumber large herds, milk production is dominated by large operations. In 2002, operations with 500 head or more, which represent only 3% of all dairy farms, produced over 40% of the milk (Blayney and Normile, 2004). Milk production per cow has also increased dramatically, from approximately 5,000 lbs (2,268 kg) per cow in 1950 to almost 19,000 lbs (8,618 kg) per cow now. This increase was achieved through numerous technological and scientific developments. One of the most important was the development of artificial insemination techniques, which facilitated genetic selection for production characteristics. Another major change was an increased understanding of nutritional requirements at the various stages of production (Drackley et al., 2006; Eastridge, 2006). Other developments include improvements in health care and management practices to minimize environmental stressors (Collier et al., 2006).

The main challenges to dairy cattle health and welfare deal with the lack of access of the animals to pasture and high priority given to milk yield in selection programs over other traits. Cows selected for high production efficiency show undesirable correlated effects (Rauw et al., 1998). Numerous studies show that high levels of milk yield are associated with increased health and reproductive problems and higher rates of culling (Kelm et al., 2000). Additional details on the impact of this issue can be found in Ingvartsen et al. (2003) and Rauw et al. (1998). High milk yield has been identified as a risk factor for numerous health problems, including digestive problems, lameness, skin and skeletal problems, retained placentas, udder edema, and mastitis (Fleischer et al., 2001; Fourichon et al., 2001). Laminitis resulting in lameness, the most common welfare concern on high-producing farms, has also been linked to selection for increased milk production (Greenough and Weaver, 1997). This link is controversial, however, as some papers have reported conflicting results (Rajala-Schultz et al., 1999; Ingvarsten et al., 2003).

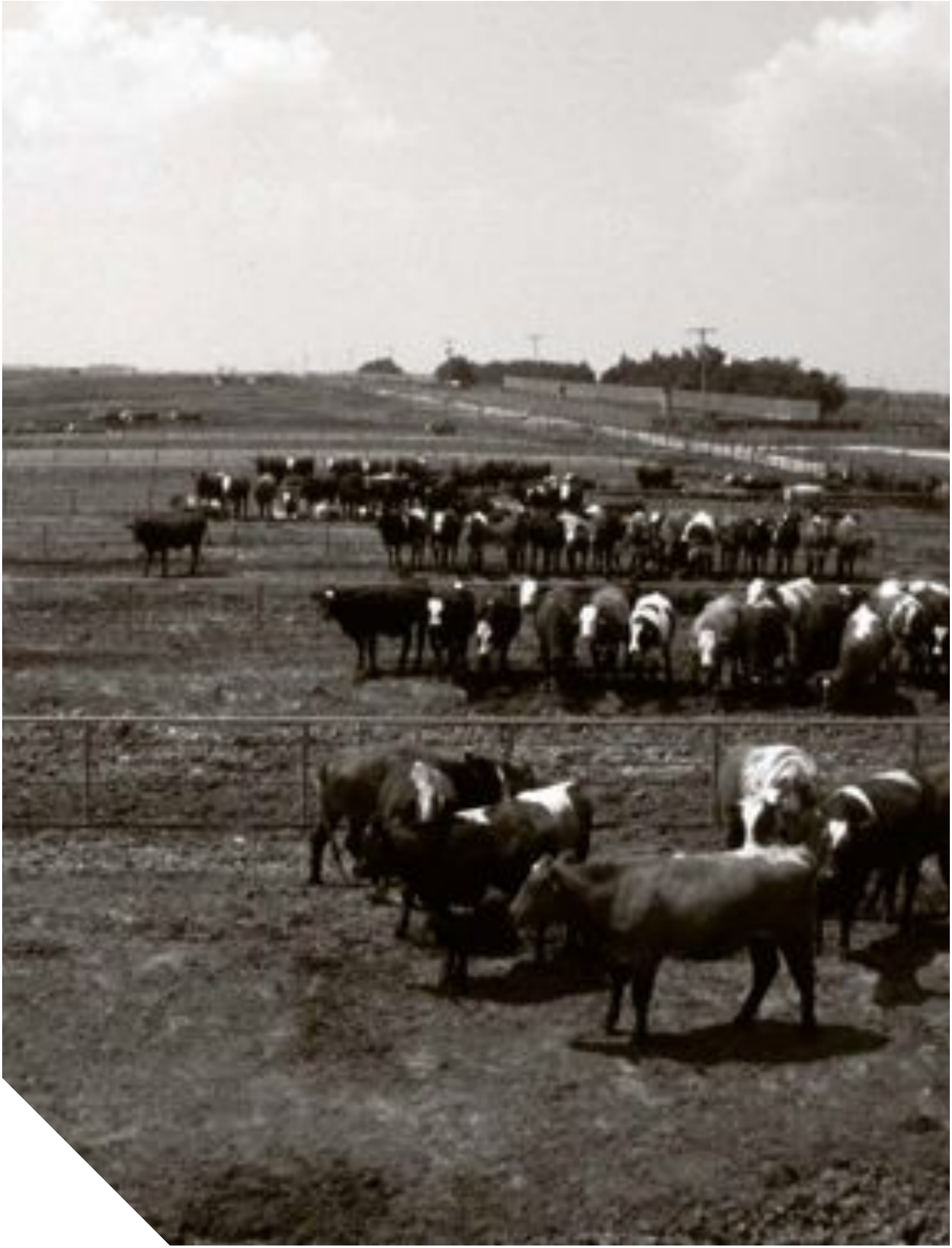
As fewer and fewer cows are given access to pasture (less than 25% of lactating cows and 50% of dry cows; USDA, 2002) and are instead housed indoors or on drylots, it is becoming apparent that there are animal health and welfare issues associated with moving away from pasture-based systems. This move occurred for a variety of reasons. Historically, cows often spent time inside during the winter months. As farms became electrified, milking parlors were developed, and inexpensive standard nutritional diets superior to poor pasture became available, economics and ease of management led to increased time off pasture. Lactating cows without access to pasture have a higher incidence of mastitis, metritis, dystocia, ketosis, and other health concerns (Washburn et al., 2002). Lack of access to pasture during winter is a risk factor for the occurrence of digital dermatitis and other hoof problems (Somers et al., 2003), although some studies report an increased risk of hoof problems when cows do have access to pasture (Holhzauer et al., 2006). Other studies have reported positive welfare effects if animals are provided with pasture access and exercise. For example, Hernandez-Mendo et al. (2007) demonstrated an improvement in gait score and specific gait score improvements as a result of cows being on pasture.

Although moving cows inside has a number of animal welfare issues associated with it, cows on pasture are not free of welfare problems. Cows kept on pasture have a higher parasite load and may experience inadequate energy intake and have to compete for food if pasture quality is limited or stocking rates are too high (see Hemsworth et al., 1995; Petherick, 2005). These challenges must then be addressed through additional husbandry and management practices.

In the last century, the swine industry has changed from a pasture-based system, with 1–2 farrowings per sow per year and limited commercial prospects, to a large-scale confinement operation which produces pigs year-round for domestic and international markets. Although smaller herds still dominate the industry in terms of number of farms, farms that have more than 5,000 sows produced 82% of the pig crop in 2003 (NASS, 2006).

Increased specialization in both building design and labor started in the 1950s and 60s with a shift towards raising animals in confinement. More recent changes involve the development of animal management/flow systems (so-called all-in, all-out systems) that are designed in an attempt to improve herd health by minimizing exposure to microorganisms. Each of these systems requires additional specialized facilities and labor. There have also been changes in nutrition and feeding systems that have improved animal health and survivability. Significant advances have included the discovery of the role of vitamin B12, the judicious use of antibiotics, and the supplementation of amino acids. Diets are now highly specialized for each stage of production.

The development of artificial insemination (AI) technology has facilitated selection for growth rates and other economically desirable meat characteristics, such as leanness. Use of AI technology is increasing on farms, with large farms using it more than medium-sized or small farms. Pen mating still occurs but mostly on small farms. Over-selection for high production efficiency or for specific production traits can have undesirable side effects (Grandin and Deesing, 1998; Rauw et al., 1998). For example, selection of lean lines of pigs has been associated with mulberry heart disease, porcine stress syndrome, and osteochondrosis, as well as increased excitability, anxiety, and aggression (Grandin, 1994; Shea-Moore 1998; Busse and Shea Moore, 1999; Pajor et al., 2000a). This increased level of fear and anxiety results in more handling problems for producers and



processors (Grandin, 1994; Rauw et al., 1998; Pajor et al., 2000a). High lean swine also have more leg problems due to their decreased leg strength (Sather, 1987).

The main challenges to swine welfare in today's industry are directly related to the industrialization of animal husbandry and the economic demands associated with producing pork at the lowest cost possible for consumers. The result for most animals is a barren environment where productivity is excellent and costs are low, but behaviors are restricted. Other welfare issues in the swine industry are also discussed in more detail below.

Although beef cattle are still raised extensively in relatively small herds, most are now finished in feedlots rather than on range as they once were. Beef cattle are now typically born on a ranch on pasture, where they stay for the first six months of life. They are then weaned, kept on pasture, and prepared for the feed yard. On average, the beef animal gains half of its market weight on pasture and half on a high grain and chopped forage ration.

In the early history of feedlot development, farmers and ranchers fed cattle grain residuals left over from the harvest. As grain surpluses grew and the number of grain-fed cattle increased, feedlots expanded and moved to lower moisture regions of the United States. Problems with mud in dirt lots in higher rainfall areas, the centralization of grain production, and the need for shorter transport of feed products to feedlots pushed the industry into the High Plains areas where rainfall is typically less than 20 inches per year.

Cattle in feedlots are kept in large dirt pens. Between 10,000 and 100,000 cattle are typically housed in a feedlot. Each pen has a long concrete feed bunk running the entire length of one side of the pen. The other side of the pen borders a drive alley used for moving cattle in and out of the pen. Each pen contains watering facilities. Pens are fully exposed to the outdoors, except in a small number of feedlots located in high rainfall areas. In areas with high moisture conditions, fed cattle are typically housed in roofed facilities. Large feedlots manufacture their own feed and formulate diets for each phase of cattle growth.

The major welfare issues associated with feedlots are related to environmental conditions (mud and thermal stress) and handling. These, along with other feedlot welfare issues, are discussed in more detail below.
A developing concern is the increasing use of corn for ethanol production. Thirty-six percent of cattle feeding operations surveyed are now feeding co-products of ethanol production, and 34% are considering the option (nass, 2007). The feed product fed to cattle from ethanol production cannot be transported economically from the Midwest (where most corn is produced) to the High Plains. This means that feedlots might move back to the Midwest or eastern parts of the United States, and thus need to change to more intensive practices, such as raising the cattle on slatted or concrete floors indoors or under roofed facilities to protect them from more severe weather.

Since the publication of the Brambell Report, a large number of concerns have been raised about how housing, management, and slaughter practices affect the welfare of agricultural animals. While some of these concerns (e.g., air quality) are specific to confinement operations, others also apply to more extensive systems, as previously mentioned. In fact, some problems are more prevalent in so-called "alternative" or "welfare-friendly" systems. The following are brief summaries of these areas of concern, illustrated by examples.

Behavioral restriction is probably the most contentious farm animal welfare issue. The behavior of agricultural animals can be restricted either because they are crowded or because the physical or social resources necessary for the performance of particular behaviors are inadequate or absent (e.g., space, no rooting or dustbathing material, lack of particular social partners). Behavioral restriction can cause physical problems (e.g., sores, muscle wasting), and is also implicated as a major cause of the development of abnormal behaviors (see Section V-D). Some abnormal behaviors (for example, feather pecking, cannibalism, tail biting) can result in the injury or death of other animals in the herd or flock and so also have economic consequences.

The three environments considered to be most behaviorally restrictive are conventional cages for laying hens, gestation stalls for sows, and tie stalls for dairy cows. Hens kept in cages at appropriate stocking densities (e.g.,, the UEP standard, see Section IX-C) can stand, turn, lie down, and perform basic grooming behaviors, but cannot fully raise their wings or locomote freely. Conventional cages also do not contain nestboxes, perches, or litter material for performing dustbathing behavior, considered by many to be important elements of the behavioral repertoire of hens (Appleby et al., 2004). For these reasons, these cages will be phased out in the European Union in 2012, to be replaced either by noncage systems or so-called "furnished" cages, which contain a nestbox, perch, and a dustbath.

Traditional gestation stalls are also restrictive, providing sows only enough room to stand up and lie down. Although individual housing has some management and welfare benefits for sows as compared to group housing, including reduced aggression, fewer injuries (Anil et al., 2002; Gjein and Larssen, 1995), decreased competition, improved control of feed intake, and ease of observing and treating individual animals (Rhodes et al., 2005), the picture is far from clear. Despite these potential advantages, the Rhodes et al. (2005) report notes that "except for injuries, individual sow and herd health are primarily affected by factors other than housing system" and that the production performance of animals in either a stall or group system is equivalent. Sow stalls also have disadvantages such as the lack of space and movement, the inability for sows to avoid aggressive neighbors and settle dominance relationships, and sows being stepped or laid upon by sows in adjacent stalls (Rhodes et al., 2005). Group housing systems also have animal welfare advantages in that sows in groups have freedom of movement and social interaction. In addition, housing sows in groups improves muscle mass and bone strength and decreases joint problems that can develop due to the lack of movement (Marchant and Broom, 1996). Because of these advantages, many animal welfare experts consider group housing to be superior to tethers, individual stalls, and individual stalls with additional space (Bracke et al., 1999). It has recently been commented that stalls need to be bigger simply to accommodate the range of sizes of sows currently in commercial operations (McGlone et al., 2004; Salak-Johnson et al., 2007).

It is important to note that the welfare advantages in stall systems are the result of *individual* housing, and that many of the welfare disadvantages are the result of the limited space. In contrast, the welfare advantages of group housing are related to increased space, while the disadvantages are related to social interactions. Thus, attempts to compare individual stalls with group housing are of limited benefit. In fact, direct scientific comparisons of the animal welfare advantages and disadvantages of each system are not possible. However, the recommended characteristics of sow housing systems described in Rhodes et al. (2005) are a reasonable starting point.

Movement, nest building, and maternal behaviors of sows are also restricted in farrowing crates. Increasing the amount of space for the sow does result in more natural behavior but may increase the risk of death to piglets in the first 48 hours (Edwards and Fraser, 1997; Marchant et al., 2000). Therefore, farrowing crates provide a welfare advantage, at least to the piglets. There are numerous housing options (stall and nonstall) in use for farrowing, including turn-around stalls, hinged stalls, sloped stalls, communal pens, Swedish multisuckling systems, and outdoor arcs (Edwards and Fraser, 1997; Johnson and Marchant-Forde, in press).

Tie stalls for dairy cattle also severely limit movement and social interactions. Tethered cattle cannot turn around, may not be able to groom themselves adequately, have limited opportunities for contact with other animals,

and are unable to escape from a dominant neighbor. Cows in tie stalls may also have difficulty in rising and lying down normally (Krohn and Munksguaard, 1993), although this may be due to design features of the stall such as flooring (Herlin, 1997), not just to tethering.

Behavioral restriction can also involve the restriction of normal social behavior, as occurs in the case of individually housed animals like sows housed in gestation stalls. Another example is early-weaned animals like dairy calves and piglets (Weary et al., 2008). There appears to be considerable stress associated with the abrupt separation of piglets from the sow 2–4 weeks after birth (Robert et al., 1999; Worobec et al., 1999). At this time, the piglets are also generally moved to new environments, provided with a diet of solid food and water, and may be mixed with piglets from other litters. Piglets often become ill and experience a decrease in growth rate or an actual weight loss in the days immediately after separation (Pajor et al., 1991). They also appear to be restless and agitated, vocalize, and may develop abnormal behaviors such as 'belly nosing' (Weary and Fraser, 1995). In some instances, the separation of young from the mother at an early age can provide beneficial health effects such as the prevention of Johne's disease in cattle (Groenendaal, 2003).

Restriction of behavior is not the only behavioral problem for farm animals. Problems can also arise in systems where animals are provided with sufficient space and resources, but where group sizes are large. The extremely large group sizes typical of noncage systems for hens are a major contributing factor to injury due to cannibalism (Appleby et al., 2004).

Many interactions between people and farm animals are negatively reinforcing events involving restraint, movement, or veterinary visits. Consequently, the main reaction that farm animals often have to people is fear. Excessive fear of humans can have negative effects on both the welfare and performance (e.g., growth, milk yield) of farm animals (Breuer et al., 2000; Rushen et al., 1999; Hemsworth and Coleman, 1998).

Human-animal interactions occur frequently in dairy production, particularly at milking. Aversive handling not only impacts milk production but can result in injuries to people and cows, and has been associated with an increase in the occurrence of lameness (Chesterton, 1989). Therefore, identifying management practices that can lead to aversive handling or cause fear in animals is essential to improving dairy cattle welfare (Pajor et al., 2000b). Increased gentle handling of younger cattle can decrease fear response to humans (Boivin et al., 1992a,b). Feedlot cattle typically experience handling when they are loaded and transported to the feedlot or from the feedlot to the processing plant, moved through a chute for vaccination, weighing, and other procedures, and sorted and allocated or reallocated to feeding pens. They are also handled periodically during the feeding period (for example, for the purpose of providing veterinary care). Feedlots contain handling facilities for loading and unloading trucks and for vaccinating and veterinary treatment of cattle. Proper layout and design of such facilities is an important factor in promoting gentle and efficient handling of cattle (Grandin, 2007; Grandin, 1998; Grandin, 1997). Problems in handling feedlot cattle can result in the excessive use of electric prods causing injury (Grandin, 1981). Poor handling can also cause increased bruising of carcasses (McKenna et al., 2002; Boleman et al., 1998).

In contrast to livestock production, there is little direct human-animal interaction in poultry production, at least until the birds are caught or herded for transport to the processing plant. Hatchery processing is almost completely automated, although the hatchlings may be handled briefly for vaccination and beak trimming (the birds may also be handled briefly within the first few weeks of age if a later trim is required). Human interaction after that point primarily consists of workers coming through the house several times per day to cull sick birds and remove dead birds, although birds may be caught and moved to a different house for some types of production (e.g., from the pullet house to the laying hen house), and samples of birds may be periodically caught to be weighed (although that can now also be automated for meat bird production by installing scales that the birds perch upon).

Numerous factors, including the stockperson's attitudes, animal learning, and genetic selection, need to be considered when addressing the welfare concerns associated with human-animal interactions. One of the key factors in determining how animals are treated is the attitude of the stockpersons (Grandin, 2000). Training programs can be very effective in improving the skills and attitudes of handlers and thus in decreasing animals' fear responses (Coleman et al., 2000).

Disease and other health problems are important welfare issues in all animal production operations. In concentrated operations, infectious diseases can spread more rapidly from animal to animal because of the high animal densities, and this rapid spread also allows infectious organisms to mutate more quickly into highly pathogenic strains. On the other hand, confined operations facilitate disease monitoring and maintenance of good biosecurity to prevent the entrance of pathogens into the herd or flock.

Morbidity and mortality can result from a variety of causes. In feedlots, there is an estimated mortality of 1-2% (USDA, 2000). The main disease issues are respiratory diseases and digestive disorders (Snowder, 2006; Lonergan et al., 2001). Approximately 57% of mortality in feedlots has been reported to be due to respiratory disease (Lonergan et al., 2001). Liver abscesses are prevalent and are associated with the feeding of diets with high grain content (Nagaraja and Chengappa, 1998; Nagaranja and Lechtenberg, 2007). Another emerging issue is that calves are not being vaccinated by some producers. The segregation of the cow-calf sector from the feedlot industry has led to a situation where producers are no longer rewarded for vaccinating calves on the farm, although the consequence could be a higher risk of disease in feedlots.

Common causes of death in newborn piglets are chilling, starvation, enteritis, and crushing. Diarrhea is the most common disease in weaned pigs (Blackwell, 2004), and respiratory diseases and systemic airborne diseases are also serious problems in swine (Christensen et al., 1999). In dairy cows, the most frequent health issues are clinical mastitis, lameness, and infertility problems (usda, 2007). Poultry are susceptible to a variety of parasites, infections, and metabolic diseases, with the primary causes of mortality varying by production system, species, and genetic stock.

One growing problem is the presence of health problems due to selection for increased production, so-called production diseases (Garry, 2004). An example in addition to the problems already discussed is osteoporosis in laying hens due to the high calcium demand associated with egg shell production to support high rates of lay. Calcium supplementation of the feed is insufficient to overcome this problem, and many hens show evidence of old healed bone breaks, or sustain bone breaks during depopulation and transport, as a result of their osteoporosis (Whitehead, 2004).

Management can also influence the incidence and severity of production diseases. One example is the use of recombinant bovine somatotropin (rbst) to increase the milk yield of dairy cows. Approximately 22% of US dairy cattle were reported to have been injected with rbst (nahms, 2002). Clinical mastitis has been reported in some studies to be longer lasting and to have a higher incidence when rbst is used (Hansen et al., 1994; Dohoo et al., 2003), although a number of other studies found no differences between rbst-treated and nontreated cows (Bijman, 1996; Bauman et al., 1999). Similarly, increases in somatic cell counts in cows treated with rbst have (Peel et al., 1988; McClary et al., 1994) and have not (Masoero et al., 1998) been found. Concern about these problems led the eu and Canada to prevent the use of rbst in cattle (scahaw, 1999). In the United States, the use of rbst was instead combined with management improvement programs, such as a comprehensive mastitis control program. Although there is an increased risk of animal welfare problems when rbst is used, many US dairy scientists believe that this risk can be minimized with appropriate management (Garry, 2004).

One important health-related issue is on-farm euthanasia of sick or injured animals, particularly during disease outbreaks when large numbers of animals have to be killed. Methods of on-farm euthanasia are a serious concern related to human-animal interactions in terms of the development and use of appropriate methods and the training of workers to use those methods to ensure timely and humane euthanasia. Guidelines for on-farm euthanasia have been produced for swine (npb/aasv, undated), cattle (aabp, undated), and laying hens (uep, 2007). For poultry, there are humane issues related to all currently used methods for on-farm euthanasia (carbon dioxide, blunt force trauma, cervical dislocation), and this is an area where research into alternatives is badly needed. The poultry captive bolt developed in the United Kingdom is humane and effective, but difficult to use, aesthetically unpleasant, and carries biosecurity risks. usda has recently approved the use of firefighting foam for large scale depopulation of some poultry during disease outbreaks or disasters that make it unsafe for humans to use other methods. Foam is a fast and effective method that minimizes risks to humans, but the mechanism of action (airway blockage leading to suffocation) is not optimal from a humane point of view. For swine, various options for euthanasia are recommended. These include penetrating captive bolts, gunshot (this method is typically also used for mass depopulation of cattle during disease outbreaks), blunt force trauma, electrocution, and drug overdose. Controlled drugs can only be used under the supervision of licensed veterinarians. Carbon dioxide is likely more effective for piglets than for older swine (avma, 2007). Recently, Meyer and Morrow (2005) developed a technique for using carbon dioxide for commercial swine units. The development of criteria for timely euthanasia across all species is required to decrease animal suffering.

The most serious air quality problem in confinement housing for poultry and swine is probably ammonia. Air quality can even be an issue in congested dairy tie stall barns. The osha and niosh standards for human exposure to ammonia are 50 and 25 parts per million twa (time weighted average over 8 hours), respectively. While there are no scientifically established maximum ammonia exposure standards for animals, studies have shown that high ammonia levels can have adverse health effects on animals (Holland et al., 2002; Hamilton et al., 1996; Kristensen and Wathes, 2000), and a maximum long-term exposure limit of 10–25 parts per million is generally recommended. During cold winter months when ventilation rates have to be decreased to maintain house temperatures, ammonia levels can greatly exceed this level in commercial facilities. The amount of ammonia reaching the lungs is related to the concentration of respirable dust in the building; for this reason, ammonia presents a greater problem in housing systems that are dusty due to the presence of bedding (e.g., floor housing systems for poultry). Ammonia amendments that can be added to the feed or litter are now available and can be extremely helpful in reducing ammonia levels (Liang et al., 2005; Do et al., 2005). Dust itself can also cause ocular and respiratory problems.

Thermal stress is a significant welfare problem in certain parts of the country. Many thousands of poultry die during summer heat waves, and it is not uncommon for sow mortality to double in some parts of the country during the summer due to heat stress (St. Pierre et al., 2003). Heat stress is also a significant problem for dairy and feedlot cattle (West, 2003; Mader et al., 2006; Cook et al., 2007), and is associated with increased mastitis and increased mortality. For poultry and swine, environmental temperatures are controlled primarily via ventilation. For cattle, there are a variety of methods that have been recommended for reducing heat stress, including shade, sprinklers, fans, and evaporative cooling systems (Collier et al., 2006).

The design of housing and handling facilities, of course, has an important effect on animal welfare (Curtis, 1983). Important design considerations include feeding and watering systems, ventilation, and flooring/substrate. Badly designed or maintained facilities can promote injury or disease. Good design (e.g., correct placement of feeders and waterers of appropriate type) is also important to minimize adverse effects due to social competition for resources among animals.

Flooring is an important element of animal housing. Maintaining good litter quality is critical to minimizing foot and leg problems like footpad and hock burns in floor-housed poultry (Berg, 2004). Inappropriate artificial flooring can cause animals to slip and contributes to problems with lameness in large animals (Cook et al., 2004). For dairy and beef cattle housed on dirt, mud is a major welfare issue. Cattle kept in muddy conditions have more health problems, and evidence an inability to rest, weight loss, cold stress (during cold weather), and hide damage (Mader, 2003). Excessive mud on cattle also presents problems at the processing plant and can harbor pathogens such as salmonella and *E. coli* (Elder et al., 2000; Smith et al., 2001).

Another important facility design issue relates to configuring stalls to allow animals to more easily engage in normal behaviors. For dairy cows, for example, important elements are size, width of stall, and position and shape of neck rails to allow natural lunging (Tucker et al., 2004; 2005). Cows prefer lying on well-bedded surfaces (Haley et al., 2001) and standing on soft floors (Tucker et al., 2006), design elements which need to be incorporated into newer stall designs to improve cow comfort. As a result of research carried out in Sweden, laying hen cages have undergone major design changes to facilitate easier movement of hens and to reduce problems with foot health, trapping, and injury (Tauson, 1985).

Farm animals may be deprived of food and water for management or production reasons. For example, the parent flocks of meat-type poultry are typically feed restricted, sometimes by as much as 65% (Mench, 2002). Gestating swine are also fed limited amounts of concentrated diet. In all of these cases, feed restriction is necessary to maintain the animal in good health, but its necessity is a direct consequence of the genetic selection of their progeny for high feed intake and rapid growth rate. The diet fed may meet the animal's energy and nutrient requirements but not satiate the animal, leading to the performance of abnormal behaviors (Mench, 2002; Appleby and Lawrence, 1987). Food-restricted poultry often over-consume water to compensate, leading to wet droppings and/or litter, so water may also be restricted.

Feeding methods may also impact hunger. For example, if group-housed sows are fed using a dump feeding system, competition between individuals may result in unequal feed intake and lower than recommended intakes for some sows, resulting in under-nutrition (Anderson and Bøe, 2001; Gonyou, 2005).

Until recently, it was common to feed-deprive laying hens for extended periods of time to induce a molt, but this practice has now been largely abandoned by the US egg industry (uep, 2007; feed withdrawal molting is not permitted on the uep Certified Program, which covers more than 80% of US laying hens) in favor of nonfeed-withdrawal molts as a result of research funded by the United Egg Producers to find effective alternative molt methods. Meat-type breeders (e.g., turkeys) may still be molted using these methods, however.

These involve practices where surgical procedures are performed on animals in order to improve meat quality, or to protect animals or their handlers from injury. These practices include castration, dehorning, and tail docking of cattle and swine; tooth resection of piglets; and toe trimming, removal of the combs and wattles, and beak or bill trimming of poultry. They cause acute, and sometimes chronic, pain, but are frequently peformed without anesthesia or analgesia because of practical limitations (e.g., time, lack of demonstrated efficacy of anesthetics or analgesics, absence of fda-approved drugs for use in the particular species), an attempt to minimize the handling of the animal, cost, or concerns about residues.

A great deal of research attention has been directed toward assessing the extent and duration of the pain caused by these procedures (e.g., see reviews in Weary et al., 2006; Rutherford, 2002; Stafford and Mellor, 2005; Bretschneider, 2005; Glatz, 2000; Hester and Shea-Moore, 2003). Considerable attention has also been directed towards finding alternatives to reduce the need for performing these procedures (e.g., see Prunier and Bonneau, 2006; Hester and Shea-Moore, 2003).

In some cases, these procedures appear to be unnecessary from the point of view of animal welfare, although they may have benefits to producers in terms of ease of handling or management. Tail docking of dairy cattle is one such example. Tail docking makes milking easier and is also believed by producers to decrease the risk of mastitis by keeping the cow's udders cleaner (Barnett et al., 1999). In fact, the scientific evidence indicates that tail docking has no benefits for udder cleanliness or cow health (Schreiner and Ruegg, 2002a,b; Stull et al., 2002).

In other cases, these practices are important for maintaining animal health and welfare. An example is beak or bill trimming of poultry, which was discussed at the beginning of this section, and which is still the only reliable method for preventing injury and mortality due to feather pecking and cannibalism in flocks of laying hens and ducks. Another similar example is tail docking of pigs (McGlone and Hicks, 1993) to prevent outbreaks of tail biting. There are a variety of both internal (genetics, gender, health status) and external (environment, rooting materials, indoor/outdoor climate, stocking density), risk factors for tail biting (Schroder-Petersen and Simonsen 2001). Stocking density, overcrowding, and lack of environmental enrichment are particularly crucial factors. Numerous studies indicate that the provision of straw or objects for chewing or rooting, such as feed dispensers or mushroom compost (Beattie et al., 2001; Van de Weerd et al., 2006) can help to decrease tail biting. Nevertheless, tail docking, although likely to be painful, has been identified as the most important factor in minimizing, although not preventing, outbreaks of tail biting (Hunter et al., 2001). A final example is the physical or chemical dehorning of cattle. Hornless cattle cause fewer injuries than horned animals (Meischke et al., 1974). Stafford and Mellor (2005) review a number of methods that can minimize the pain associated with dehorning. A potential alternative is to produce polled (genetically hornless) cattle. This approach appears to hold promise for the beef industry (Prayaga, 2007), but additional research is required to encourage the adoption of this technology by the dairy industry.

Another type of special agricultural practice is the use of painful methods for animal identification. Either hot-iron or freeze branding are commonly used to identify cattle. Although both are painful, freeze branding seems to be somewhat less painful (Lay et al., 1992; Schwartzkopf-Genswein et al., 1997). Ear notching is used as a means of identification and is more stressful to piglets than tagging (Marchant-Forde et al., 2006). Alternatives to ear notching are currently being developed and include visual ear tags (tags can be read by the human eye), electronic ear tags, and intraperitoneally injected transponders (Babot et al., 2006).

Transport imposes a variety of stressors, including human handling, loading or crating, possibly mixing with unfamiliar animals, and, during transit, noise, vibration, feed and water deprivation, and possibly thermal stress. These can result in injury and mortality.

In the United States, approximately 0.5% of broiler chickens die annually during the process of being transported to the processing plant (Wabeck, 2002); death losses are even higher for turkeys, which may be transported longer distances. Because of the scale of poultry production, these small percentages translate into a very large number of birds—approximately 40 million broilers. The primary causes of death during transit for broilers have been investigated (Weeks and Nicol, 2000). The major cause is thermal stress, with birds in the core of the truck where the heat load is highest dying of heat stress, and those on the outside of the truck dying of cold stress if they are transported during cold, windy conditions (Mitchell and Kettlewell, 1998). Climate-controlled vehicles have been developed in the United Kingdon for poultry transport, but these have not been widely adopted by the industry due to cost. Injury associated with catching and loading also probably plays a role in death losses. Poultry are typically hand-caught and loaded (the exception is Pekin ducks, which are herded), and this can be associated with significant rates of bruising and bone breakage. Automated broiler catching machines are available, and these can sometimes decrease these problems (Appleby et al., 2004), but the machines are difficult to maneuver in some houses and are reported to have frequent mechanical problems. This results in already-loaded birds remaining in their transport crates for excessive periods of time while machines are repaired, leading to bird fatigue and mortality.

Disposal of laying hens at the end of their production period (spent hens) represents a particularly difficult problem. Spent hen meat was primarily used as an ingredient in soup, but is no longer used for this purpose because meat from broiler chickens can be processed more efficiently and inexpensively. The major remaining purchaser of spent hen meat in the United States is the federal government, for school lunches, the military, and prisons (Gregory, undated). Spent hens, therefore, have little economic value, and there are few processing plants in the United States willing to take them—the last spent hen processing plant in California (which is the 5th-largest egg producing state), for example, closed down in 2006 (Young, 2006). Therefore, these hens may be transported, sometimes long distances, to secondary markets, such as live animal markets in large US cities or Canada. Many spent hens are now killed on the farm and are then disposed of by composting, rendering, or other means.

Although reviews of transportation stress are available for cattle (Knowles, 1999; Grandin, 2000), little information exists specifically for dairy cattle. Dairy cattle are transported for a variety of reasons. Dairy bulls (young and old), culled dairy cows, and veal calves are transported to slaughter; veal calves are also transported to veal operations and specialty heifer growers. There is also an increase in the transportation of dairy heifers and lactating cows as well as day-old calves (Eicher, 2001). It is clear that transportation is stressful for cattle and attention needs to be paid to stocking density, age at transport, mixing of animals, handling, duration of trip, and other factors. Additional research specifically on dairy cattle transportation is needed. Mortality attributed to transport for fed cattle is very low. Improper handling practices during loading and unloading present the greatest challenges and result in bruising and reduction of meat quality (Grandin, 2007; Swanson and Morrow-Tesch, 2001). Transportation of unfit animals is a serious animal welfare issue for cattle and other species.

An examination of the costs of changing specific animal husbandry practices is complex. It is not simply a question of asking, "How much more or less will it cost producers of laying hens to shift from cage to free-range production?" A full economic analysis requires an assessment of *all* impacts of changes to animal production practices. Changes in animal husbandry practices will be felt directly by the producers and the animals, and indirectly as externalities by all others linked to or affected by the animal production process.

Externalities are the positive or negative effects felt by parties external to, or not directly a part of, an activity. For example, if a person gets asthma from breathing air polluted by a local concentrated hog feeding operation (Radon et al., 2007), the person bears a cost ("negative externality") that is not paid by the hog producer. The existence of externalities makes it difficult to estimate the full economic impact of changes in husbandry practices because it is not clear what impacts are important for animal welfare and how those impacts can be translated into measurable costs and benefits. Importantly, even experts are not always in agreement as to how to define animal welfare and how welfare considerations should be weighted (e.g., Bracke et al., 1999).

For example, consider a hypothetical shift from a confined to a free-range animal production system. In a well-designed system, some aspects of animal welfare, such as the opportunity for the animal to perform natural behaviors, would improve. However, other aspects of welfare, such as health and safety, could be negatively affected because the producer will have less control over predation, thermal and environmental conditions, and the spread of disease. Environmental impact must thus be taken into consideration when estimating the costs of changing animal husbandry practices since waste disposal may be easier when animals are raised in confinement operations, whereas some outdoor animal production systems may result in an increased risk of excess nitrogen and phosphorus building up in the soil and entering rivers, streams, and underground freshwater reservoirs.

Moreover, if changing animal welfare practices increases costs to producers, a proportion of the cost increases will be passed to consumers through higher prices. Different production practices have different energy requirements, necessitating an examination of comparative energy usage. The number of workers and the skill sets needed to operate and manage animal feeding operations will differ depending on the type of system used. For instance, open forage or free-range systems are generally more labor intensive than confined animal feeding operations (Bell, 2005). Impacts on worker health and safety will also need to be examined. Furthermore, a consideration of labor availability in agriculture may force the consideration of questions regarding the use of undocumented workers. If costs increase for producers, then processors and consumers may have incentives to locate lower-cost substitutes for domestically produced animal food products. Thus, imports of meat products may rise, particularly from countries that do not promote best management practices. The rise in imports may result in an increase in animal agriculture in exporting countries. If this is the case, then efforts to improve animal welfare in the United States may result in more animals living in poorer conditions elsewhere.

In addition to externalities (both negative and positive), there may be constraints that make transition to desired husbandry practices difficult or even prohibitive. One example is that a shift to alternative production practices may be constrained by the availability of qualified workers. Another is the fact that animal agriculture might be characterized by strong complementarities in factors of production, meaning that changes in one aspect of production (e.g., moving from a confined to a free-range production process) must be coordinated with all complementary elements of the system, a fact that is true for most industries (James et al., 2007).

Importantly, we know little about which animal production systems may be characterized by complementarities and how strong the interdependencies are, although researchers are beginning to identify some production factors that appear to be complementary. For example, consider the case of labor availability. If changed animal husbandry practices require labor involving a particular skill set, then this change must also be coordinated with the hiring of sufficient numbers of appropriately skilled workers. Consider another example: Hogs raised in large-scale concentrated animal feeding operations are genetically bred to be leaner than hogs raised in open forage systems. Leanness is a meat characteristic that is highly desired by consumers and promoted by the pork industry. However, there is an increase in disease sensitivity to both pathogenic and nonpathogenic organisms in certain lean genotypes (Leininger et al., 2000). Therefore, lean hogs may be more susceptible to diseases and infections when raised outdoors (Rich, 2008). There is very little research on the extent to which animal agriculture is characterized by complementarities (James et al., 2007), making it difficult to determine what factors need to be changed, and to what extent, when considering variations in animal husbandry practices.

Scale is also a complementary consideration. It is estimated that to reach the "break point" for economic efficiency on a commercial broiler farm in the United States, a company must now process 65 million birds per year (Aho, 2002). Mechanization drives further increases in concentrated production to improve economic efficiency.

There are few studies in the United States that examine the comparative effects (on costs, productivity, or profitability) of changing animal husbandry practices in an effort to improve animal welfare. Most evidence on comparative economic effects of changing livestock husbandry practices comes from research conducted in Europe rather than in the United States. One must exercise caution when attempting to translate findings generated in Europe to the United States, in part because European agriculture and its regulatory apparatus are considerably different than that in the United States. Finally, studies utilize different methods and procedures, usually consisting of computer models, surveys of experts, or experiments comparing different production practices. Results from experiments in which different production practices are actually implemented are the most informative, but they cannot necessarily be compared with results produced from computer models and surveys, which require experts to "estimate" or assume what effects might result from changing specific husbandry practices.

Overall, research suggests that costs to producers will generally rise, with the cost increases being small to moderate. In some cases, changing animal husbandry practices results in increased productivity, such as improved feed efficiency or decreased injury (Lyons et al., 1995; Wolter et al., 2000; Gonyou and Stricklin, 1998). These improvements in productivity may not be strong enough to fully mitigate cost increases in improving animal welfare, however. Therefore, producers will have incentives to adopt alternative animal husbandry practices and systems only if consumer demand for such products is high enough to result in price increases that offset the higher costs of production.

Most research on cost, productivity, and profitability impacts of different poultry production systems focuses on space allowance and alternative housing systems. In general, increasing the space allotted to a broiler or laying hen results in higher production costs, the majority of which come from higher up-front capital costs, although labor and land costs must also be considered.

For broilers, data from the eu suggest that reducing stocking density by about 20% would increase costs by about 5%, while reducing stocking density by about 35% would increase costs by about 15% (Moynagh, 2000). These costs would be fully borne by the producers since increased space allowances for broilers are not associated with improvements in health or productivity as long as the buildings in which the birds are housed are sufficiently well-ventilated (Dawkins et al., 2004).

For laying hens, data from Elson's 1985 study of production in the United Kingdom (Table 2) suggested that increasing the space allowance in cages by nearly two-thirds, from 450cm^2 to 740cm^2 (the eu required 550cm^2 in 2003), would increase costs by about 15%, while housing layers in a deep litter system would increase costs by 18%. More recently, Van Horne and Bondt (2003) published a large-scale analysis of eu-wide costs based on 2001–2003 flock data, and concluded that egg production costs in aviaries were 21% more than in conventional cages stocked at a 450cm^2 per-hen space allowance; costs in "furnished" cages stocked at a space allowance of 750cm^2 were 13% higher than in the conventional cages. A 2004 report commissioned by the European Commission (Agra ceas Consulting, 2004) similarly concluded that fixed costs to produce barn eggs were 26% higher than for conventional cage eggs. Free-range production could increase costs by as much as 50%, although some researchers suggest the cost increase would only be half that much (Appleby et al., 2004).

Bell (2005) made cost projections on the comparative economic impacts of cage, barn, and free-range production systems in the United States, based on assumptions regarding expected cost effects. Table 3 presents his conclusions, which assume that there are no productivity differences (in terms of egg production, mortality, or egg size) for the different systems. He predicts that, relative to cage systems, barn systems will result in a 27% increase in total costs, while free-range systems will increase production costs by nearly two-thirds. For the barn system, the higher costs come primarily from housing, with moderate increases in labor costs. For free-range production the higher costs come from additional labor requirements and land.

There are a few studies examining the cost impact to producers of adopting alternative husbandry hog production systems or practices. These studies generally examine increasing the space allowance per pig and providing bedding or rooting materials. Overall, these studies predict that costs would increase roughly in the 5 to 30% range.

Bornett et al. (2003) conducted a computer simulation of expected cost impacts of four different hog production systems in the United Kingdom—two types of confined feeding operations with concrete floors, a straw-based system and free-range production. They found that costs increase by less than 10% when the straw and free-range systems are used. Den Ouden et al. (1997) surveyed 11 European consumer interest groups and production experts to assess their beliefs on the relative cost impacts of variations in farrowing, fattening, and slaughtering stages of pig production in the Netherlands. Specifically, they asked respondents to assess the cost impacts of making moderate changes in the housing of nonlactating sows, mixing of unfamiliar pigs, stocking density, supply of straw for rooting, floor space, and illumination, among other welfare considerations. The authors found that total costs would increase between 22% and 32% when changes were made with respect to all of the welfare considerations listed above.

An Iowa State University study (Kliebenstein et al., 2003) comparing the costs, revenues, and profitability of hoop systems versus confinement operations, illustrates the complex tradeoffs that exist when examining the alternative husbandry practices. In contrast to an enclosed, cement-floored confinement building, a hoop system consists of a tarp-covered arched metal frame that provides shelter over an earthen floor. Fixed costs are lower in the hoop system, but operating expenses are higher (Table 4). Confinement systems, on the other hand, have a higher net present value (discounting expected future revenues less expected future costs), showing an average net income premium of $2.75 per hog, in part because the confinement buildings have a longer life span (15-20 years) compared with hoop systems (7–10 years) so that the cost of constructing confinement buildings can be amortized over a longer time period.

There is some evidence that concrete flooring without straw or other bedding material and restricted floor space increase hog morbidity levels (e.g., Tuyttens, 2005). Moreover, pigs raised in restricted floor space grow more slowly and consume less feed than pigs in less crowded environments, although there is little difference in gain to feed ratio (Hamilton et al., 2003; Gonyou and Stricklin, 1998). Thus, there may be productivity advantages in providing bedding and rooting material for hogs, although these need to be balanced against the added costs associated with the purchase and disposal of bedding materials.

The most obvious way in which government can affect animal welfare is via legislation. Although there is a burgeoning field of animal law in the United States (Wise, 2003), federal regulation of the treatment of farm animals is minimal, consisting of only two major laws. The first is the 28-hour Law, which was passed in 1873 and required that livestock be unloaded and fed, watered and rested for at least 5 consecutive hours prior to the resumption of transport after 28 hours of interstate travel by rail, steam, sail, or "vessels of any description." This law was amended in 1994 to state that it applied to animals transported by "rail carrier, express carrier, or common carrier (except by air or water)." However, usda did not agree to regulate truck transport (the major means by which livestock are transported) until 2006, after animal protection groups protested (hsus, 2006) and the courts ruled that they could no longer apply "regulatory discretion" to truck transport.

The second law is the Humane Methods of Slaughter Act (hmsa), which was initially passed in 1958 (the most recent version was passed in 1978) and stipulated that livestock be rendered insensible to pain prior to slaughter. Poultry were not specifically mentioned in the hmsa, and poultry processing plants are therefore excluded from the usda enforcement program, except with respect to the good commercial practices requirements of the Poultry Products Inspection Act. All other attempts to pass federal laws setting standards for farm animal housing, transport, or slaughter have been unsuccessful, with the exception of the federal standards for the transport of slaughter horses that were authorized under the 1996 Farm Bill (Stull, 2001). This stands in contrast to the situation for some mammals (including farm animals) used in biomedical research, teaching, and testing, the use and care of which are regulated under the provisions of the Animal Welfare Act (9 cfr, as most recently amended in 2007). The agricultural industries have historically been very successful in preventing bills introduced into Congress from reaching the floor for a vote, and so have forestalled on-farm animal welfare regulation (Garner, 1998).

Perhaps because of the lack of federal regulation, there has been increasing emphasis on the introduction of state and local regulation. All states already have some form of animal cruelty legislation, and enforcement is becoming stricter with more significant fines imposed for violations (Wise, 2003). However, there is considerable variation between the states in terms of what practices are considered to be unacceptable, and many states exempt some or all common agricultural practices from the definition of cruelty. Many of these exemptions have been enacted since 1990 (Wise, 2003), probably in response to the attempts by animal activists to use cruelty prosecutions to stop particular production practices. Thus, mechanisms other than bringing cruelty charges are now being used in an attempt to regulate or outlaw these practices. These include constitutional amendments, voter referenda, and legislative action, all of which have now been used in several states and cities to ban practices such as the use of sow gestation crates (for example in Florida and Arizona) or foie gras production (California) or consumption (Chicago) (Mench, 2008). Although the net effect of these initiatives on farm animal welfare is very small (e.g., neither Florida nor Arizona is a major swine production state), such initiatives may be strategic victories for animal protection groups.

In 1996, New Jersey became the first (and only) state to enact a requirement for its Department of Agriculture to write comprehensive standards for "humane raising, keeping, care, treatment, marketing and sale of domestic livestock" (njda, 2003). The department's proposed regulations were not issued until 2004 and were immediately criticized by animal protection groups as endorsing the status quo (hsus, 2005), although the preface to the standards makes it clear that the intent was to provide minimal requirements to create a framework for the prosecution of animal cruelty cases. Animal protection groups filed suit against the state of New Jersey, and it is unclear whether or not (or when) the proposed regulations will be finalized and enforced.

Another critical role of government is in supporting farm animal welfare–related research, training, and outreach activities. usda supports such research and outreach activities via competitive grants, multistate projects, and in-house programs, such as the establishment of usda Agricultural Research Service centers and programs focusing on animal welfare (see Reynnells, 2004; Mench, 2008) like the Livestock Behavior Research Unit located at Purdue University.

The primary means for individual consumers to influence animal production practices is via their purchasing choices. In the absence of a national product labeling scheme in the United States that informs consumers about how the animals whose products they are purchasing have been raised, this has to occur through niche marketing. Niche marketing in general is becoming important in the United States (e.g., Honeyman et al., 2006), with organic being the most significant market segment. Although only about 1% of US livestock are raised under the National Organic Standards, this is growing steadily (usda-ers, 2002). The organic standards contain some provisions for animal housing, but these are very general and have many exceptions—for example, the standards state that access of animals to the outdoors can be restricted for a number of reasons, including stage of production. It is unclear whether the organic standards are uniformly interpreted by different organic auditors, and the picture is complicated by the fact that there are also state organic standards that may incorporate additional housing requirements.

There are, however, several smaller certification programs that focus specifically on animal welfare (Table 5). The largest of these is Certified Humane Raised and Handled. This iso-65 guide certified labeling program, which is modeled on the Freedom

Foods program established by the Royal Society for the Prevention of Cruelty to Animals (rspca) in the United Kingdom, is supported by 27 humane organizations.

An examination of purchasing patterns for such products can be informative. For example, survey research in Britain showed that purchasers of organic products are partially motivated by animal welfare, and examination of focus groups reinforced the finding that animal welfare is of importance to most of these organic shoppers, and of singular importance to some. The same focus group study showed that animal welfare was of concern to few nonorganic buyers (Harper and Makatouni, 2002). In general, however, actually determining what motivates consumers to purchase (or not purchase) particular animal products, and assessing the extent of consumers' knowledge and expectations regarding animal husbandry practices, is extremely difficult. By definition, the category of "consumers" encompasses the entire diversity of the human race. The range of attitudes thus extends from those individuals whose primary value focus in consumption choices is the welfare of animals to those who give no regard to animal welfare whatsoever.

Some economic studies have demonstrated that consumers are willing to "pay for animal welfare" (Bennett, 1996), but even in Europe, where there has been far more discussion about these issues than in the United States, most consumers have little knowledge about animal production practices, and their purchasing patterns do not consistently reflect their attitudes toward animal welfare or their purchasing intentions (Roex and Miele, 2005; Schröder and McEachern, 2004). For example, fewer than 40% of uk consumers indicate that they will buy eggs from caged hens, even though those eggs actually make up about 70% of the eggs sold in the United Kingdom (Mintel, 2002). Interviews with Scottish consumers (Schröder and McEachern, 2004) showed that all professed to care about animal welfare to some extent, but many viewed it as an issue that should be dealt with through regulation rather than consumer purchasing decisions. Many purchased costlier "welfare-friendly" foods only when they were on special offer.

There are currently very few similar studies of US populations. Rauch and Sharp (2005) focused on the attitudes of Ohioans about animal welfare. A nationwide survey by Lusk et al. (2007) has also recently been completed. At the same time, claims relating to animal welfare have begun to appear on labels, suggesting that at least some suppliers and retailers believe that an effective market for "humanely" produced products exists. One key issue for actual (as opposed to expressed) willingness to pay is whether consumers have confidence that welfare claims can be certified as accurate. There are thus many areas of complexity relating to consumers' responsiveness to welfare claims that have yet to be studied (Thompson et al., 2007). However, this is an area of critical importance for additional future research.

In contrast to the legislative approach taken in Europe, the primary drivers of improved animal welfare standards in the United States are the producers and food retailers, although this is a very recent development. Producer initiatives have taken the form of standards implemented at the level of particular companies, integrators, cooperatives, or commodity groups. One of the first producer groups to write standards was a commodity group, the United Egg Producers (uep). In response to a public letter-writing campaign against induced molting in 1998, the uep took the unusual step of assembling a committee of independent experts (initially animal scientists, food scientists, veterinarians, and a representative from an animal protection group) to critically examine not just molting, but all current production practices for egg-laying hens. The committee reviewed the scientific literature with respect to hen welfare and made recommendations for cage-housed hens (Bell et al., 2004). These recommendations were then formulated into a set of uep guidelines by a separate committee composed of egg producers, who also determined the timeline for implementation of the standards. This process served as a model for several of the other producer groups and also for the Food Marketing Institute and National Council of Chain Restaurants programs (Mench, 2003; Mench, 2008; see Section IX-D).

All of the major producer groups now have animal welfare guidelines or animal welfare quality assurance (QA) programs; these are detailed in Table 5. The level of input from independent experts into these guidelines was variable; some commodity groups, like uep, based their standards on recommendations written by independent experts, while other groups primarily solicited advice from such experts during the review of their draft guidelines. Quality assurance programs that have an animal welfare component have also been developed at the state level (for example, the California Dairy Quality Assurance Program [www.cdqa.org]).

Producer adherence to these guidelines and standards may be completely voluntary, and/or be audited using first-, second-, or third-party auditing mechanisms. The UEP has a true third-party auditing system for its standards, and producers who pass the audit can display the "UEP Certified" logo (which is Process Verified by the USDA) on their egg cartons. The "5-Star Dairy Quality Assurance" (DQA) program uses various indicators of quality including indicators of animal care, such as mortality and lameness. The DQA program uses third-party audits but is not focused only on animal welfare. The National Beef Quality Audits (McKenna et al., 2002; Boleman et al., 1998) are funded by the industry and provide a tool to quantify the national impacts of feedlot practices. The audits include measures of carcass bruising (related to handling), mud on cattle, liver defects, and many other parameters associated with quality of care and beef quality. The National Pork Board recently launched the Pork Quality Assurance Plus (PQA Plus) program that incorporates a third-party auditing mechanism. Although this is voluntary, it is predicted that passing the audit will be required by packers to provide assurance to the retail markets (see Section IX-D).

Another important mechanism developed by producers to improve animal welfare is training programs. This training is provided via written materials, videos, and producer-oriented education workshops. The PQA Plus program, for example, includes a training program coupled with on-farm assessment of effectiveness. A nonproducer-related training program that has been well received is the National Pork Board's Trucker Quality Assurance program, which educates truckers in behavioral principles of moving animals and the proper loading and transport of pigs.

National and multinational retailers are playing a major role in developing and enforcing animal welfare standards. At about the same time UEP was developing its guidelines, McDonald's began auditing packing plants to ensure that the beef products supplied to them were handled and killed humanely, and according to the voluntary standards developed by the American Meat Institute (see Table 5). McDonald's then appointed an animal welfare committee composed of outside experts and began establishing on-farm standards for their suppliers, beginning with laying hens (Mench, 2003).

Other retailers quickly followed suit and. in 2000, the trade associations of the supermarkets (the Food Marketing Institute, FMI) and the chain restaurants (National Council of Chain Restaurants, NCCR) joined together and consolidated their recently established animal welfare expert committees to try to provide a coordinated and uniform program (Brown, 2004). The process involved working with the various commodity groups to assist them in developing guidelines (Table 5). The FMI-NCCR recommended that each commodity group follow a process similar to that of the UEP, involving scientific review and consultation with independent experts. The committee also detailed the items that should be covered in each set of guidelines, worked with the various commodity groups to guide them through the process, and helped to create an auditing program that could be used by the retailers to ensure compliance (Mench, 2003). Many retailers also have established their own animal welfare advisory committees.

US and multinational retailers have enormous potential to effect changes in animal welfare by instituting purchasing specifications for their suppliers. The same consolidation seen in the agricultural industries is also present in the retail sector—the retail sector, overall, is as concentrated as broiler or turkey production in the agricultural sector (Hendrickson and Heffernan, 2005), leading to a situation where a few companies have a significant amount of purchasing power. The top five supermarkets in the United States had grocery sales of nearly $200 billion in 2004, and one US-based supermarket, Wal-Mart, had worldwide sales of nearly $245 billion, four times greater than its nearest competitor, the French chain Carrefour (Hendrickson and Heffernan, 2005). The influence that animal protection groups have had on the retailers should not be underestimated. Several of these groups have been quite successful in using shareholders' resolutions (Singer, 1998) and publicity campaigns to pressure retailers to set animal welfare standards for their suppliers. This is part of a growing trend for social-cause activists to use the market to accomplish political ends, brought about by frustration over the congestion of traditional legislative channels. This trend has been facilitated by a number of factors, including the fragmentation of traditional large agricultural interest groups into smaller groups with competing interests, consumer affluence, and the concentration of food markets (Schweikhardt and Browne, 2001).

There is no question that industry and retail programs have already caused significant changes in farm animal management—in fact, the most significant changes that have occurred so far in the United States with regard to farm animal welfare. McDonald's auditing of its packing plants led to marked improvements in handling and stunning in those plants (Grandin, 2006) and had industry-wide ramifications. The poor initial performance found by the McDonald's auditors in those plants led to calls for stronger enforcement of the Humane Slaughter Act; in 2002, Congress passed a resolution providing increased funding for compliance inspections and tracking, along with a requirement that usda report the inspection results to Congress annually (Becker, 2005).

The uep program for caged laying hens has also had far-reaching effects, now covering 80% of caged hens in the United States. Another example is the ncba program (2007). Under this program, handling of beef cattle has improved as a result of training, scoring of handling, and emphasis by food retailers (Grandin, 1998b; 2005). Some progressive cattle feeding organizations have contracted for third-party audits for animal welfare, food safety, and environmental management. Assessment and audit methods originally developed for measuring handling within beef processing facilities are also being adapted to cattle raising environments. Large feedlots and alliances have begun to measure animal handling at their facilities.

The market is, of course, not a perfect driver of social change for animal welfare. Although the hfac labeling program is steadily increasing its market share, growing since its inception in 2003 to cover more than 14 million animals on more than 500 farms, as well as 20 restaurants and supermarket chains that feature Certified Humane products (Douglass, pers. comm.), niche-marketed products in general are likely to appeal to only a relatively small number of consumers. The fmi-nccr approved–standards have not been adopted by all fmi and nccr members, and there are also retailers that are not fmi or nccr members (e.g., Wendy's and Whole Foods) that have chosen to write their own standards. The attempt by fmi-nccr to provide a uniform national third-party auditing system for the retailers (the awap audit) has been abandoned due to lack of retailer uptake, coupled with resistance from producers (Mench, 2008). A plethora of programs involving different (and sometimes contradictory) standards have thus evolved, and at this time consumers would be hard-pressed to understand the features of these programs. Nor can they be assured that all of these are audited or in some way enforced through purchasing specifications or by other means.

It should be noted that the goal of most of these producer and retail standards is to identify best management practices in the production systems that are currently typical in the United States. This is not to say that they cannot also result in a movement towards alternative systems, as shown by Smithfield's announcement that they will phase out sow gestation stalls as a result of discussions with McDonald's and Wal-Mart (Etter, 2007). There are, of course, economic reasons for the decision to focus standards and programs on current production systems, but there are also animal welfare considerations. As the Europeans have moved away from confinement systems to more extensive systems, many problems have arisen that need to be addressed by further research and development. Laying hen systems provide a perfect example of some of these problems. While hens housed in noncage systems can locomote and perform more normal behaviors than caged hens, there has been an increase in serious health problems, including broken bones, feather pecking and cannibalism, and infestation with internal and external parasites (efsa, 2005; Lay Wel, 2007). In a sense, the historical process of development of the laying hen industry has been reversed, with hens now given increasing behavioral freedom but at some cost to their health status.

Animal welfare issues are, of course, not the only things that must be considered when moving toward less intensive systems—additional factors are food safety, environmental issues, and worker impacts. This last factor is particularly important for animal welfare since good husbandry is the most critical component of animal welfare.

Changes in US husbandry practices are occurring against the backdrop of an effort to develop internationally applicable farm animal welfare standards. As part of its strategic planning process, the World Organisation for Animal Health (oie), an intergovernmental organization that in the past has focused primarily on animal disease identification and control, highlighted animal welfare as one of its priorities. The oie convened a Working Group on animal welfare in 2002, with members from Belgium, Canada, Egypt, India, Kenya, New Zealand, Norway, and the United Kingdom, and held an international animal welfare conference in 2004 (oie, 2004). The primary task of the Working Group is the "development of policies and guiding principles…from which to elaborate draft recommendations and standards" (oie, 2007), with an initial focus on agriculture and aquaculture. Draft standards are developed with input from ad hoc groups and circulated to member countries for comment prior to adoption. To date, standards for the transport of animals (by land, air, and sea), and for animal slaughter and killing animals for the purpose of disease control, have been adopted and incorporated into the oie Terrestrial Animal Health Code (http://www.oie.int/eng/normes/mcode/en_titre_3.7.htm) as appendices. Guidelines and principles for aquatic animal welfare are currently under review. The intent is to also develop guidelines for farm animal management, housing, and transport. A discussion paper on Development of Animal Welfare Guidelines for Production Systems (Terrestrial Animals) was circulated by oie for comments by member countries in 2007, and the oie has now established an ad hoc committee to begin the process of guidelines development.

There are several possible avenues for improving farm animal welfare, each with its own strengths and limitations.

A primary benefit of federal regulation of animal production practices would be that it would set minimum nationwide standards. However, there are also significant limitations with regard to federal regulation, at least as it is currently structured, as an effective vehicle for implementing improvements in farm animal welfare:

1. Given that there are more than 1 million farms producing billions of livestock and poultry in the United States (nass, 2002), in the current climate it is difficult to see how there could be a systematic enforcement program involving regular inspection of producers. Such a program would be very costly and would require many more qualified inspectors than are presently available. usda-aphis already encounters significant financial and personnel challenges inspecting exhibitors, licensed dealers, and registered biomedical research premises under the Animal Welfare Act; compared to animal agriculture, that program involves an extremely small number of animals and facilities. Regulation without enforcement would fail to assure the public that the regulations were being followed, and would likely lead to an increase in break-ins and undercover investigations of farms by activists attempting to identify non-compliant producers.
2. The US regulatory process is cumbersome and often does not rely on a consultative process during initial rulemaking. This can create a situation where there is an adversarial rather than a cooperative relationship between the stakeholders and the regulators, and ultimately a lack of "buy-in" by those stakeholders.
3. Legislative standards tend to be rigid and difficult to change once implemented. Because almost all currently existing livestock management systems have both advantages and disadvantages for animal welfare, there is currently an insufficient knowledge base to legislate one particular system over another for any species. Rigid standards would create a climate where the innovation and experimentation that are necessary to refine and develop alternative systems are actually penalized rather than encouraged.
4. A related issue is the progress that has been made in improving farm animal welfare in the last eight years because of market forces. If instead it is decided that housing and husbandry should be regulated, any progress that involves costs to producers to implement will likely slow down or stop during the regulatory development process since producers will be very reluctant to spend money to install new systems (and retailers will be very reluctant to pay them a premium to do so) when those may wind up being outlawed. This regulatory process (and the resulting impasse) could take a long time—usda announced its intent to provide standards under the Animal Welfare Act for primate enrichment over 20 years ago and, as of 2007, there are still no detailed regulations.
5. Legislative recommendations, by their nature, tend to be engineering-based (e.g., require provision of so many square feet of space per animal, or provision of so many waterers per animal, etc.). It has become obvious in the last few years that specific engineering-type provisions (which are called "resource-based" provisions in Europe) enacted in other countries to try to improve animal welfare often have not had the intended effects. For example, a recent study of organic hen production in Austria (Zaludik et al., 2007) evaluated the usefulness of the government's Animal Needs Index (ani), which involves auditing how much space, feeder space, etc., the hens are given, as a measure of welfare. There was no relationship between a good score on the ani and hen welfare as assessed by mortality, injury, measures of abnormal behavior, and footpad and breast lesions. Thus, providing the hens with particular resources thought to be important did not in fact lead to clear improvements in their welfare as assessed by performance-based (animal-based) measures. There have been many other recent studies confirming this across species (e.g., see papers in *Animal Welfare*, Volume 16), leading European countries to begin to de-emphasize engineering standards in favor of performance standards (e.g., health, mortality, injury, body condition, behavior, etc.). This is critical because we still have little understanding of how all of the complex inputs on commercial farms (whether those are husbandry inputs or genetic inputs) interact to cause or minimize animal welfare problems.

Regulation at the state or local level, although having the benefit of raising public awareness of issues affecting farm animals and consumers, is likely to be a particularly unproductive approach to improving animal welfare since there are no trade barriers between states. If producers in a particular state are forced to adopt practices that add to their cost of production, they will be unable to remain competitive with producers in other states. They will, therefore, either go out of business or relocate their operations to states with fewer regulations, or to other countries where animals may be kept in poor conditions. This latter situation could also result from federal regulation, of course, in cases where there are no trade barriers to prevent animal products being imported into the United States.

Having discussed the limitations of regulation, it should also be noted that regulation is likely to be the best mechanism for improving animal welfare in situations where other types of oversight are difficult or impossible to achieve. One such example is the transport of spent (end-of-lay) hens, which was mentioned earlier (see Section viii-h). These hens are often transported long distances under poor conditions. Because there is almost no market remaining (either for human or animal consumption) for their meat, this is not an area where the retailers can exert any control. Although the uep has standards for loading these hens, once they leave the producer's premises, the hens are no longer the producer's property, and there are no commodity standards covering their transport or slaughter. Thus, the only obvious mechanism for ensuring the humane treatment of these hens once they leave the farm appears to be via regulation.

Enormous improvements have been made recently in animal husbandry as a result of market forces. However, for the reasons discussed earlier, market forces alone are insufficient to ensure consistent and transparent national standards. One potential mechanism used in other countries for the development of such standards is to create a more open, consultative effort involving diverse stakeholders. For example, many countries (e.g., Canada, Australia) have national Codes of Practice drawn up by committees composed of producers, consumers, scientists, veterinarians, government representatives, and other appropriate stakeholders. These Codes are voluntary, and in other countries are typically referred to only if there is a cruelty complaint against a producer. In the United States, however, these could serve as a set of baseline standards for auditing by retailers or commodity groups. In either case, it would be important to couple these standards with another mechanism to ensure transparency, uniformity, and accountability, perhaps a consumer labeling/information program.

A process that might provide an excellent mechanism for this is currently underway in Europe. The eu has funded a multimillion-Euro project called Welfare Quality Assessment (www.welfarequality.net) that involves producers, consumer group representatives, biological and social scientists, veterinarians, representatives from regulatory agencies, and other stakeholders. The primary goal of this project during the first year was to assess consumer attitudes towards animal welfare in the eu and to understand the relationships between those attitudes and purchasing patterns. The other major goal is to create welfare assessment tools for each species by identifying performance-based measures of animal welfare in different production systems, and then validating them on commercial farms for their reliability and practicality (proposed tools are currently being evaluated on 600 farms throughout Europe). These tools are intended to be used for self-assessment and training of producers, but may also replace current eu regulation in setting minimum standards and/or be audited in conjunction with either a voluntary or compulsory consumer labeling program that identifies products produced under "minimum" or "high" animal welfare standards.

The field of animal welfare science has shown rapid growth since the publication of the Brambell Report (Rushen, 2008). This growth has been slower in the United States than in Europe and some other countries (notably Canada, Australia, and New Zealand), for reasons that are discussed in more detail by Mench (2008), and there is still a critical shortage of animal welfare scientists in the United States to address the research and outreach needs associated with evaluating and changing husbandry practices.

Nevertheless, there is now a considerable body of scientific literature (except in the area of comparative cost studies) on farm animal welfare–related topics. Research by scientists and veterinarians, or scientists and veterinarians working in collaboration with industry (whether producers, breeders, or manufacturers of vaccines, feed, or equipment), has provided a great deal of critical information that could potentially be used to improve the handling, housing, and husbandry of farm animals in the United States. A discussion of all of these potential improvements is not possible because of space constraints, but some general comments about adoption by producers of changed practices are warranted.

Sometimes scientific information is readily acted upon by industry. This tends to be true when changes in practices are also associated with an economic advantage—such as a reduction in bruising and carcass damage due to improved handling and equipment design (Gregory and Grandin, 1999) or to take advantage of a niche market. Sometimes producers wish to adopt modified practices but have difficulty doing so because of technical or other problems—examples are broiler catching machines and gas stunning for broilers, which would reduce labor costs but still have unresolved technical and animal welfare issues associated with them. Producers are obviously least likely to implement scientifically based changes if these result in significant cost increases, especially if there is no clear economic incentive for them to do so. Producers do, however, occasionally adopt changes for ethical or social reasons (for example, to avoid perceived threats to existing markets or to demonstrate to consumers that they are socially responsible), even though these changes are associated with increased cost because there is no *a priori* market incentive. An example is the uep Certified producers' adoption of increased space allocations, air quality standards and nonfeed-withdrawal molting methods for caged hens (although in this case the predicted cost increases were not fully borne out since the changes resulted in decreased mortality and improved per-hen egg production).

An important constraint in terms of the application of research is that, although small-scale experimental studies of animal welfare have added immensely to our knowledge base and have provided a great deal of practical information, there is a critical shortage of on-farm studies. What works in the university or research station setting may not work in the field because of the complexity of the production environment. Although many of the on-farm performance measures of welfare being developed as part of the EU Welfare Quality Assurance program will no doubt be useful in the United States, others will not because of our farm sizes (for example, behavioral measures that would require an excessive time investment to record accurately on a farm of typical US size, like social interactions in the flock or herd, or fear responses to human handlers). We have now reached a point where it will be very difficult to make further scientific progress in improving animal welfare without a major commitment to on-farm research, which must involve multi-site and multi-disciplinary collaboration.

Experimental studies at universities and research stations will continue to be important. Researchers need to have the capacity to work on commercial farms, but also to conduct independent research that allows full evaluation not only of existing, but of potential alternative production practices. However, such research is currently hampered by the aging infrastructure of research farms at Land Grant Universities, many of which no longer resemble the kinds of facilities found on commercial farms with respect to environmental control, the capability for automation of feeding and watering systems, building construction, stall or pen design, or other features.

By and large selection criteria for farm animals have emphasized production traits (conformation, growth rate, feed efficiency, carcass characteristics, milk or egg production) rather than behavior or other aspects of welfare. Intensive or continuous selection for a single trait can result in numerous reproductive, neurological, and behavioral problems, which are commonly referred to as production diseases (see Section V-B). Belayev (1979) referred to this type of selection as destabilizing selection, in contrast to the stable selection which occurs in nature. Destabilizing selection has often been associated with an increase in the incidence or severity of certain welfare problems, such as lameness, which occurs in poultry, dairy cattle, and swine. Aggressiveness is likely to be the result of increased selection for individual performance in a competitive social environment for both poultry (Muir, 1996) and swine (Muir and Schinckel, 2002). Other, more species-specific problems, such as tail biting in pigs are at least in part the result of selection for performance parameters and are more heritable in certain breeds than others (Breuer et al., 2005). A related concern is that intensive selective breeding and the use of artificial insemination technology has resulted in a significant loss of genetic diversity for some farm animals (e.g., Holstein cows), particularly at the Major Histocompatibility (MHC) locus, raising concerns about the potentially catastrophic effects of new or emerging diseases on farm animal populations (Vandenberg et al., 2003).

In some cases, the breeders have begun selecting against these problems; for example, poultry breeding companies have now incorporated selection for skeletal strength into their selection programs for broilers, and there is anecdotal evidence that this has resulted in a decrease in the incidence of overt lameness (Appleby et al., 2004). It would certainly appear to be at least theoretically possible for breeders to directly select for other traits related to behavior and welfare (such as levels of fearfulness, and propensity to develop abnormal behaviors, sociability, body conformation) that would minimize the need for feed restriction in their selection programs (Kjaer and Mench, 2003). Breeders probably already do this to some extent indirectly when selecting commercial lines that tend to have better performance characteristics in particular environments (e.g., outdoor versus indoor housing). In fact, alternative systems, such as loose housing systems or extensive systems for swine, increase the importance of selection for behavioral characteristics, such as maternal behavior, to ensure offspring survival (Grandinson, 2005).

There are, however, limitations as to what can be accomplished using genetic selection. First, most traits associated with welfare problems were not selected for directly but were correlated effects associated with selection for other traits. So, for example, it appears that higher levels of aggression in hens are a correlated effect of selection for early onset of sexual maturity and hence egg production (Appleby et al., 2004). Selection efforts directed towards correcting such problems or developing new strains of animals adapted to particular environments will almost certainly affect other correlated traits, with unpredictable effects on various parameters, including animal welfare. For example, decreased flightiness and strong maternal care are associated with elevated maternal defense in several species. Selection for the former traits could lead to undesirable changes in maternal aggressiveness in beef cattle (Turner and Lawrence, 2007). Direct selection for piglet survival may lead to a decrease in early growth rate of piglets (Grandinson, 2005). In particular, many behavioral traits are under complex multigene control, making them both difficult to select and very likely to result in correlated effects.

Second, traits have to have at least moderate heritability to be amenable to direct selection. Some traits of interest with respect to improving animal welfare have moderate to high heritability, but others do not (Kjaer and Mench, 2003; Mench, 2004). Third, different housing environments may be more conducive than others in terms of utilizing effective selection techniques. For example, indirect group (rather than direct individual) selection of laying hens has been shown to be effective in modulating social behaviors, including reducing feather pecking, cannibalism, and aggression (Muir, 2003). However, group selection of this kind requires that the birds be housed in relatively small groups, as is typical of cage housing, rather than in the large groups that would be typical of noncage housing. Last, it must be recognized that welfare problems are not usually solely genetic, but result from complex genetic-environment interactions. Thus, although broiler chickens have been selected for rapid growth rate , the rapid growth rate is associated

with skeletal problems and can be exacerbated by many management factors, including feeding high concentrate diets *ad libitum* and providing light cycles designed to stimulate feeding but minimize activity (Mench, 2004).

Genetic selection is a potentially powerful tool for improving animal welfare, assuming that producers are willing and able to use strains that are better selected for particular conditions. It should be noted that in some production systems (e.g., poultry) local producers may have very limited input into genetic selection programs since the primary breeders are separate, large multinational corporations that cater to the demands of international markets for particular phenotypic traits. In addition, social concerns regarding animal biological integrity and animal telos (Rollin, 1995b) may well limit improvements to welfare using genetic modification, particularly in the case of the use of new genetic technologies, like transgenic technologies, that at least theoretically have the potential to overcome some of the limitations related to correlated effects and low heritability noted above (Vandenberg et al., 2003). Regardless, continued improvements in animal management, along with an increased understanding of the complexity of genetic and environmental interactions, will be required whatever types of environments are used for rearing farm animals.

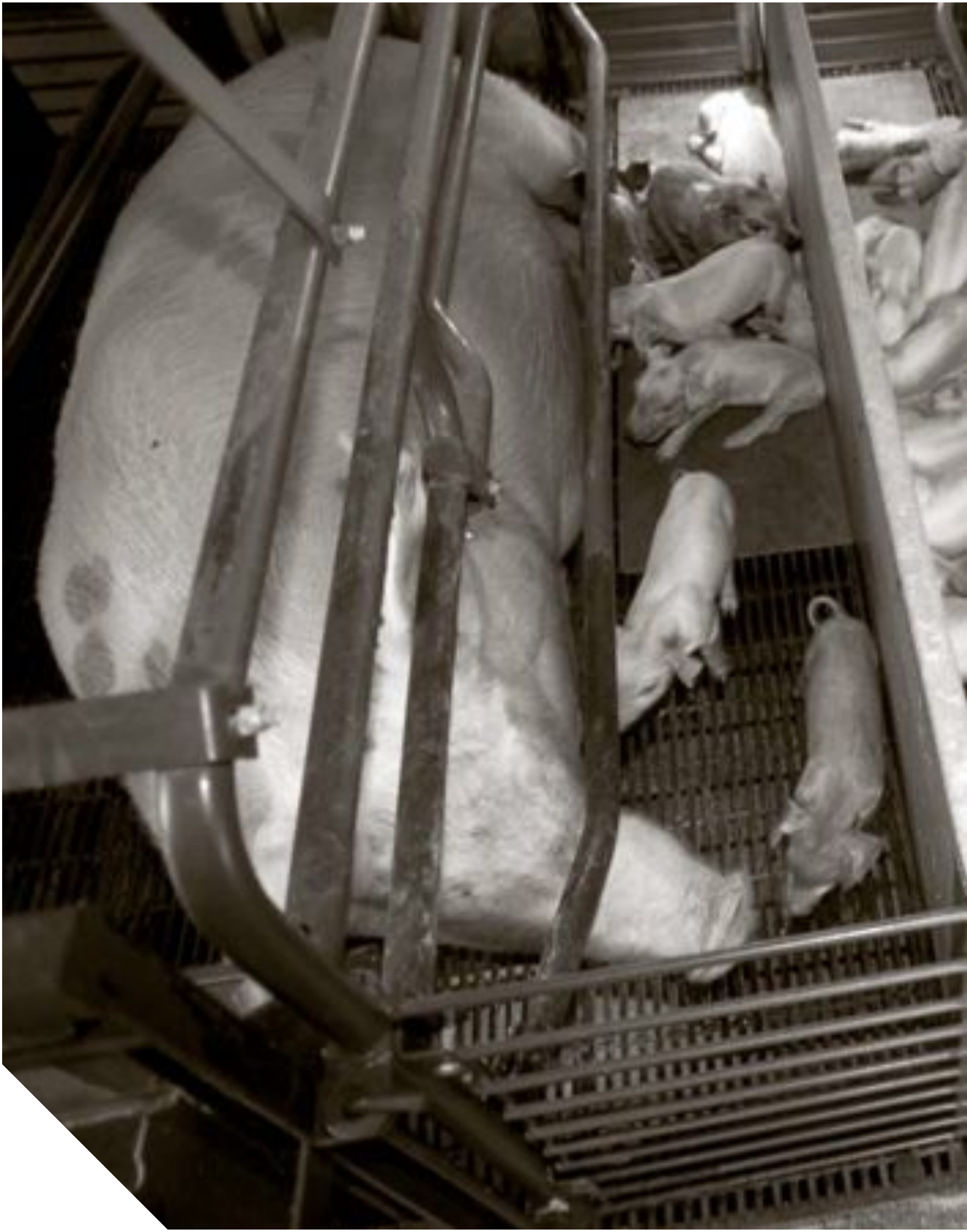
It seems clear that the time has come for a national dialogue about what to do about farm animal welfare. Such a dialogue needs to result in a national process that will assure consumers of animal products that the animals have been raised and treated appropriately. As such, the relevant stakeholders need to be represented in the discussion. An important first component of this process would be to improve our understanding of consumer knowledge, attitudes, and purchasing patterns. Whatever process is then developed should be based on a well-articulated set of ethical principles regarding the treatment of animals, such as the Five Freedoms discussed in Section V.

A successful national process could and should accomplish the following goals:

- Set standards for current production practices where there is already sufficient scientific information available to ensure that those standards will have the desired effect in improving animal welfare. For example, the standards adopted by the uep were based on a review of a rich scientific literature on poultry behavior, health, and welfare.
- Develop and validate scientifically determined and performance-based standards of animal welfare that can provide benchmarks for improvement.
- Include follow-up mechanisms to ensure that any changes are having effects that meet the desired goal.
- Incorporate mechanisms to increase and sustain a dialogue among producers, scientists, veterinarians, and other stakeholders to allow the kind of innovation that is necessary to continue to improve animal welfare on-farm.
- Facilitate transparency and ethical consistency
- Provide incentives (e.g., subsidies, tax breaks, low-income loans) for producers to encourage them to adopt and follow improved welfare practices.

There is another critical component of a national standards development, and that is workforce assessment. Well-motivated recommendations or requirements that fail to take account of the impact that those changes will have on the quality of the husbandry provided (for example, by requiring skills that do not match workforce capabilities) are ill-advised. The more complex the system or practices that are required, the more that can go wrong. The main losers when husbandry skills are insufficient to meet the challenges of new systems or practices are the animals that will receive inadequate care. Changes in production systems, therefore, must not be made precipitously, and any recommended changes should be supported by a US-based workforce analysis documenting that producers, hired labor, and the veterinary community have the ability to implement them in a way that does not cause adverse impacts on animal welfare. Investment in worker training will also be critical. Research at the farm level will also be necessary to determine costs and impacts associated with different production methods, including impacts on consumers, producers, and rural communities of changes in husbandry practices designed to improve animal welfare. Because of the complementarities that exist in many animal production systems (see Section VIII), studies of alternative production systems must also examine their effects on food safety and the environment.

Ultimately, to be successful, any process that is adopted must help to create a climate in which animal producers are willing to adopt recommendations and innovations, but also one in which they can be open when problems arise so that scientists and veterinarians can work with them to help them improve or modify practices as necessary. Otherwise, we risk making changes that absolve the conscience of consumers at the expense of the animals themselves.



aabp (Undated). *Practical Euthanasia of Cattle*. http://www.aabp.org/resources/euth.pdf.

Agra ceas Consulting Ltd. (2004). Study on the socio-economic implications of the various systems to keep laying hens. Final Report for the European Commission. 2120/CC/December 2004. http://www.ceasc.com/.

Aho PW (2002). The world's commercial meat and chicken industries. In: *Commercial Chicken Meat and Egg Production, 5th Edition,* pp. 3–7, Bell DD (ed). Dordrecht, The Netherlands: Kluwer.

Anderson IL, Bøe KE (2001). Feeding systems for pregnant sows. In: *Livestock Environment VI: Proceedings of the 6th International Symposium.* Stowell RR, Bucklin R, Botthcher RW (eds). Louisville, KY, pp. 195–202.

(2007) Animal Welfare, *Animal Welfare at the Farm and Group Level.* Special Edition, Volume 16(2).

Anil L, Anil SS, Deen J (2002). Relationship between postural behaviour and gestation stall dimensions in relation to sow size. *Applied Animal Behaviour Science* 77: 173.

Appleby, MC (1999). *What Should We Do About Animal Welfare?* Oxford: Blackwell.

Appleby MC, Hughes BO (eds) (1997). *Animal Welfare.* Wallingford: cab International.

Appleby MC, Lawrence AB (1987). Food restriction as a cause of stereotypic behavior in tethered gilts. *Animal Production* 45: 103–110.

Appleby M, Mench J, Hughes B (2004). *Poultry Behavior and Welfare.* Wallingford: cabi Publishing.

AVMA (2007). AVMA Guidelines on Euthanasia. http://www.avma.org/issues/animal_welfare/euthanasia.pdf

Babot D, Hernandez-Jover M, Caja G, Santamarina C, Ghirardi JJ (2006). Comparison of visual and electronic identification devices in pigs: On-farm performances. *Journal of Animal Science* 84: 2575–2581.

Barnett JL, Coleman GJ, Hemsworth PH, Newman, EA, Fewings-Hall S, Ziini, C (1999). Tail docking and beliefs about the practice in the Victorian dairy industry. *Australian Veterinary Journal* 77: 742–747.

Bauman DE, Everett RW, Weiland WH, Collier RJ (1999). Production responses to bovine somatotropin in northeast dairy herds. *Journal of Dairy Science* 82: 2564–2573.

Beattie VE, Sneddon IA, Walker N, Weatherup RN (2001). Environmental enrichment of intensive pig housing using spent mushroom compost. *Animal Science* 72: 35–42.

Becker G. (2005). *Humane Treatment of Farm Animals: Overview And Issues.* Washington, DC: Congressional Research Service.

Belayev DK (1979). Destabilizing selection as a factor in domestication. *Journal of Heredity* 70: 301.

Bell D (2005). A review of recent publications on animal welfare issues for table laying hens: Welfare and socio-economic issues. In: *Report prepared for the United Egg Producers annual meeting,* October 2005. http://animalscience.ucdavis.edu/Avian/WelfareIssueslayingHens.pdf

Bell D, Chase B, Douglass A, Hester P, Mench J, Newberry R, Shea-Moore M, Stanker L, Swanson J, Armstrong J (2004). uep uses scientific approach in its establishment of welfare guidelines. *Feedstuffs* 76: 1–9.

Benjamin M (2005). Pig trucking and handling—stress and the fatigued pig. *Advances in Pork Production* 16: 1–7.

Bennett R (1996). People's willingness to pay for farm animal welfare. *Animal Welfare* 5: 3–11.

Berg C (2004). Pododermatitis and hock burn in broiler chickens. In: *Measuring and auditing broiler welfare*, CA, Butterworth A (eds). Wallingford, uk: cabi Publishing.

Betts EM (ed) (1953). *Thomas Jefferson's Farm Book, with Commentary and Relevant Extracts from Other Writings.* Princeton, Princeton University Press.

Biggs PM (1990). Vaccines and vaccinations—past, present, and future. *British Poultry Science* 31: 3–22.

Bijman J (1996). Recombinant bovine somatotropin in Europe and the usa. *Biotechnology And Development Monitor*, 2–5.

Blackwell T (2004). Production practices and well-being: swine. In: *The Well-Being of Farm Animals: Challenges and Solutions*, Benson GJ, Rollin BE (eds). Ames, Iowa: Blackwell.

Blayney DP, Normile MA (2004). *Economic Effects of US Dairy Policy and Alternative Approaches to Milk Pricing.* Washington, DC, usda. http://www.usda.gov/documents/NewsReleases/dairyreport1.pdf

Boivin X, Leneindre P, Chupin JM (1992a). Establishment of cattle-human relationships. *Applied Animal Behaviour Science* 32: 325–335.

Boivin X, Leneindre P, Chupin JM, Garel JP, Trillat G (1992b). Influence of breed and early management on ease of handling and open-field behavior of cattle. *Applied Animal Behaviour Science* 32: 313–323.

Boleman SL, Boleman SJ, Morgan WW, Hale DS, Griffen DB, Savelle JW, Ames RP, Smith MT, Tatum JD, Filed TG, Smith GC, Gardener BA, Morgan JB, Northcutt SL, Dolezal HG, Gill DR, Ray FK (1998). National Beef Quality Audit-1995: Survey or producer-related defects and caracass quality and quantity attributes. *Journal of Animal Science* 76: 96–103.

Borg KE, Esbenshade KL, Johnson BH (1991). Cortisol, growth hormone, and testosterone concentrations during mating behavior in the bull and boar. *J. Anim Sci.* 69: 3230–3240.

Bornett H, Guy J, Cain P (2003). Impact of animal welfare on costs and viability of pig production in the uk. *Journal of Agricultural and Environmental Ethics* 16: 163–186.

Bracke MBM, Metz JHM, Spruijt BM, Dijkhuizen AA (1999). Overall welfare assessment of pregnant sow housing systems based on interviews with experts. *Netherlands Journal of Agricultural Science* 47: 93–104.

Brambell F (1965). *Report of the Technical Committee to Enquire into the Welfare of Animals Kept under Intensive Husbandry Systems.* London: Her Majesty's Stationery Office, Command Paper 2836.

Bretschneider G (2005). Effects of age and method of castration on performance and stress response of beef male cattle: A review. *Livestock Production Science* 97: 89–100.

Breuer K, Hemsworth PH, Barnett JL, Matthews LR, Coleman GJ (2000). Behavioural response to humans and the productivity of commercial dairy cows. *Applied Animal Behaviour Science* 66: 273.

Breuer K, Sutcliffe MEM, Mercer JT, Rance KA, O'Connell NE, Sneddon IA, Edwards SA (2005). Heritability of clinical tail-biting and its relation to performance traits. *Livestock Production Science* 93: 87.

Broom DM, Johnson KG (1993). *Stress and Animal Welfare.* London: Chapman, Hall.

Brown KH (2004). A marketplace perspective. In: *Proceedings of the Global Conference on Animal Welfare: An OIE Initiative.* Paris, oie, pp. 79–91.

Bruckmaier RM, Blum JW (1998). Oxytocin release and milk removal in ruminants. *Journal Of Dairy Science* 81: 939–949.

Busse CS, Shea-Moore MM (1999). Behavioral and physiological responses to transportation stress in three genetic lines of pigs. *Journal of Animal Science* 77: 147.

Chesterton RN (1989). Examination and control of lameness in dairy herds. *New Zealand Veterinary Journal* 37: 133.

Christensen G, Sorensen V, Mousing J (1999). Diseases of the respiratory system. In: *Diseases of Swine* (Ed. by al, BS e.). Ames: Iowa State University Press.

Colditz IG (2002). Effects of the immune system on metabolism: implications for production and disease resistance in livestock. *Livestock Production Science* 75: 257–268.

Coleman GJ, Hemsworth PH, Hay M, Cox M (2000). Modifying stockperson attitudes and behaviour towards pigs at a large commercial farm. *Applied Animal Behaviour Science* 66: 11–20.

Collier RJ, Dahl GE, VanBaale MJ (2006). Major advances associated with environmental effects on dairy cattle. *Journal of Dairy Science* 89: 1244–1253.

Cook NB, Bennett TB, Nordlund KV (2004). Effect of free stall surface on daily activity patterns in dairy cows with relevance to lameness prevalence. *Journal of Dairy Science* 87: 2912–2922.

Cook NB, Mentink RL, Bennett TB, Burgi K (2007). The effect of heat stress and lameness on time budgets of lactating dairy cows. *J. Dairy Sci.* 90: 1674–1682.

Cowan RS (1997). *A Social History of American Technology.* New York, Oxford University Press.

Cronon W (1991). *Nature's Metropolis: Chicago and the Great West.* New York, WW Norton.

Curtis S (1983). *Environmental Management in Animal Agriculture.* Ames: Iowa State University Press.

Damm BI, Pedersen LJ, Marchant-Forde JN, Gilbert CL (2003). Does feed-back from a nest affect periparturient behaviour, heart rate and circulatory cortisol and oxytocin in gilts? *Applied Animal Behaviour Science* 83: 55.

Dawkins MS (1990). From an animal's point of view: motivation, fitness and animal welfare. *Behavioral and Brain Sciences* 13: 1–9.

Dawkins MS (1998). *Through Our Eyes Only? The Search for Animal Consciouness.* Oxford: Oxford University Press.

Dawkins MS (2003). Behaviour as a tool in the assessment of animal welfare. *Zoology (Jena)* 106: 383–387.

Dawkins MS (2005). The science of suffering. In: *Mental Health and Well-Being in Animals*. McMIllan FD(ed). Ames: Iowa State Press.

Dawkins MS (2006). A user's guide to animal welfare science. *Trends in Ecology and Evolution* 21: 77–82.

Dawkins MS, Donnelly CA, Jones TA (2004). Chicken welfare is influenced more by housing conditions than by stocking density. *Nature* 427: 342–344.

Den Ouden M, Nijsing J, Dijkhuizen A, Huirne R (1997). Economic optimization of pork production-marketing chains: I. Model input on animal welfare costs. *Livestock Production Science* 48: 23–37.

Do JC, Choi IH, Nahm KH (2005). Effects of chemically amended litter on broiler performance, atmospheric ammonia concentration, and phosphorous solubility in litter. *Poultry Science* 84.

Dohoo IR, Leslie K, DesCoteaux L, Fredeen A, Dowling P, Preston A, Shewfelt W (2003). A meta-analysis review of the effects of recombinant bovine somatotropin 1. Methodology and effects on production. *Canadian Journal Of Veterinary Research-Revue Canadienne De Recherche Veterinaire* 67: 241–251.

Douglass A. Personal communications with Adele Douglass, Founder and Executive Director, *Humane Farm Animal Care* (HFAC).

Drackley K, Donkin SS, Reynolds CK (2006). Major advances in fundamental dairy cattle nutrition. *Journal of Dairy Science* 89: 1324–1336.

Eastridge ML (2006). Major advances in applied dairy cattle nutrition. *Journal of Dairy Science* 89: 1311–1323.

Edwards SA, Fraser D (1997). Housing systems for farrowing and lactation. *Pig Journal* 37: 77–89.

efsa (2005). Welfare aspects of various keeping systems for laying hens. *The efsa Journal* 197: 1–23 (the full report can be downloaded at http://www.efsa.europa.eu/efsa/efsa_locale-1178620753812_1178620775132.htm).

Eicher SD (2001). Transportation of cattle in the dairy industry, current research and future directions. *Journal of Dairy Science* 84: E19–E23.

Elder RO, Keen JE, Siragusa GR, Barkocy-Gallagher GA, Koohmarie M, Lagried W (2000). Correlation of entero-hemorrhagic *Escherichia coli* 0157 prevalence in feces, hides and carcasses of beef cattle during processing. *Proceedings of the National Academy of Science* 97: 2999–3003.

Elson H (1985). The economics of poultry welfare. In: *Proceedings, Second European Symposium on Poultry Welfare*. Wegner R (ed). pp. 244–253. Celle, Germany: World's Poultry Science Association.

Etter L (2007). Smithfield to phase out crates: big pork producers yields to activists, customers on animal-welfare issue. *Wall Street Journal*, January, p. A14.

Fite G (1976). The pioneer farmer: A view over three centuries. *Agricultural History* 50: 275–289.

Fite G (1984). *American Farmers: The New Minority*. Bloomington, Indiana University Press.

Fleischer P, Metzner M, Beyerbach M, Hoedemaker M, Klee W (2001). The relationship between milk yield and the incidence of some diseases in dairy cows. *J. Dairy Sci.* 84: 2025–2035.

Forkman B, Boissy A, Meunier-Salaün MC, Canali E, Jones RB (2007). A critical review of fear tests used on cattle, pigs, sheep, poultry and horses. *Physiology and Behavior* 92: 340–374.

Fourichon C, Beaudeau F, Bareille N, Seegers H (2001). Incidence of health disorders in dairy farming systems in western France. *Livestock Production Science*, 68: 157.

Fraser D (1989). Role of ethology in determining farm animal well-being. In: Guttman HN, Mench JA, Simmonds RC (eds). *Science and Animals: Addressing Contemporary Issues.* Bethesda MD: Scientists Center for Animal Welfare.

Fraser D (1995). Science, values and animal welfare: exploring the 'inextricable connection'. *Animal Welfare*, 4: 103.

Fraser D, Matthews L (1997). Preference and motivation testing. In: *Animal Welfare*. Appleby MC, Hughes BO (eds). Wallingford: cab International.

Fraser D, Mench JA, Millman S (2001). Farm animals and their welfare in 2000. In: *State of the Animals 2000*. Rowan A, Salem D (eds). Washington, DC: Humane Society of the United States.

Fraser D, Weary DM (2004). Quality of life for farm animals: linking science, ethics, and animal welfare. In: *The Well-Being of Farm Animals: Challenges and Solutions*. Benson GJ, Rollin BE (eds). Ames: Blackwell.

Fraser D, Weary DM, Pajor EA, Milligan BN (1997). A scientific conception of animal welfare that reflects ethical concerns. *Animal Welfare* 6: 187–205.

Garner R (1998). *Political Animals: Animal Protection Politics in Britain and the United States.* New York: St. Martin's Press.

Garry FB (2004). Animal well-being in the US dairy industry. In: *The Well-Being of Farm Animals: Challenges and Solutions.* Benson GJ, Rollin BE (eds). Ames, IA: Blackwell.

Gjein H, Larssen RB (1995). Housing of pregnant sows in loose and confined systems—a field study. 1. Vulva and body lesions, culling reasons, and production results. *Acta Veterinaria Scandinavia* 36: 185–200.

Glatz PC (2000). Beak trimming methods - Review. *Asian-Australasian Journal Of Animal Sciences* 13: 1619–1637.

Glatz PC (2005). *Beak Trimming.* Nottingham: Nottingham University Press.

Goldschmidt W (1998). Conclusion: the urbanization of agriculture. In: *Pigs, Profits and Rural Communities*, KM Thu and EP Durrenberger Eds.. Albany, suny Press, pp. 183–198.

Gollehon M, Ribaudo M, Kellogg R, Lander C, Letson D (2001). *Confined Animal Production and Manure Nutrients.* Washington DC: usda Economic Research Service, Agricultural Informational Bulletin No. 771.

Gonyou HW (1994). Why the study of animal behavior is associated with the animal welfare issue. *J. Anim Sci.* 72: 2171–2177.

Gonyou HW (2005). Experiences with alternative methods of sow housing. *Journal of the American Veterinary Medical Association* 226: 1336–1340.

Gonyou HW, Stricklin WR (1998). Effects of floor area allowance and group size on the productivity of growing/finishing pigs. *Journal of Animal Science* 76: 1326–1330.

Grandin T (1981). Bruises on Southwestern feedlot cattle. *Journal of Animal Science*, 53 (Suppl. 1), 213.

Grandin T (1994). Solving livestock handling problems. *Veterinary Medicine* 89: 989–998.

Grandin T (1997). The design and construction of facilities for handling cattle. *Livestock Production Science* 49: 119–125.

Grandin T (1998). Handling methods and facilities to reduce stress in cattle. *Veterinary Clinics of North America: Food Animal Practice* 14: 325–341.

Grandin T (2000). *Livestock Handling and Transport*, Second Edition. Wallingford: cab International.

Grandin T (2005). Maintenance of animal welfare standards in beef slaughter plants by use of auditing programs. *Journal of the American Veterinary Medical Association* 226: 370–373.

Grandin T (2006). Progress and challenges in animal handling and slaughter in the US *Applied Animal Behaviour Science* 100: 129–139.

Grandin T (2007). *Livestock Handling and Transport, 3rd Edition*, 3rd edn. Wallingford, uk: cab International.

Grandin T, Deesing MJ (1998). Genetics and animal welfare. In: *Genetics and Behavior of Domestic Animals.* Grandin T (ed). San Diego, CA: Academic Press.

Grandinson K (2005). Genetic background of maternal behavior and its relation to offspring survival. *Livestock Production Science* 93: 43–50.

Green LE, Lewis K, Kimpton A, Nicol CJ (2000). Cross-sectional study of the prevalence of feather pecking in laying hens in alternative systems and its associations with management and disease. *Veterinary Record* 147: 233–238.

Greenough PR, Weaver AD (1997). *Lameness in Cattle.* London: WB Saunders Company.

Gregory C (Undated). Spent layers: A valuable resource? http://www.poultryworkshop. Gregory NG, Grandin T (1999). *Animal Welfare and Meat Science.* Wallingford, uk: cabi Publishing.

Gregory NG, Grandin T (1999). *Animal Welfare and Meat Science.* Wallingford, uk: cabi Publishing.

Grimes G, Plain R (2006). *US Hog Marketing Contract Study.* University of Missouri: Department of Agricultural Economics Working Paper Numbers aewp 2006–01.

Groenendaal H (2003). Controlling Johne's disease: Results of computer modeling. *Cattle Practice* 11: 219–225.

Gustafson LA, Cheng HW, Garner JP, Pajor EA, Mench JA (2007). The effects of different bill-trimming methods on the well-being of Pekin ducks. *Poultry Science* 86: 1831–1839.

Haley DB, de Passille AM, Rushen J (2001). Assessing cow comfort: effects of two floor types and two tie stall designs on the behaviour of lactating dairy cows. *Applied Animal Behaviour Science* 71: 105–117.

Hamilton D, Ellis M, Wolter B, Schinckel A, Wilson E (2003). The growth performance of the progeny of two swine sire lines reared under different floor space allowances. *Journal of Animal Science* 81: 1126–1135.

Hamilton TDC, Roe JM, Webster AF (1996). The synergistic role of gaseous ammonia in the aetiology of Pasterella multocida induced atrophic rhinitis in swine. *Journal of Clinical Microbiology* 43.

Hansen WP, Otterby DE, Linn JG, Anderson JF, Eggert RG (1994). Multi-farm use of bovine somatotropin for 2 consecutive lactations and its effects on lactational performance, health, and reproduction. *Journal of Dairy Science* 77: 94–110.

Harper G, Makatouni A (2002). Consumer perception of organic food production and farm animal welfare. *British Food Journal* 104: 287–299.

Harrison R (1964). *Animal Machines.* London: Vincent Stuart.

Hemsworth PH, Barnett JL, Beveridge L, Matthews LR (1995). The welfare of extensively managed dairy cattle: A review. *Applied Animal Behaviour Science* 42: 161.

Hemsworth PH, Coleman GJ (1998). *Human-Livestock Interactions: The Stockperson and the Productivity and Welfare of Intensively Farmed Animals*, 1st Edition. Wallingford: cab International.

Hendrickson M, Heffernan W (2005). *Concentration of Agricultural Markets.* University of Missouri: Department of Rural Sociology Working paper. Available at: http://www.cattlelawyers.com/CM/cattle_articles/cattle_articles428.html.

Herlin AH (1997). Comparison of lying area surfaces for dairy cows by preference, hygiene and lying down behaviour. *Swedish Journal Of Agricultural Research* 27: 189–196.

Hernandez-Mendo O, von Keyserlingk MA G, Veira DM, Weary DM (2007). Effects of pasture on lameness in dairy cows. *Journal of Dairy Science* 90: 1209–1214.

Hester PY, Shea-Moore M (2003). Beak trimming egg-laying strains of chickens. *Worlds Poultry Science Journal* 59: 458–474.

Hewson P (1986). Origin and development of the British poultry industry: the first hundred years. *British Poultry Science* 27: 525–539.

Holland RE, Carson TL, Donham KJ (2002). Animal health effects. In: *Iowa Concentrated Animal Feeding Operations Air Quality Study.* Ames: Iowa State University. http://www.public-health.uiowa.edu/ehsrc/cafostudy/cafo_final2–14.pdf.

Holzhauer M, Hardenberg C, Bartels CJM, Frankena K (2006). Herd- and cow-level prevalence of digital dermatitis in The Netherlands and associated risk factors. *Journal of Dairy Science* 89: 580–588.

Honeyman MS, Pirog RS, Huber GH, Lammers PJ, Hermann JR (2006). The United States pork niche market phenomenon. *Journal of Animal Science* 84: 2269–2275.

Horowitz R (2005). *Putting Meat on the American Table: Taste, Technology and Transformation.* Baltimore, John's Hopkins University Press.

hsus (2005). Coalition asks court to overturn New Jersey farming regulations. Humane Society of the US press release. http://www.hsus.org/press_and_publications/press_releases/coalition_asks_court_to.html.

hsus (2006). usda reverses decades-old policy on farm animal transport. http://www/hsus.org/farm/news: Humane Society of the US.

Hughes BO, Curtis PE (1997). Health and disease. In: *Animal Welfare.* Appleby MC, Hughes BO (eds), pp. 109–126. Wallingford, uk: cab International.

Huh S (2000). Consumer expectations for animal products: availability, price, safety and quality. In *Livestock Ethics and the Quality of Life.* Hodges J, Han K (eds). Wallingford, uk, cab International, pp. 119–129.

Hunter EJ, Jones TA, Guise HJ, Penny RHC, Hoste S (2001). The relationship between tail biting in pigs, docking procedure and other management practices. V*eterinary Journal* 161: 72–79.

Ingvartsen KL, Dewhurst RJ, Friggens NC (2003). On the relationship between lactational performance and health: is it yield or metabolic imbalance that cause production diseases in dairy cattle? A position paper. *Livestock Production Science* 83: 277–308.

James HJ, Klein P, Sykuta M (2007). Markets, contracts of integration? The adoption, diffusion and evolution of organizational form. In: *Contracting and Organizations Research Institute Working Paper.* Department of Agricultural Economics, University of Missouri. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=980301.

Jensen P, Toates FM (1993). Who needs 'behavioural needs'? Motivational aspects of the needs of animals. *Applied Animal Behaviour Science* 37: 161.

Johnson AK, Marchant-Forde JN (in press) Welfare of pigs in the farrowing environment. In: *The Welfare of Pigs.* Marchant-Forde JN (ed). Wallingford, uk, cab International.

Jones RB (1997). Fear and distress. In: *Animal Welfare.* Appleby MC, Hughes BO (eds). pp. 75–88. Wallingford, uk: cab Publishing.

Journal of Agricultural and Environmental Ethics (1993). *An International Conference on Farm Animal Welfare: Ethical, Scientific and Technological Perspectives.* Volume 6, Special Supplement 1.

Kelm SC, Freeman AE, Committee NC T (2000). Direct and correlated responses to selection for milk yield: results and conclusions of regional project NC-2, "Improvement of dairy cattle through breeding, with emphasis on selection." *Journal of Dairy Science* 83: 2721–2732.

Kirkden RD, Pajor EA (2006). Using preference, motivation and aversion tests to ask scientific questions about animals' feelings. *Applied Animal Behaviour Science* 100: 29.

Kjaer JB, Mench JA (2003). Behavior problems associated with selection for increased production. In: *Poultry Genetics, Breeding and Biotechnology.* Muir WM, Aggery SE (eds). pp. 67–82. Wallingford, uk: cab International.

Kliebenstein J, Larson B, Honeyman M, Penner, A (2003). A comparison of production costs, returns and profitability of swine finishing systems. In: *Department of Economics working paper number 03006.* Iowa State University. http://ideas.repec.org/p/isu/genres/10221.html.

Knowles TG (1999). A review of the road transport of cattle. *The Veterinary Record* 144: 97–201.

Kristensen HH, Wathes CM (2000). Ammonia and poultry welfare: a review. *World's Poultry Science Journal*, 56, 235–245.

Krohn CC, Munksgaard L (1993). Behaviour of dairy cows kept in extensive (loose housing/pasture) or intensive (tie stall) environments ii. Lying and lying-down behaviour. *Applied Animal Behaviour Science* 37: 1.

Kunkel HO (2000). *Human Issues in Animal Agriculture.* College Station, TX, Texas A&M University Press.

Lay DC, Friend TH, Randel RD, Bowers CL, Grissom KK, Jenkins OC (1992). Behavioral and physiological-effects of freeze or hot-iron branding on crossbred cattle. *Journal of Animal Science* 70: 330–336.

Lay DC, Wilson ME (2004). Considerations when using physiological data in assessing animal well-being. *Journal of Animal and Veterinary Advances* 3: 614–626.

LayWel (2007). *Welfare implications of changes in production systems for laying hens.* Deliverable 7.1: Overall strengths and weaknesses for each defined housing system for laying hens, and detailing the overall welfare impact of each housing system. http://www.laywel.eu/.

Lefcourt AM, Kahl S, Akers RM (1986). Correlation of indexes of stress with intensity of electrical shock for cows. *Journal of Dairy Science* 69: 833–842.

Leininger MT, Portocarrero CP, Schinckel AP, Spurlock ME, Bidwell CA, Nielsen JN, Houseknecht KL (2000). Physiological responses to acute endotoxemia in swine: effect of genotype on energy metabolism and leptin. *Domestic Animal Endocrinology* 18: 71–82.

Liang Y, Zin H, Li H, Koziel JA, Cai L (2005). Evaluation of treatment agents and diet manipulation on mitigating ammonia and odor emissions from laying hen manure. *Proceedings of the American Society of Agricultural and Biological Engineers Annual Meeting*, Paper No. 054160.

Lonergan GH, Dargatz DA, Morely PS, Smith MA (2001). Trends in mortality rates among cattle in US feedlots. *Journal of the American Veterinary Medical Association* 21: 1122–1127.

Lusk JL, Norwood RW, Prickett (2007). *Consumer Preferences for Farm Animal Welfare: Results of a Nationwide Telephone Survey.* http://asp.okstate.edu/baileynorwood/AW2/Initial ReporttoAFB.pdf.

Lyons CAP, Bruce JM, Fowler VR, English PR (1995). A comparison of productivity and welfare of growing pigs in four intensive systems. *Livestock Production Science* 43: 265–274.

MacDonald JM, Korb P, United States. Dept. of Agriculture. Economic Research Service (2006). *Agricultural Contracting Update: Contracts in 2003.* Washington, DC, United States Dept. of Agriculture Economic Research Service.

MacDonald JM, United States. Dept. of Agriculture. Economic Research Service (2004). *Contracts, Markets, and Prices: Organizing the Production and Use of Agricultural Commodities.* Washington, DC, US Dept. of Agriculture Economic Research Service.

Mader TL (2003). Environmental stress in confined beef cattle. *Journal of Animal Science* 81: (E. Suppl. 2): E110–E119.

Mader TL, Davis MS, Brown-Brandl T (2006). Environmental factors influencing heat stress in feedlot cattle. *J. Anim Sci.* 84: 712–719.

Marchant JN, Broom DM (1996). Effects of dry sow housing conditions on muscle weight and bone strength. *Animal Science* 62: 105–113.

Marchant JN, Rudd AR, Mendl MT, Broom DM, Meredith MJ, Corning S, Simmins PH (2000). Timing and causes of piglet mortality in alternative and conventional farrowing systems. *Veterinary Record* 147: 209–214.

Marchant-Forde JN, Lay Jr DC, Marchant-Forde R, McMunn KA, Pajor EA, Cheng H (2006). Alternative piglet processing procedures given singly affect cortisol behavior and growth. *Journal of Animal Science* 84: 412.

Martin SW (1983). Vaccination: is it effective in preventing respiratory disease or influencing weight gains in feedlot calves. *Can. Vet. J.* 24: pp. 10–19

Martinez S (1999). Vertical coordination in the pork and broiler industries: implications for pork and chicken products. In: *Agricultural Economic Report No. 777.* US Department of Agriculture, Economic Research Service.

Masoero F, Moschini M, Rossi F, Piva G (1998). Effect of bovine somatotropin on milk production, milk quality and the cheese-making properties of Grana Padano cheese. *Livestock Production Science* 54: 107–114.

Mason GJ, Latham NR (2004). Can't stop, won't stop: is stereotypy a reliable animal welfare indicator? *Animal Welfare*, 13, S57–A69.

Mason GJ, Rushen J (eds) (2007). S*tereotypic Animal Behaviour: Fundamentals and Applications to Animal Welfare*, second ed. edn. Wallingford: cabi.

McClary DG, Green HB, Basson RP, Nickerson SC (1994). The effects of a sustained-release recombinant bovine somatotropin (Somidobove) on udder health for a full lactation. *Journal of Dairy Science* 77: 2261–2271.

McEwen BS (2001). From molecules to mind: stress, individual differences, and the social environment. *Annals of the New York Academy of Sciences* 935: 42–49.

McGlone JJ, Hicks TA (1993). Teaching standard agricultural practices that are known to be painful. *J. Anim Sci.* 71: 1071–1074.

McGlone JJ, Vines B, Rudine AC, DuBois P (2004). The physical size of gestating sows. *Journal of Animal Science* 82: 2421–2427.

McKenna DR, Rober DL, Bates PK, Schmidt TB, Hale DS, Griffin DB, Savell JW, Brooks JC, Morgan JB, Montgomery TH, Belk KE, Smith GC (2002). National Beef Quality Audit 2000: Survey of targeted cattle and carcass characteristics related to quality, quantity, and value of fed steers and heifers. *Journal of Animal Science* 80: 1212–1222.

McMillan FD (Ed.) 2005. *Mental Health and Well-Being in Animals.* Boston, Massachusetts: Blackwell.

Meischke HRC, Ramsay WR Shaw, FD (1974). The effect of horns on bruising cattle. *Australian Veterinary Journal* 50: 432–434.

Mench JA (1998). Why it is important to understand animal behavior. *ILAR Journal* 39: 20–26.

Mench JA (2002). Broiler breeders: feed restriction and welfare. *World's Poultry Science Journal* 58: 23–29.

Mench JA (2003). Assessing animal welfare at the farm and group level: a US perspective. *Animal Welfare* 12: 493–503.

Mench JA (2004). Lameness. In: *Measuring and Auditing Broiler Welfare* (Ed. Weeks, CA, Butterworth, A.), pp. 3–18. Wallingford, uk: cabi Publishing.

Mench JA (2008). Farm animal welfare in the US—farming practices, research, education, regulation and assurance programs. *Applied Animal Behaviour Science.* Doi:10.1016/j.applanim.2008.01.009.

Mench JA, Mason GM (1997). Behavior. In: *Animal Welfare.* Appleby MC, Hughes BO (eds). Wallingford, uk: cab International.

Meyer RE, Morrow WEM (2005). Carbon dioxide for emergency on-farm euthanasia of swine. *Journal of Swine Health And Production* 13: 210–217.

Millman ST, Duncan IJH, Stauffacher M, Stookey JM (2004). The impact of applied ethologists and the International Society for Applied Ethology in improving animal welfare. *Applied Animal Behaviour Science* 86: 299–311.

Mintel (2002). *Eggs: Market Intelligence.* London: Mintel International.

Mitchell MA, Kettlewell PJ (1998). Physiological stress and welfare of broiler chickens in transit: solutions not problems! *Poultry Science* 77: 1803–1814.

Moberg GP (2000). Biological response to stress: implications for animal welfare. In: *The Biology of Animal Stress.* Moberg G, Mench J (eds). Wallingford: cab International.

Moynagh J (2000). eu regulation and consumer demand for animal welfare. *AGBioForum* 3: 107–114.

Muir WM (1996). Group selection for adaptation to multiple hen cages: Selection program and direct responses. *Poultry Science* 75: 447–458.

Muir WM (2003). Indirect selection for improvement of animal well-being. In: *Poultry Genetics, Breeding and Biotechnology*. Muir WM, Aggery SE (eds). pp. 247–256. Wallingford, uk: cabi Publishing.

Muir WM, Schinckel A (2002). Incorporation of competitive effects in breeding programs to improve productivity and animal well-being. In: *Proceedings 7th World Congress of Genetics Applied to Livestock Production*, pp. 35–38.

Nagaraja TG, Chengappa MM (1998). Liver abscesses in feedlot cattle: a review. *J. Anim Sci.* 76: 287–298.

Nagaranja TG, Lechtenberg K (2007). Liver abscesses in feedlot cattle. *Veterinary Clinics of North America: Food Animal Practice* 32: 351–365.

nahms (2002). *Part 1: Reference of Dairy Health and Management in the United States*. Fort Collins, Colorado: National Animal Health Monitoring System.

nass (2002). *2002 Census of Agriculture—United States*. Washington, DC, usda National Agricultural Statistics Service.

nass (2006). *US Hog Breeding Structure*. Agricultural Statistics Board, usda.

nass (2007). Ethanol co-products used for livestock feed. www.nass.gov.

ncba. 2007. *Guidelines for Handling and Care of Cattle*. Englewood, Colorado: National Cattlemen's Beef Association.

Newberry RC (2004). Cannibalism. In: *Welfare of the Laying Hen* (Ed. by GC Perry), pp. 239–258. Wallingford, uk: cabi Publishing.

njda (2003). Humane treatment of domestic livestock. Proposed new rule njda 2:8. http://www.state.nj.us/agriculture/rule168.pdf.

npb/aasv (Undated). *On Farm Euthanasia of Swine – Options for the Producer*. http://www.aasv.org/aasv/euthanasia.pdf.

oie (2004). *Global Conference on Animal Welfare*. Paris: oie.

oie (2007). http://www.oie.int/eng/bien_etre/en_introduction.htm.

Pajor EA, Fraser D, Kramer DL (1991). Consumption of solid food by suckling pigs: individual variation and relation to weight gain. *Applied Animal Behaviour Science* 32: 139.

Pajor EA, Busse C, Torrey S, Shea-Moore MM, Stewart T (2000a). The effect of selection for lean growth on swine behavior and welfare. *Proceedings Swine Day Report*, Purdue University, pp. 1–3.

Pajor EA, Rushen J, de Passille AMB (2000b). Aversion learning techniques to evaluate dairy cattle handling practices. *Applied Animal Behaviour Science* 69: 89–102.

Peel CJ, Eppard PJ, Hard DL (1998). Evaluation of sometribove (methionyl bovine somatotropin) in toxicology and clinical trials in Europe and the United States. In: *Biotechnology in Growth Regulation*. Heap RB, Prosser CG, Llamming GE (eds). London: Butterworths.

Petherick JC (2005). Animal welfare issues associated with extensive livestock production: The northern Australian beef cattle industry. *Applied Animal Behaviour Science* 92: 211.

Plain RL (2006). Trends in the US Swine Industry. *US Meat Export Federation Pork Conference*, 1997, http://www.ssu.missouri.edu/faculty/RPlain.

Prayaga N (2007). Genetic options to replace dehorning in beef cattle—a review. *Australian Journal of Agricultural Research* 58: 1–8.

Price B (2003). What happened to cattle cycles? *Cattle Feeders Annual—Cattle Marketing*, http://www.tcra.rog/Annual/AnnualTOC.htm.

Prunier A, Bonneau M (2006). Alternatives to piglet castration. *Productions Animales* 19: 347–356.

Purvis A (1998). An industrializing animal agriculture: challenges and opportunities associated with clustering. In: *Privatization of Information and Agricultural Industrialization*, SA Wolf, ed. New York, crc Press, pp. 117–149.

Radon K, Schulze A, Ehrenstein V, van Strien R, Praml G, Nowak D (2007). Environmental exposure to confined animal feeding operations and respiratory health of neighboring residents. *Epidemiology* 18: 300–308.

Rajala-Schultz PJ, Grohn YT, McCulloch CE (1999). Effects of milk fever, ketosis, and lameness on milk yield in dairy cows. *J. Dairy Sci.* 82: 288–294.

Rauch A, Sharp JS (2005). *Ohioans' Attitudes about Animal Welfare*. Social Responsibility Initiative. Department of Human and Community Resource Development, The Ohio State University. http://ohiosurvey.osu.edu/pdf/2004_Animal_report.pdf.

Rauw WM, Kanis E, Noordhuizen-Stassen EN, Grommers FJ (1998). Undesirable side effects of selection for high production efficiency in farm animals: a review. *Livestock Production Science* 56: 15–33.

Reynells RD (2004). United States Department of Agriculture: building bridges through innovative animal well-being initiatives. *Animal Welfare* 13: S175–180.

Rhodes RT, Appleby MC, Chinn K, Douglas L, Firkins LD, Houpt KA, Irwin C, McGlone JJ, Sundberg P, Tokach L, Wills RW (2005). Task Force Report—A comprehensive review of housing for pregnant sows. *Journal of the American Veterinary Medical Association* 227: 1580–1590.

Rich R (2008). Fecal Free: Biology and authority in industrialized Midwestern pork production. *Agricultural and Human Values* in press.

Robert S, Weary D, Gonyou H (1999). Segregated early weaning and welfare of piglets. *Journal of Applied Animal Welfare Science* 2: 31–40.

Rodenberg TG, Koene P (2004). Feather pecking and feather loss. In: *Welfare of the Laying Hen*. Perry GC (ed). pp. 227–238. Wallingford, uk: cabi Publishing.

Roex J, Miele M (2005). *Farm Animal Welfare Concerns: Consumers, Retailers and Producers*. Cardiff, Cardiff University.

Rollin B (1992). *Animal Rights and Human Morality*. Buffalo, New York, Prometheus.

Rollin B (1995a). *Farm Animal Welfare: Social Ethical and Bioethical Issues*. Ames, Iowa: Iowa State University Press.

Rollin BE (1995b). *The Frankenstein Syndrome: Ethical and Social Issues in the Genetic Engineering of Animals*. New York: Cambridge University Press.

Rushen J (ed). (2008). Farm animal welfare since the Brambell Report. *Special Edition, Applied Animal Behaviour Science* in press.

Rushen J, de Passille AMB, Munksgaard L (1999). Fear of people by cows and effects on milk yield, behavior, and heart rate at milking. *Journal of Dairy Science* 82: 720–727.

Rushen J, Passile AM D, von Keyserlingk MA, Weary DM (2008). *The Welfare of Cattle*. Springer, New York, New York.

Rutherford KMD (2002). Assessing pain in animals. *Animal Welfare*, 11, 31–53.

Salak-Johnson JL, Niekamp SR, Rodriguez-Zas SL, Ellis M, Curtis SE (2007). Space allowance for dry sows in pens: Body condition, skin lesions, and performance. *Journal of Animal Science* 85: 1758–1769.

Sapolsky RM, Romero LM, Munck AU (2000). How do glucocorticoids influence stress responses? integrating permissive, suppressive, stimulatory, and preparative actions. *Endocrine Review* 21: 55–89.

Sather AP (1987). A note on the changes in leg weakness in pigs after being transferred from confinement housing to pasture lots. *Animal Production* 44: 450–453.

scahaw (1999). *Animal welfare aspects of the use of bovine somatotropin:* Scientific Committee on Animal Health and Welfare.

Schreiner DA, Ruegg PL (2002a). Responses to tail docking in calves and heifers. *J. Dairy Sci.* 85: 3287–3296.

Schreiner DA, Ruegg PL (2002b). Effects of tail docking on milk quality and cow cleanliness. *J. Dairy Sci.* 85: 2503–2511.

Schroder M, McEachern M. (2004). Consumer value conflicts surrounding ethical food purchase decisions: a focus on animal welfare. *International Journal of Consumer Studies* 28: 168–177.

Schroder-Petersen DL, Simonsen HB (2001). Tail biting in pigs. *Veterinary Journal* 162: 196–210.

Schwartzkopf-Genswein KS, Stookey JM (1997). The use of infrared thermography to assess inflammation associated with hot-iron and freeze branding in cattle. *Canadian Journal Of Animal Science* 77: 577–583.

Schweikhardt DB, Browne WP (2001). Politics by other means: the emergence of a new politics of food in the United States. *Review of Agricultural Economics* 23: 302–318.

Shea-Moore MM (1998). The effect of genotype on behavior in segregated early-weaned pigs tested in an open field. *Journal of Animal Science* 76: 100.

Sinclair U (1906). *The Jungle*, 1st ed. Plain Label Books.

Singer P (1998). *Ethics into Action - Henry Spira and the Animal Rights Movement*. Oxford: Rowman, Littlefield.

Singer P (1975). *Animal Liberation*. New York, Random House.

Singer P (1990). *Animal liberation*, 2nd Edition. New York, Avon.

Smith D, Blackford M, Younts S, Moxley R, Gray J, Hungerford L, Milton T, Klopfenstein T (2001). Ecological relationships between the prevalence of cattle shedding Escherichia coli O157:H7 and characteristics of the cattle or conditions of the feedlot pen. *Journal of Food Protection* 64: 1899–1903.

Smith P, Daniel C (1982). *The Chicken Book*. San Francisco: North Point Press.

Snowder GD, Van Vleet LD, Cunniff LV, Bennett GL (2006). Bovine respiratory disease in feedlot cattle: environmental, genetic and economic factors. *Journal of Animal Science* 84: 1999–2008.

Somers JG CJ, Frankena K, Noordhuizen-Stassen EN, Metz JHM (2003). Prevalence of claw disorders in Dutch dairy cows exposed to several floor systems. *J. Dairy Sci.* 86: 2082–2093.

Stafford KJ, Mellor DJ (2005). The welfare significance of the castration of cattle: a review. *New Zealand Veterinary Journal* 53: 271–278.

St. Pierre NR, Cobanov B, Schnitkey G (2003). Economic losses from heat stress by US livestock industries. *Dairy Science* 86: E52–E77.

Stull CL (2001). Evolution of the proposed federal slaughter horse transport regulations. *Journal of Animal Science* 79: (E. suppl.), E12–E15.

Stull CL, Payne MA, Berry SL, Hullinger PJ (2002). Evaluation of the scientific justification for tail docking in dairy cattle. *Journal of the American Veterinary Medical Association* 220: 1298–1303.

Sunde M (2003). Seventy-five years of rising American poultry consumption: Was it due to the Chicken of Tomorrow contest? *Nutrition Today* 38: 60–62.

Swanson JC, Morrow-Tesch J (2001). Cattle transport: historical, research and future perspectives. *Journal of Animal Science* 79: E102–109.

Tauson R (1985). Mortality in laying hens caused by differences in cage design. *Acta Agriculturae Scandinavica* 34: 193–209.

Te Velde H, Aarts N, Woerkom vC (2002). Dealing with ambivalence: farmers and consumers perceptions of animal welfare in livestock breeding. *Journal of Agricultural and Environmental Ethics* 15: 203–219.

Thompson PB, Harris C, Holt D, Pajor EA (2007). Livestock welfare product claims: the emerging social context. *Journal of Animal Science* 85: 2354–2361.

Tucker CB, Weary DM, De Passille AM, Campbell B, Rushen J (2006). Flooring in front of the feed bunk affects feeding behavior and use of freestalls by dairy cows. *Journal of Dairy Science* 89: 2065–2071.

Tucker CB, Weary DM, Fraser D (2004). Free-stall dimensions: Effects on preference and stall usage. *Journal of Dairy Science* 87: 1208–1216.

Tucker CB, Weary DM, Fraser D (2005). Influence of neck-rail placement on free-stall preference, use, and cleanliness. *Journal of Dairy Science* 88: 2730–2737.

Turner SP, Dwyer CM (2007). Welfare assessment in extensive animal production systems: challenges and opportunities. *Animal Welfare* 16: 189.

Turner SP, Lawrence AB (2007). Relationship between maternal defensive aggression, fear of handling and other maternal care traits in beef cows. *Livestock Science* 106: 182–188.

Tuyttens F (2005). The importance of straw for pig and cattle welfare: A review. *Applied Animal Behavior Science* 92: 261–282.

Young T (2006). Recycling chickens. Santa Rosa Press Democrat. http://www1.pressdemocrat.com.

Young T (2006). Recycling chickens. The Press Democrat, November 22. http://www1.pressdemocrat.com/apps/pbcs.dll/article?aid=/20061122/news/611220399/1033/news01. Accessed April 30, 2008.

uep (2007). *Animal Husbandry Guidelines for US Egg-Laying Flocks*. http://www.uepcertified.com/.

usda (2000). *Part I: Baseline Reference of Feedlot Management Practices, 1999*. usda-aphis: vs, ceah, National Animal Health Monitoring System, Fort Collins, Colorado. #N327.0500.

usda (2002). *Part I: Reference of Dairy Health and Management in the US* usda.

usda (2007). *Dairy 2007, Part I: Reference of Dairy Health and Management Practices in the United States*. usda-aphis-vs, ceah. Fort Collins, Colorado. #N480.1007.

usda-ers (2002). Recent growth patterns in the US organic food market. Publication AIB-777. United States Department of Agriculture Economic Research Service.

Van De Weerd HA, Docking CM, Day JE L, Breuer K, Edwards SA (2006). Effects of species-relevant environmental enrichment on the behaviour and productivity of finishing pigs. *Applied Animal Behaviour Science* 99: 230–247.

Vandenberg JG, Ahl AS, Coffin JM, Eyestone WH, Hallerman EM, Lee TC, Mench JA, Muir WM, Roberts MR, Schettler TH, Shook LB, Taylor MR (2003). *Animal Biotechnology: Science-Based Concerns*. Washington, DC: National Academy Press.

Van Horne PLM, Bondt N (2003). *Impact of EU Council Directive 99/74/ED "Welfare of Laying Hens" on the Competitiveness of the EU Egg Industry*. Final Report, Project 63742. LEI, The Hague.

Wabeck C (2002). Quality assurance and food safety —chicken meat. In: *Commercial Chicken Meat and Egg Production*. Bell DD, Weaver WD (eds). pp. 871–887. Dordrecht, The Netherlands: Kluwer.

Washburn SP, White SL, Green Jr JT, Benson GA (2002). Reproduction, Mastitis, and Body Condition of Seasonally Calved Holstein and Jersey Cows in Confinement or Pasture Systems. *Journal of Dairy Science* 85: 105–111.

Weary DM, Fraser D (1995). Signalling need: costly signals and animal welfare assessment. *Applied Animal Behaviour Science* 44: 159.

Weary DM, Jasper J, Hotzel MJ (2008). Understanding weaning distress. *Applied Animal Behaviour Science* 110: 24–41.

Weary DM, Niel L, Flower FC, Fraser D (2006). Identifying and preventing pain in animals. *Applied Animal Behaviour Science* 100: 64–76.

Weeks C, Nicol C (2000). Poultry handling and transport. In: *Livestock Handling and Transport, 2nd Edition* (Ed. by Grandin, T.). Wallingford, uk: cab International.

West JW (2003). Effects of heat-stress on production in dairy cattle. *Journal of Dairy Science* 86: 2131–2144.

Whitehead CC (2004). Skeletal disorders in laying hens: the problem of osteoporosis and bone fractures. In: *Welfare of the Laying Hen*. Perry GC (ed). pp. 259–278. Wallingford, uk: cabi Publishing.

Wise S (2003). The evolution of animal law since 1950. In: *State of the Animals II: 2003*. Salem D, Rowan A (eds). pp. 99–105. Washington, DC: Humane Society Press.

Wolfson DJ, Sullivan M (2004). Foxes in the henhouse: animals, agribusiness and the law: an American fable. In: *Animal Rights: Current Debates and New Directions*, Sunstein C, Nussbaum M (eds). New York, Oxford University Press, pp. 205–233.

Wolter BF, Ellis M, Curtis SE, Parr EN, Webel DM (2000). Group size and floor space allowance can affect weanling pig performance. *Journal of Animal Science* 78: 2062–2067.

Worobek E, Duncan IJH, Widowski T (1999). The effects of weaning at 7, 14 and 28 days on piglet behaviour. *Applied Animal Behaviour Science* 62: 173–182.

Zaludik K, Lugmair A, Baumung R, Troxler J, Niebuhr K (2007). Results of the Animal Needs Index (ANI-35L) compared to animal-based parameters in free-range and organic laying hen flocks in Austria. *Animal Welfare* 16: 217–219.

Zimmerman PH, van Hoof JA (2000). Thwarting of behaviour in different contexts and the gackel-call in the laying hen. *Applied Animal Behaviour Science* 69: 2559264.

The pcifap is a two-year study funded by The Pew Charitable Trusts through a grant to the Johns Hopkins Bloomberg School of Public Health. This report was commissioned to examine the specific aspects of ifap contained herein. It does not reflect the position of the Commission. The positions and recommendations of the pcifap are contained in its final report.

Acknowledgments: This report is supported by a grant from The Pew Charitable Trusts. The opinions expressed are those of the author(s) and do not necessarily reflect the views of The Pew Charitable Trusts.

The Commission gratefully acknowledges the contribution of Dr. Amira Roess during her tenure as Science Director with the Commission.

Joy A. Mench
Professor
Director of the Center for Animal Welfare
Department of Animal Science
University of California, Davis

Harvey James
Associate Professor
Department of Agricultural Economics
University of Missouri

Edmond A. Pajor
Associate Professor
Director of the Center for Food-Animal Well-Being
Department of Animal Sciences
Purdue University

Paul B. Thompson
W.K. Kellogg Professor of Agriculture
Food and Community Ethics
Departments of Philosophy,
Agricultural Economics and Community,
Agriculture, Recreation and Resource Studies
Michigan State University

The pcifap thanks the reviewers for their time, expertise, and insights. The opinions expressed in this report do not necessarily represent the views of these individuals or their organizations.

PEW COMMISSION ON
INDUSTRIAL FARM
ANIMAL PRODUCTION