

Farm Animal Welfare: In Legislatures, Corporate Boardrooms, and Private Kitchens

7

CHAPTER

Andrea Gavinelli and Miyun Park

Introduction

Luxembourg, April 2004: The Council of the Agricultural Minister of the European Union fails to achieve long-awaited political agreement among member countries for the adoption of a new European regulation to upgrade existing legislation on the protection of animals during transport.

In one month's time, ten countries would be joining the European Union (EU) and become part of a unique European market, increasing the already large number of animals traveling on European roads. With the impending expansion of the EU, the passage of such a regulation was paramount.

Intense negotiations to find a proper compromise between animal protection and the economic interests of the sectors involved had been going on for months. Member states fought from opposite extremes: no changes to the status quo because of negative economic impacts on one side, and no transport of animals for slaughter on the other. Indeed, that particular night, the European ministers felt great pressure from both the general public, worried about the possibility of increasing the suffering of animals traveling thousands of kilometers primarily just to be slaughtered,

and the economic operators, who were ready to develop an even larger transport network to cope with the new demands of an enlarged European market.

The debate concluded in December 2004 with an agreement by the EU ministers on a new European regulation for the protection of animals during transport (European Commission 2005a). The regulation did not mandate more appropriate traveling times and loading densities for the transported animals, but, as a compromise, it did introduce for the first time the use of satellite navigation systems to trace the transport of animals in the EU.

The months of negotiations, argument, and political strategizing reveal the climate of debate on animal protection in Europe in 2004. They clearly indicated that a new approach—one not based only on adopting new legislation—was needed to advance the demands of a society in the process of changing its relationship with animals while at the same time associating respect for an animal's welfare with the concept of a higher-quality product. These demands are found not only in the EU, but increasingly, in the United States as well.

A Global Perspective

According to the Food and Agriculture Organization of the United Nations, globally, approximately 56 billion land animals—including nearly 48 billion broiler chickens—are slaughtered for human consumption in a single year (Food and Agriculture Organization of the United Nations 2004), in addition to an untold number of aquatic animals. The numbers of individual animals raised and killed by the meat, egg, and dairy industries far surpass the number of animals with whom human beings have any other relationship—whether they be those seen as fabric, target practice, test tubes, companions, or sideshow spectacles.

By continent, Asia raises approximately 23 billion farm animals, Africa nearly 4 billion animals, and Australia an estimated 500 million, while Europe, North America, and South and Central America (combined) each raise approximately 10 billion animals. With the exception of Africa, chickens (broiler chickens and laying hens) account for 90 percent of all nonaquatic farm animals used in agriculture on each continent. Globally, broiler chickens

comprise 85 percent of the total farm animals used, laying hens 8 percent, beef cattle 3 percent, goats 2 percent, and pigs and dairy cows 1 percent each.

As of 2006 traditional (extensive) farming methods remained widespread in Africa and parts of Asia, but the reach of industrialized animal agribusiness customary in Western countries had extended to developing countries, particularly in Asia and Latin America, increasingly favoring intensive production systems over more welfare-friendly practices (Nierenberg 2006).

Productivity and Its Impact

Although animal agribusiness representatives often claim it is in their own interest to treat animals well, the simplistic notion that “only happy animals produce,” thereby making welfare critical to the practice and efficacy of animal production—whether extensive or intensive—is disputed by expert animal welfare scientists and ethologists.

According to poultry welfare expert J. Mench,

It is now generally agreed that good productivity and health are not necessarily indicators of good welfare....Productivity...is often measured at the level of the unit (e.g., number of eggs or egg mass per hen housed), and individual animals may be in a comparatively poor state of welfare even though productivity within the unit may be high. (Mench 1992, 112)

Farm animal welfare expert D. Broom observes,

[E]fforts to achieve earlier and faster growth, greater production per individual, efficient feed conversion and partitioning, and increased prolificacy are the causes of some of the worst animal welfare problems. (Broom 2000, n.p.)

Agricultural ethicist B.E. Rollin (n.d., n.p.) asserts, “[I]n industrial agriculture, this link between productivity and well-being is severed. When productivity as an economic metric is applied to the whole operation, the welfare of the individual animal is ignored.” A recent review concluded that:

Apart from a favorable increase in production, animals in a population that have been selected for high production efficiency seem to be more at risk for behavioral, physiological, and immunological problems. (Rauw et al. 1998)

Looking to the most prominent Western country, the United States, and its poultry industry, as a case study, it is clear that productivity has caused serious concern about the consequences for the animals’ health and welfare. The overwhelming majority of the nearly 10 billion birds raised for egg production or human consumption each year in the United States, as reported by the U.S. Department of Agriculture (USDA), are members of breeds bred selectively for high rates of lay or to achieve slaughter weight in the shortest time. During 2004 approximately 300 million hens produced 76.2 billion table eggs, with each hen laying an annual average of 260 eggs (U.S. Department of Agriculture [USDA], National Agricultural Statistics Service 2005a). This is a more than tenfold increase over the approximately 25 eggs their ancestors, Red Junglefowl (Arshad 1999), laid each year and more than double the average 100 eggs laid annually by hens in the 1940s (United Egg Producers 2006). In just the last five decades, the rearing time for broiler chickens decreased by nearly half, from 84 to 45 days (Duncan 2001; personal correspondence, G. Matheny with S. Pretanik, director of Science and Technology, National Chicken Council, January 14, 2004), and 2006’s turkeys reached thirty-five pounds in weight in 132 days,

rather than the 220 days it took forty years ago (Ferket 2004). Emphasizing productivity can often be at odds with animal welfare and, as a result, has severely reduced the health and well-being of farmed birds. Data show that up to nine of ten egg-laying hens now suffer from osteoporosis, a disorder largely genetic in origin and exacerbated by the battery-cage system customary in the U.S. egg industry (Webster 2004). Forced rapid growth has caused many broiler chickens and turkeys acute and chronic pain, leg abnormalities and disorders, skeletal and cardiovascular disease, and other disabilities (Scientific Committee on Animal Health and Welfare 2000; Duncan 2004a; Mench 2004; The Humane Society of the United States 2006).

Human-Animal Relationship

As countries urbanize and farm animal production intensifies, consumers become increasingly removed from animals raised by the meat, egg, and dairy industries. This detachment could explain the prevalence of intensive animal agriculture in the United States as well as Americans’ minimal understanding of farm animal welfare concerns when compared with, for example, the practices and knowledge of EU citizens. According to a 2002 U.S. census of agriculture, approximately 1 million Americans (compared with a total population of nearly 300 million) are animal farm operators, and numerous sources point to the growing population numbers in urban or suburban areas, compared to rural, farming communities. In contrast, according to a European Commission’s (EC) (2005b) Eurobarometer report, 68 percent of EU citizens (in twenty-two out of twenty-five countries) had visited animal production farms, and nearly 40 percent of them had

done so more than three times. These and other findings led the authors to conclude that “[v]isits to farms seem to increase the awareness [of] and concern for animal welfare” (European Commission 2005b).

Consumer Concern for the Treatment of Farm Animals

“[C]onsumers are increasingly concerned by the quality of food they buy, where it comes from and how it was produced,” reported Scotland’s *The Herald* (Buglass 2006). Said T. Fowler, senior economist with the U.K. Meat and Livestock Commission and author of the study “Ethical Consumerism in the U.K.,”

Fair trade, organic, free range, or cruelty free are the most widely accepted understandings (of ethical consumerism).... There is a surprisingly high proportion of consumers—52 percent—whose buying patterns are determined by perceptions of what is ethical. (In Buglass 2006, n.p.)

Indeed, whether they have direct experience with animal production or have never visited a facility, when asked, a majority of citizens of the United States and the EU share concerns about the welfare of farm animals.

In the United States, a number of surveys show that the majority of Americans favor the humane treatment of farm animals: 81 percent of Americans polled agreed that birds should be included in the federal Humane Methods of Slaughter Act, which would require them to be rendered insensible to pain before shackling and slaughtering (Penn, Schoen, and Berland 2005); 82 percent agreed that effective laws should protect farm animals against cruelty and abuse (Zogby International 2003); 72 percent believed

farms should be inspected by government officials to ensure laws protecting animals from cruelty are being followed (Zogby International 2003); 66 percent found farm animal exemption from state cruelty laws to be unacceptable (Zogby International 2003); and 62 percent supported passing strict laws concerning the treatment of farm animals (Moore 2003).

In Europe, in responding to specific surveys, citizens say they no longer view farming animals simply as a means of food production. Instead, they see it as relevant to other key social goals, such as food safety and quality, environmental protection, sustainability, and the humane treatment of animals. In 2001 the results of an EU-funded study on consumer concerns about animal welfare and their impact on food choice showed that

[a]lthough consumers are concerned about farm animal welfare, this concern is not a priority in food choice...consumers use animal welfare as an indicator of other, usually more important product attributes, such as food safety, quality and healthiness.... Although the majority of consumers report high level of concerns about farm animal welfare, such concerns are not translated into behavior, the research identified a series of barriers to purchasing animal friendly products. (Harper and Henson 2001)

In 2005 and 2006, Eurobarometer surveys and Internet consultations conducted on behalf of the European Commission highlighted the importance of animal protection to European consumers: 60 percent of respondents said they were worried about farm animal welfare, which scored higher than concerns over BSE (bovine spongiform encephalopathy, or mad cow disease) or gaining weight, and previously 82 percent felt they had a duty to protect ani-

mals, whatever the cost (Harper and Henson 2001). The findings expressed dissatisfaction with the level of significance government attributed to the treatment of farm animals, with 55 percent stating that animal welfare/protection does not receive enough importance in their countries’ agricultural policies (European Commission 2005b).

In this context it is important to educate consumers about measures taken at the EU and international levels to ensure improved animal protection as well as any extra costs associated with such initiatives. While 74 percent of respondents believed that buying animal welfare-friendly products could have a positive effect on animal welfare, only 43 percent stated that they could identify such products from the label. Other similar surveys in the United Kingdom have shown that consumers considered production methods, such as organic or free-range, as more important for food choice than country of origin or brand name.

Willingness to Pay

As improvements in animal welfare are demanded at the farm level, the issue of consumers’ willingness to absorb higher costs for products becomes increasingly important—and controversial. The question of who will bear any extra costs derived from higher animal welfare standards is commonly raised in both the EU and the United States. Increasing data show that investments in good standards for animal welfare are economically advantageous.

Consumers in the EU and the United States report a willingness to pay higher prices for products sourced from more animal welfare-friendly production systems. In the EU 57 percent of survey respondents in the Eurobarometer stated they would pay a premium for more animal welfare-friendly eggs, for example. In the United States, sim-

ilar findings have been reported. In a 2004 Golin/Harris poll for the United Egg Producers, 54 percent of consumers said they were willing to pay 5–10 percent more for eggs labeled “Animal Care Certified,” without any information about what the label actually meant; 10 percent reported they were willing to pay 15–20 percent more; and 77 percent reported they would consider switching to a brand with such a label (Golin/Harris International 2004). Research suggests consumers are willing to pay an average of 17–60 percent more for eggs from non-cage systems (Bennett and Larson 1996; Bennett 1997a; Animals Australia 1998; Rolfe 1999; Bennett and Blaney 2003).

Although survey data indicate a clear willingness to pay for higher-welfare products, the problem lies in putting these stated claims into practice. Nevertheless, the concerns of the majority of consumers regarding the treatment of farm animals have not yet been taken seriously.

The public good benefits of measures to improve animal welfare also deserve assessment. A study on moral intensity and willingness to pay with regard to farm animal welfare issues and the implications for agricultural policy revealed that the value to society of measures to improve animal welfare must be considered in a cost-benefit framework—for example, the value of benefits to an individual could be assessed in terms of her willingness to pay for animal welfare improvements. Using such models, various studies have shown that the benefits of animal welfare measures greatly outweigh the costs of better farming practices over customary intensive systems that deprive animals of many behavioral and physiological needs. In addition to those consumers who demand and purchase animal welfare-friendly products, others can derive significant satisfaction derived from the knowledge that

such animals are afforded protections denied to those reared in industrial systems. Therefore, private consumption and public good aspects need to be taken into account. Some have postulated that

Providing that consumers are fully informed about the animal welfare implications of their purchasing decisions, the market will ensure that consumers purchase animal products which will maximize their individual net benefits from consumption. (Bennett 1997b, 243)

and that “society is placing an implicit (money) value on animal suffering” (Bennett 1997b, 241).

Consumers have identified a series of barriers to purchasing animal-friendly products—chiefly lack of education and information about production methods, lack of transparency, lack of availability of products, lack of belief in the ability of individual consumers to make a difference in animal welfare standards, disassociating the product from the animal of origin, and the increased cost of animal-friendly products. Consumers expressed a preference for a combined strategy of setting minimum animal welfare standards and adapting present agricultural policy to provide farmers with incentives to change over to more humane systems.

Responses to Growing Interest in Farm Animal Welfare

Given increasing consumer concern over the treatment of animals raised for meat, eggs, and milk, it follows that animal welfare is increasingly on the agendas of government agencies, academic institutions, corporations, nongovernmental organizations (NGOs), investment banks, and leading public

health and animal health organizations. As a result a number of recommendations, standards, directives, laws, and initiatives have emerged at national and international levels, providing guidelines or minimum standards to improve the well-being of animals in agriculture. These movements indicate an increasing awareness that human beings’ relationship with and treatment of farm animals are issues worthy of attention.

In recent years such diverse entities as the Austin, Texas-based grocer and Fortune 500 company, Whole Foods Market, the International Finance Corporation of the World Bank, the World Organization for Animal Health (OIE), and Google have helped to move farm animal welfare to the foreground of public discourse with their respective policies or recommendations. For example, Whole Foods Market as of 2007 had not only made a commitment to offer welfare-friendly products, but it had also taken a leadership role in moving animal agribusiness toward more extensive production systems (those with non-intensive production practices) with its development of Animal Compassionate Standards (<http://www.wholefoodsmarket.com/issues/animalwelfare/index.html>). In October 2006 the International Finance Corporation ([http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/p_AnimalWelfare_GPN/\\$FILE/AnimalWelfare_GPN.pdf](http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/p_AnimalWelfare_GPN/$FILE/AnimalWelfare_GPN.pdf)) issued its Animal Welfare in Livestock Operations Good Practice Note, which begins

Animal welfare is gaining increased recognition as an important element of commercial livestock operations around the world...Animal welfare is just as important to humans for reasons of food security and nutrition... Higher animal welfare standards are also increasingly seen to be a prerequisite to enhancing business efficiency

and profitability, satisfying international markets, and meeting consumer expectations.

The OIE, a worldwide organization with 167 member countries, adopted a complete set of guidelines in 2005 to protect animals during transport by land and by sea, at slaughterhouses, and at killing for disease eradication. And in May 2006 Internet giant Google adopted a corporate policy to discontinue the use of eggs from caged laying hens in all of its employee cafés.

Legislative Efforts: A European Perspective

In the United States, animals reared by the meat, egg, or dairy industries are afforded no legal protections while on the farm and only minimal protection during transport. USDA does not require the overwhelming majority of them (specifically birds, who account for nine of ten farm animals) to be rendered insensible to pain before shackling and slaughter. In contrast, the EU has adopted a specific legislative approach for the welfare of animals from the farm to the slaughter plant.

The first EU legislation on animal welfare, adopted in 1974, concerned the stunning of animals before slaughter (European Economic Community 1974). While this initiative indicated the importance the European Economic Community (EEC) already attached to animal welfare and the prevention of unnecessary suffering, its purpose was strictly to reduce the impact on the internal market of different measures in EEC member states that could create additional costs. Despite the pure economic aim, the Directive of 1974 (n.p.) posited:

Whereas the Community should also take action to avoid in gen-

eral all forms of cruelty to animals; whereas it appears desirable, as a first step, that this action should consist in laying down conditions such as to avoid all unnecessary suffering on the part of animals when being slaughtered....

Following the humane charge outlined in the directive on protecting animals at slaughterhouses, many other legislative steps have been taken. As of 2006 in the EU, calves older than eight weeks had to be kept in groups without tethering and muzzling, pregnant sows could no longer be kept in individual crates, and cages for laying hens without materials for enrichment—animal production practices that remain customary in the United States—were to be phased out. During transport, animals in the EU could be trucked for a maximum of eight hours; if they must travel for longer, the animals must do so in vehicles specially equipped for long-distance journeys with water and food in sufficient quantity. Since 1993 specific welfare requirements detail protections for handling, managing, and stunning or killing animals in slaughterhouses.

Directive 98/58/EC on the protection of animals kept for farming purposes underlines the principles forming the basis of EU animal welfare legislation and highlights the need to treat animals according to their physiological and ethological needs. Respecting the basic five freedoms¹—freedom from discomfort; from hunger and thirst; from fear and distress; from pain, injury and disease; and freedom to express natural behavior—is a fundamental principle, and the EU has already taken various practical steps to secure real improvements in animal welfare.

Also underpinning the EU's animal welfare policy is a specific protocol on the Protection and Welfare of Animals introduced via the

Treaty of Amsterdam in 1999. This protocol recognizes that animals are “sentient beings” and obliges the European institutions and member states to pay full regard to the welfare requirements of animals when formulating and implementing community legislation in agriculture, transport, internal market, and research.

The Socio-Economic Costs of Animal Welfare

It has been demonstrated that any requirement implying investments and changes to existing production systems may have an impact on production costs.

In recent years, the European Commission has taken important steps in developing specific studies and impact assessments on the socioeconomic implications of animal welfare measures. These efforts have been undertaken by several public and private organizations. In particular, important university institutes in Europe have studied the impact of animal welfare on the trade of animal products and on the European market, and the economic impact of animal welfare measures on products that are globally competitive, such as eggs, pork, and poultry (see as examples *Agra CEAS Consulting* 2004; *DEFRA, U.K.* 2005; *van Hoorne* 2005). In the United States, The Humane Society of the United States has prepared a series of analyses comparing intensive production methods with more welfare-friendly systems (see <http://www.farmanimalwelfare.org>). The findings indicate that practices that improve animal well-being are economically viable.

As the EU and U.S. poultry industries are very similar and integrated, analysis of broiler production may be of interest, particularly since poultry meat has become a global commodity.

Stocking Density

In studies concerning a 2005 European Commission proposal on the welfare of chickens kept for meat production, it has been shown that the price of a chicken would rise by either 8 or 2.5 Euro cents to maintain farmers' earnings at the maximum stocking densities of 30 or 38 kg/m², respectively, foreseen in the European Commission's recent legislative proposal on this issue. Nevertheless, while this may seem negligible, the margins at which modern farms operate and international trade competes also need to be considered. A U.K. study on broiler production calculated an average overall net margin of 3.0 pence per bird for the 600 million birds produced in England in 2002.

Growth

Virtually all chickens reared for meat are members of fast-growing breeds selectively bred to reach market weight as efficiently as possible—that is, in a shorter time with less feed. Eighty-five to 90 percent of these significant reductions in time and feed intake is due to genetics, and 10 percent to 15 percent to nutritional changes (Havenstein, Ferket, and Qureshi 2003). Such rapid growth has contributed to serious welfare challenges for birds, including skeletal and cardiovascular disease as well as chronic hunger in breeding stock (Scientific Committee on Animal Health and Animal Welfare 2000; Duncan 2004a; Mench 2004). “Without a doubt, the biggest [animal] welfare problems for meat birds are those associated with fast growth,” concludes poultry welfare science expert I. Duncan (2004a, 310).

It used to be thought that all farm animal welfare problems could be solved by correct environmental design. Experience with modern broilers and their parent stock, broiler breeders, has cast doubt on this assumption....[T]o a large extent, the

welfare problems [of broiler chickens]...will not be solved by environmental manipulations. It is the bird that must be changed, and the long-term solution is in the hands of the primary breeding companies. (Duncan 2004b, xii)

The costs of poultry breeding programs are negligible—around 0.5 percent of live production value (Arthur and Albers 2003). However, adopting slower-growing breeds does involve increased running costs. The EU's Scientific Committee on Animal Health and Animal Welfare (SCAHAW) modeled the additional production costs involved in adopting slower-growing poultry breeds (Scientific Committee on Animal Health and Animal Welfare [SCAHAW] 2000), and found that slower growth would increase running costs primarily by delaying the slaughter age from forty one to fifty one days (in the European case). These costs would be partly offset by a 65 percent reduction in weekly mortality rates, a 10 percent increase in feed conversion ratios, and a lower chick price because of improved breeder fertility and egg hatchability in slower-growing breeds. SCAHAW concluded that running production costs of slower-growing breeds would be about 5 percent higher than those of conventional breeds (SCAHAW 2000).

In its model, SCAHAW did not include quality price premiums made possible through slower growth, for example, color and water-holding capacity are frequently reported to be poorer in faster-growing flocks (Remignon and Le Bihan-Duval 2003). The SCAHAW model also did not include the decrease in condemnations and downgrades due to better bone health in slower-growing breeds, which could represent significant savings. A 1994 survey in the United States estimated that losses to producers due to leg problems were \$80 million to \$120

million for broilers and \$32 million to \$40 million for turkeys (Sullivan 1994). Adjusting for the increase in the value of poultry production and assuming no change in the percentage of birds with leg problems, annual losses could now run \$144 million to \$216 million for broilers and \$37 million to \$46 million for turkeys (USDA/National Agricultural Statistics Service 1998, 2005b).

Catching of Poultry

Customary catching and crating of broiler chickens for transport to slaughter involves manual efforts. Birds generally are caught by hand and carried inverted by a single leg, three or four birds per hand. During an average shift, a single catcher will lift between five and ten tons of birds at a rate of 1,000 to 1,500 animals an hour (Nijdam et al. 2004; Ramasamy, Benson, and Van Wicklen 2004). In the United States, catching crews typically are paid by the shed (unit of housing) or by weight, so there is little incentive to be gentle in handling (Grandin 2003). Nijdam et al. (2004) report that “[f]or a member of a catching team, it could be difficult to maintain concentration and exercise care throughout a longer catching time.” Rough handling, which causes birds to experience fear (Jones 1992), can increase as crews become fatigued. Lacy and Czarick (1998) concluded that

[A]s fatigue sets in, one's primary motivation becomes just getting the job over with. Catching and crating the birds as quickly as possible with the minimum effort possible becomes the major focus. Careful handling becomes secondary.

Birds raised for meat are typically unaccustomed to being touched by humans. When handled, their plasma corticosterone levels elevate, a physiological indicator of stress (Duncan 1989; Elrom 2000). The method of handling can also

affect stress. Kannan and Mench (1996) report that both being carried with other birds and being inverted elevate plasma corticosterone levels compared to the levels of birds carried singly and upright.

In addition to stress and fear, birds suffer a number of injuries during catching, including bruises, broken bones, torn skin, and dislocations. Injuries associated with manual catching are well documented:

- Kettlewell and Turner (1985) found that as many as 20 percent of birds experienced injuries during catching that led to carcass downgrading.
- *The Wall Street Journal* reported that “up to 25 percent of broilers on some farms are hurt in the [catching] process” (Kilman 2003).
- Five percent to 25 percent of poultry carcasses at processing plants exhibit bruising of the breast, thighs, or wings (Farsaie, Carr, and Wabeck 1983; McGuire 2003).
- Griffiths (1985) estimated that 40 percent of bruises recorded at processing plants are caused by catching and crating, while McGuire (2003) estimated 90 percent.
- Grandin (2003) recounted one operation in which 5 percent of birds had broken wings caused by rough catching.
- Nijdam et al. (2006) reported that 29.5 percent of dead-on-arrival (DOA) broiler chickens at slaughterhouses exhibited trauma that the authors attributed to catching and crating.
- Bayliss and Hinton (1990) reported that 35 percent of DOA broiler mortality was due to catching and transport injuries.

In a review of poultry welfare problems caused during catching and transport, Knowles and Broom (1990) concluded, “[T]he most traumatic stages of the process and the stages most likely to give rise to physical damage, are the times when the birds are manually handled.”

In contrast, birds harvested mechanically with machinery that “catches” them via a ramp or rubber-fingered rotors and pulls them upright on a conveyer belt to transport crates, had significantly lower rates of bruises, fractures, and dislocations than did conventionally manually caught birds (Knierim and Gocke 2003). Leg, wing, and rump injuries were 50 percent, 22 percent, and 27 percent lower, respectively, and the number of birds with one or more injuries was 30 percent lower. Lacy and Czarick (1998) found that rates of leg bruising were 58 percent lower with mechanical harvesting, while Elrom (2000) reviewed studies finding that mechanically harvested birds had injury rates 25 percent to 87 percent lower than manually caught birds.

The principal cost associated with adoption of mechanical harvesting is the capital investment in a harvester—between \$150,000 and \$200,000 (Lacy and Czarick 1998; Bellett 2003). These systems reduce labor costs by employing crews half the size of those used in conventional manual catching, while maintaining similar catch rates. Knierim and Gocke (2003) found that three-person mechanical harvesting teams loaded 8,000 birds in an average of 55 to 60 minutes, while six-person manual catching teams loaded 8,000 birds in 40 to 50 minutes. Thus, the catch rate per person-hour for the mechanical harvester was 2,667 to 2,909 birds per person-hour—33 percent to 82 percent higher than that for the conventional manual catching team. Nijdam et al. (2005) found that the catch rate for mechanical harvesting was 114 percent higher per person-hour than the rate for conventional manual catching.

Accounting for the different wage scales of manual and mechanical catching workers, American Calan (a company that designs and builds agricultural equipment used in the feeding and data collection of

large animals at research facilities throughout the world) estimated that mechanical harvesting reduces labor costs by 67 percent (Thornton 1994), or around \$183,000 a year in current dollars. Thus, the payback period for a \$200,000 harvester with \$76,000 in annual running costs would be twenty-two months, with net savings thereafter. Similarly, Lacy and Czarick (1998) estimated a payback time of fifteen months. The estimated payback period would be even shorter if savings from reduced bruising were considered, in addition to savings from reduced health care costs and compensation claims due to improved catcher safety (Ramasamy, Benson, and Van Wicklen 2004).

Poultry Slaughter

Typically, poultry are shackled and electrically stunned in a water bath before slaughter. Raj et al. (1997) found that most broiler chickens sustained at least one bone fracture and one hemorrhage during shackling and electrical stunning. During electrical stunning, chickens can defecate and inhale water, contaminating carcasses (Gregory and Whittington 1992). These factors lead to carcass downgrades and condemnations, thereby decreasing processors’ revenue.

In contrast, many European processors are adopting controlled atmosphere stunning (CAS) slaughter of meat, egg, and breeding birds. In CAS live birds are kept in their transport crates after reaching the slaughterhouse. While still crated, they are passed through a chamber containing gas—typically either 90 percent argon in air or 30 percent CO₂/60 percent argon in air. These mixtures are not poisonous; rather, they cause the birds to die from anoxia. The dead birds are then hung on shackles for processing. According to Raj (1998), CAS reduces:

stress and trauma associated with removing conscious birds from their transport containers, in particular, under the bird

handling systems which require tipping or dumping of live poultry on conveyors; the inevitable stress, pain, and trauma associated with shackling the conscious birds, i.e. compression of birds' hock bones by metal shackles; the stress and pain associated with conveying conscious birds hanging up side down on a shackle line which is a physiologically abnormal posture for birds; the pain experienced by some conscious birds that receive an electric shock before being stunned (pre-stun shocks).... The pain and distress experienced by some conscious birds which miss being stunned adequately (due to wing flapping at the entrance to the water bath stunners) and then pass through the neck cutting procedure; [and] the pain and distress associated with the recovery of consciousness during bleeding due to inadequate stunning and/or inappropriate neck cutting procedure.

To that list should be added the pain and distress of some birds who are still conscious when they enter the scalding tanks for feather removal and then die by scalding or drowning (Duncan 1997). Duncan (1997) concludes that,

[CAS] is the most stress-free, humane method of killing poultry ever developed. The birds are quiet throughout the operation. They remain in the transport crate until dead and the killing procedure itself is fast, painless, and efficient. There is no risk of recovery from unconsciousness.

Adoption of CAS involves large capital costs to purchase gas-stunning equipment. A system in the United States that processes around 1 million birds a week (150 to 200 birds a minute) costs less than \$1 million and is compatible with existing crates and loading equipment. According to the European Integrated Pollution Preven-

tion and Control Bureau (EIPPCB), the running costs of gas, using an 80 percent nitrogen/20 percent argon mixture, are between 51 and 84 cents (in 2005 U.S. dollars) per 100 birds (European Integrated Pollution Prevention and Control Bureau [EIPPCB] 2003). CAS also results in cost savings and increased revenues by decreasing carcass downgrades, contamination, and refrigeration costs; increasing meat yields, quality, and shelf life; and improving worker conditions. Without live shackling and electrical stunning, CAS results in fewer broken bones and less bruising and hemorrhaging (Raj et al. 1990; Raj and Gregory 1991; Raj et al. 1997; Hoen and Lankhaar 1999; Canadian Food Inspection Agency 1999; EIPPCB 2003). The reduction in carcass defects increases boning yield and deboned meat quality (Raj et al. 1990; Raj et al. 1997; Hoen and Lankhaar 1999; O'Keefe 2003). In addition, CAS has been shown to reduce bruising by as much as 94 percent and bone fractures by as much as 80 percent (Raj et al. 1990; Raj et al. 1997). Conservatively assuming that CAS increases yield by only 1 percent, a plant processing 1 million broilers a week, with an average dressed carcass weight of 4.5 pounds and a wholesale price of \$0.80 per pound, would increase annual revenue by \$1.87 million after adopting CAS. And as CAS increases the rate of rigor development, it results in faster carcass-maturation times and reduces handling, floor space, and refrigeration costs (Raj et al. 1997; SCAHAW 1998; EIPPCB 2003; O'Keefe 2003). Because gas-stunned chickens do not inhale contaminated water as they do during electrical stunning, CAS also decreases contamination costs (Gregory and Whittington 1992).

CAS can improve worker conditions and safety and decrease labor costs due to production line inefficiencies, injuries, and turnover from

handling conscious birds. The Canadian Food Inspection Agency concluded that "[t]he environment for the [personnel] working in the poultry stunning area is also very much improved with the use of controlled atmosphere stunning" (Canadian Food Inspection Agency 1999). O'Keefe reports that for one CAS plant, annual labor savings due to easier handling in post-stun shackling more than offset increased operating costs (O'Keefe 2003).

Based on the estimates above, a plant that installs a CAS line at a cost of \$1 million, with a capacity to slaughter 1 million birds a week, would incur annual operating costs of between \$265,200 and \$436,800, along with increased revenue of \$1.87 million from increased meat yield. Payback would be achieved in less than one year, with increased profits thereafter. Similarly, Shane found that U.K. producers adopting CAS were able to recoup their capital investment in one year (Shane 2005).

The Global Dimension

It is clear that animal welfare has extended far beyond European borders; indeed, it is being accorded a growing level of importance in civil society around the world. The guiding principles agreed upon by all of the 167 member countries of the OIE in 2004 and part of the introduction to the guidelines for animal welfare recognize "that the use of animals in agriculture and science, and for companionship, recreation, and entertainment, makes a major contribution to the well being of people" and "that the use of animals carries with it an ethical responsibility to ensure the welfare of such animals to the greatest extent practicable" (OIE Terrestrial Animal Health Code 2006, Sec. 3.7, App. 3.7.1.).

Internationally there is a great challenge to balance competition, productivity, and animal welfare in

the increasingly global trade in agricultural products. The limited international consensus on the role of animal welfare in international trade was highlighted by a report prepared by the European Commission (2002).

The relationship among animal welfare, animal health, and food safety has also been recognized internationally. At present a particular trend is noticeable: the global confirmation from international market trends that an increase of sales in sustainably derived products is achievable in many countries worldwide. Both of these trends are clearly facilitating continued improvement of animals' welfare conditions. Consumers, who already have increased interest in welfare-friendly products, need more information to better understand the added value of welfare standards applied to each product and to facilitate their purchasing choices.

Recent years have seen important new initiatives, such as the first Global Conference on Animal Welfare, held in 2004, and the 2005 adoption of OIE guidelines on animal welfare discussed above. The OIE strategy has been developed recognizing that "animal welfare is a complex, multi-faceted public policy issue that includes important scientific, ethical, economic and political dimensions" (OIE Terrestrial Animal Health Code 2006). By Resolution No. XVII of 2004, the OIE also established a World Animal Health and Welfare Fund, whose purpose is to implement action, scientific research, and training programs; organize seminars, conferences, and workshops; produce information media; and support OIE Strategic Plans and activities of developing countries in the fields within the OIE's purview, including the promotion of animal welfare.

The Future: A Global Perspective

Clearly the EU has taken the global initiative in improving farm animal welfare—not only within its own member states, but abroad as well. Complementing the OIE's initiative, the European Commission has started to negotiate animal welfare standards to be incorporated into bilateral agreements between the EU and Third World country suppliers of animals and animal products. One of the OIE guiding principles stating that "[i]mprovements in farm animal welfare can often improve productivity and food safety, and hence lead to economic benefits" is encouraging the adoption of animal welfare standards worldwide.

Achieving international awareness about animal protection and contributing actively to the development of international standards while respecting the ethical and cultural dimension of the issue is one of the five main actions included in the Community Action Plan on Animal Welfare.

Other initiatives are planned in knowledge/training activities and development of future strategies in veterinary education, including e-learning initiatives. Taking the EU-Chile Agreement as an example, one objective is to reach a common understanding concerning animal welfare standards based on developments in the competent international standards organizations. The agreement already covers standards concerning the stunning and slaughter of animals and will be extended to include their land and sea transport. Efforts have been undertaken to exchange information and promote cooperation and exchange of expertise. The importance of training has been highlighted to promote awareness of animal welfare and application of relevant animal welfare guidelines.

In trade and external relations, the European Commission has

been active in promoting the EU perspective on the importance of animal welfare, including, among other things, a specific submission to the World Trade Organization (WTO) on animal welfare and agricultural trade (WTO, Annex to COM 2002, 626 Final) stating, "[T]he objective of the EC [European Community] in raising animal welfare issues in the context of the WTO negotiations is not to provide a basis for the introduction of new types of tariff barriers" but "to promote high animal welfare standards, to provide clear information to consumers, while at the same time maintaining the competitiveness of the EC farming sector and food industry." The EU also made a submission to the WTO Special Committee on Agriculture in December 2001 on mandatory labeling for agricultural products, whose aim should be

[T]o ensure that members can pursue their legitimate policy objectives, including relevant agriculture non-trade concerns, through labeling requirements for food and agricultural products, thereby supporting market led, least trade restrictive approaches to international trade. (WTO, Annex to COM 2002, 626 Final)

In the European Commission's communication (2002), imports from countries outside the EU that do not necessarily apply animal welfare rules equivalent to those enforced in the EU have already been addressed.

A recent seminar organized by non-governmental observers (NGOs) as part of the European Commission's Civil Society dialogue initiative (to consult stakeholders in order to develop policies on several trade-related issues: <http://trade-info.cec.eu.int/civilsoc/meetdetails.cfm?meet-11116>) had as its topic "Sustainable Agricultural Production and Good Animal Welfare Practice: Trade Opportunities for Developing Countries."

Included in the seminar's conclusions and recommendations were the following:

- Extensive and sustainable agricultural systems, with good standards of animal welfare, are still the predominant form of livestock production in many developing countries.
- Products from such systems would readily meet EU animal welfare requirements.
- Developing-country farmers who use sustainable, humane systems can find trading opportunities for welfare-friendly, quality products.
- Developing-country farmers should see good animal welfare not as an obstacle, but as an opportunity for trade expansion, and good animal welfare standards can give a country a significant advantage over its competitors in export markets.
- The EU should ensure access to its markets for welfare-friendly products by offering trade-related assistance and capacity building to developing countries, together with preferential market access, as well as information, training, and mentoring in the development and maintenance of good welfare standards on-farm, during transport, and at slaughter.
- The EU should work with its trading partners to develop a voluntary labeling scheme for animal products that would enable welfare-friendly products from developing countries to be identified as such and hence reap economic benefits in EU markets.

In sum, animal welfare standards represent opportunities for countries to access and compete in worldwide markets on a more level playing field. This can help to increase trade and prosperity while also giving due importance to animal welfare.

Conclusions and Future Directions

Increasingly throughout Europe and the United States, the farming of animals is no longer viewed simply as a means of food production. Instead it is seen as fundamental to other key social goals, such as food safety and quality, safeguarding environmental protection, sustainability, enhancing the quality of life in rural areas and the preservation of the countryside, and ensuring that animals are treated properly.

Public authorities are obliged to take these demands into account when formulating and implementing relevant policy to ensure that animals are treated humanely. In response to this situation, a Community Action Plan on the Protection and Welfare of Animals covering 2006 to 2010 has now been developed in Europe. This plan seeks to define more clearly the direction of EU policies for the coming years, to continue to promote high animal welfare standards in the EU and at the international level, and to provide greater coordination of existing resources while identifying future needs.

A more consistent and coordinated approach to animal protection and welfare needs to be ensured across several policy areas to respond to clear public concerns.

National authorities and major global players in the food chain have a duty and a responsibility to respond to citizens' demands concerning and the shifting in attitudes toward farming production.

As evidenced by polling consumers on both sides of the Atlantic, the majority of citizens are concerned about the humane treatment of animals, and as the United States and the EU share common players in the food market and country borders blur due to globalization, the development of strategic, international collaborations is critical in achieving improved farm animal welfare (European Commission 2006). Thus far,

the differing approaches—primarily, legislation in the EU and voluntary codes in the United States—have not been favorable in establishing cooperation nor in achieving rapid progress in improving the welfare of farmed animals.

Opportunities to cooperate in the development of a common, science-based approach should be explored, taking advantage of the new framework offered by multilateral organizations such as the OIE and taking into consideration all stakeholders who demand these improvements.

The views expressed herein are purely those of the authors and may not in any circumstance be regarded as an official position of the European Commission.

Note

¹Defined in 1979 by the U.K. agricultural ministry's advisory body, the Farm Animal Welfare Council.

Literature Cited

- Agra CEAS Consulting, Ltd. 2004. Study on the socio-economic implications of the various systems to keep laying hens. Contract SANCO/2003/SPC.2003258. Final report for the European Commission. December. http://ec.europa.eu/food/animal/welfare/farm/socio_economic_study_revised_en.pdf.
- Animals Australia. 1998. Opinion poll: Battery hens. Summary of People Data (Australia) Pty. Ltd. December.
- Arshad, M. 1999. An ecological study of Red Junglefowl (*Gallus gallus spadiceus*) in agricultural areas. Malaysia: Universiti Putri Malasia.
- Arthur, J.A., and G.A.A. Albers. 2003. Industrial perspective on problems and issues associated with poultry breeding. In *Poultry genetics, breeding, and biotechnology*, ed. W.M. Muir and S.E. Aggrey, 1–12. Wallingford, England: CABI Publishing.

- Bayliss, P.A., and M.H. Hinton. 1990. Transportation of broilers with special reference to mortality rates. *Applied Animal Behaviour Science* 28: 93–118.
- Bellett, G. 2003. Harvester corrals chickens. *Vancouver Sun*, June 6.
- Bennett, R.M. 1997a. Farm animal welfare and food policy. *Food Policy* 22: 281–288.
- . 1997b. Economics. In *Animal Welfare*, ed. M.C. Appleby and B.O. Hughes, 241–243. Oxon, England: CAB International.
- Bennett, R.M., and R.J.P. Blaney. 2003. Estimating the benefits of farm animal welfare legislation using the contingent valuation method. *Journal of Agricultural Economics* 29: 85–98.
- Bennett, R.M., and D. Larson. 1996. Contingent valuation of the perceived benefits of farm animal welfare legislation: An exploratory survey. *Journal of Agricultural Economics* 47(2).
- Broom, D.M. 2000. Does present legislation help animal welfare? Sustainable Animal Production: Workshops, discussion, online resources. <http://www.agriculture.de/acms1/conf6/ws5alegisl.htm>.
- Buglass, D. 2006. Ethical spend is wake-up call for producers. *The Herald*, July 12. <http://www.theherald.co.uk/business/65716.html>.
- Canadian Food Inspection Agency. 1999. Preparedness and policy coordination: Regulatory impact analysis statement. Canadian Food Inspection Agency.
- DEFRA, U.K. Animal Welfare Division. 2005. Meat chicken directive: Summary of some economics aspects from U.K. September.
- Duncan, I.J.H. 1989. The assessment of welfare during the handling and transport of broilers. In *Proceedings of the Third Annual European Symposium on Poultry Welfare*, ed. J.M. Faure and A.D. Mills, 93–107. Tours, France: French Branch of the World Poultry Science Association.
- . 1997. *Killing methods for poultry: A report on the use of gas in the U.K. to render birds unconscious prior to slaughter*. Ontario, Canada: Campbell Centre for the Study of Animal Welfare.
- . 2001. Welfare problems of meat-type chickens. Paper presented at Farmed Animal Well-being Conference, University of California-Davis, June 28–29.
- . 2004a. Welfare problems of poultry. In *The well-being of farm animals*, ed. J.B. Benson and B.E. Rollin, 307–323. Ames, Iowa: Blackwell.
- . 2004b. Foreword. In *Measuring and auditing broiler welfare*, ed. C.A. Weeks and A. Butterworth, xii. Cambridge, Mass.: CABI Publishing.
- Elrom, K. 2000. Handling and transportation of broilers: Welfare, stress, fear, and meat quality. *Israel Journal of Veterinary Medicine* 55(4).
- European Commission. 2002. Animal welfare legislation on farmed animals in Third Countries and the implications for the EU. November. http://europa.eu.int/comm/food/animal/welfare/references/2002_0626_en.pdf.
- . 2005a. Council regulation of 22 December 2004 on the protection of animals during transport and related operation of the European Union L3. January 5.
- . 2005b. *Special EURO-BAROMETER 299: Attitudes of consumers towards the welfare of farmed animals*. June. http://ec.europa.eu/food/animal/welfare/euro_barometer25_en.pdf#search+percent22Attitudes percent20of percent20consumers percent20towards percent20the percent20welfare percent20of percent20farmed percent20animals percentE2 percent80 percent9D percent22.
- . 2006. Commission working document: Strategic basis for the proposed actions on a community action plan on the protection and welfare of animals. SEC, 65.
- European Economic Community. 1974. Council directive 74/577.
- European Integrated Pollution Prevention and Control Bureau (EIPPCB). 2003. Draft reference document on best available techniques in the slaughterhouses and animal by-products industries, 281, 287, 318. p2pays.org/ref/21/20574.pdf.
- Farsaie, A., L.E. Carr, and C.J. Wabeck. 1983. Mechanical harvest of broilers. *Transactions of the American Society of Agricultural Engineers* 26: 1650–1653.
- Ferret, P.S. 2004. Tom weights up seven percent. *WATT PoultryUSA* July: 32–42.
- Food and Agriculture Organization of the United Nations. n.d. Slaughtered/Prod. Animals. faostat.fao.org/site/410/DesktopDefault.aspx?PageID=410.
- Golin/Harris International. 2004. Consumers prefer animal care certified products. Survey for the United Egg Producers.
- Grandin, T. 2003. Comments before the Canadian Agri-Food Research Council's Farm Animal Welfare and Behavior Committee, Ottawa, Ontario, June 6.
- Gregory, N.G., and P.E. Whittington. 1992. Inhalation of water during electrical stunning in chickens. *Research in Veterinary Science* 53: 362.
- Griffiths, G.L. 1985. Ageing bruises on chicken legs. *Proceedings of the 6th Australasian Poultry and Stockfeed Convention*, Melbourne, Australia, 269–299.
- Harper, G., and S. Henson. 2001. Consumer concerns about animal welfare and the impact on food choice. EU FAIR Project CT36-3678. Centre for Food Economics Research, Department of Agricultural and Food Economics, the University of Reading, England.
- Havenstein, G.B., P.R. Ferret, and M.A. Qureshi. 2003. Growth, livability, and feed conversion of

- 1957 versus 2001 broilers when fed representative 1957 and 2001 broiler diets. *Poultry Science* 82: 1500–1508.
- Hoen, T., and J. Lankhaar. 1999. Controlled atmosphere stunning of poultry. *Poultry Science* 78: 287–289.
- Humane Society of the United States, The (HSUS). 2006. An HSUS report: Welfare issues with selective breeding for rapid growth in broiler chickens and turkeys. http://www.hsus.org/farm/resources/research/practices/fast_growth_broilers.html.
- Jones, R.B. 1992. The nature of handling immediately prior to test affects tonic immobility fear reactions in laying hens and broilers. *Applied Animal Behavior Science* 34: 247–254.
- Kannan, G., and J.A. Mench. 1996. Influence of different handling methods and crating periods on plasma corticosterone concentrations in broilers. *British Poultry Science* 37: 21–31.
- Kettlewell, P.J., and M.J.B. Turner. 1985. A review of broiler chicken catching transport systems. *Journal of Agricultural Engineering Research* 3: 93–114.
- Kilman, S. 2003. Poultry in motion: With invention, chicken catching goes high-tech. *Wall Street Journal*, June 4. [online. www.wsj.com/article/SB105467590014941400.html?emailf=yes](http://www.wsj.com/article/SB105467590014941400.html?emailf=yes).
- Knierim, U., and A. Goeke. 2003. Effect of catching broilers by hand or machine on rates of injuries and dead-on arrivals. *Animal Welfare* 12: 63–73.
- Knowles, T.G., and D.M. Broom. 1990. The handling and transport of broilers and spent hens. *Applied Animal Behavior Science* 28: 75–91.
- Lacy, M.P., and P.M. Czarick. 1998. Mechanical harvesting of broilers. *Poultry Science* 77: 1794–1797.
- McGuire, A.R. 2003. Improving carcass quality. *Poultry* 10(1): 25–26.
- Mench, J. 1992. The welfare of poultry in modern production systems. *Poultry Science Review* 4: 108–109.
- Mench, J. 2004. Lameness. In *Measuring and auditing broiler welfare*, ed. C.A. Weeks and A. Butterworth, 3–17. Cambridge, Mass.: CABI Publishing.
- Moore, D.W. 2003. Public lukewarm on animal rights: Supports strict laws governing treatment of farm animals, but opposes bans on product testing and medical research. Media release. Gallup Poll News Service. May 21.
- Nijdam, E., P. Arens, E. Lambooi, E. Decuyper, and J.A. Stegeman. 2004. Factors influencing bruises and mortality of broilers during catching, transport, and lairage. *Poultry Science* 83: 1610–1615.
- Nijdam, E., E. Delezie, E. Lambooi, M.J.A. Nabuurs, E. Decuyper, and J.A. Stegeman. 2005. Comparison of bruises and mortality, stress parameters, and meat quality in manually and mechanically caught broilers. *Poultry Science* 84: 467–474.
- Nijdam, E., A.R.M. Zailan, J.H.H. van Eck, E. Decuyper, and J.A. Stegeman. 2006. Pathological features of dead on arrival broilers with special reference to heart disorders. *Poultry Science* 85: 1303–1308.
- Nierenberg, D. 2006. Rethinking the global meat industry. In *State of the world 2006: A Worldwatch Institute report on progress toward a sustainable society*, ed. L. Starke, 27. New York: W.W. Norton and Company, Inc.
- OIE Terrestrial Animal Health Code. 2006. 15h ed. *Guiding principles for animal welfare*.
- O’Keefe, T. 2003. Stunning developments. *WATT PoultryUSA* 4(6): 42–55.
- Penn, Schoen, and Berland Associates. 2005. Poll for The Humane Society of the United States, Washington, D.C. Question: Should U.S. law require the humane slaughter of birds, such as chickens, turkeys, and ducks.
- Raj, A.B.M. 1998. Untitled. *Proceedings from inert gas: A workshop to discuss the advantages of using inert gas for stunning and killing of poultry*. University of Guelph, Guelph, Canada, March 30.
- Raj, A.B.M., and N.G. Gregory. 1991. Efficiency of bleeding of broilers after gaseous or electrical stunning. *Veterinary Record* 128: 127.
- Raj, A.B.M., T.C. Grey, A.R. Audsely, and N.G. Gregory. 1990. Effect of electrical and gaseous stunning on the carcass and meat quality of broilers. *British Poultry Science* 31: 725.
- Raj, A.B.M., L.J. Wilkins, R.I. Richardson, S.P. Johnson, and S.B. Wooton. 1997. Carcass and meat quality in broilers either killed with a gas mixture or stunned with an electric current under commercial processing conditions. *British Poultry Science* 38: 169–174.
- Ramasamy, S., E.R. Benson, and G.L. Van Wicklen. 2004. Efficiency of a commercial mechanical chicken catching system. *Journal of Applied Poultry Research* 13: 19–28.
- Rauw, W.M., E. Kanis, E.N. Noordhuizen-Stassen, and F.J. Grommers. 1998. Undesirable side effects of selection for high production efficiency in farm animals: A review. *Livestock Production Science* 56: 15–33.
- Remignon, H., and E. Le Bihan-Duval. 2003. Meat quality problems associated with selection for increased production. In *Poultry genetics, breeding, and biotechnology*, ed. W.M. Muir and S.E. Aggrey, 53–66. Wallingford, England: CABI Publishing.
- Rolfe, J.C. 1999. Ethical rules and the demand for free range eggs. *Economic Analysis and Policy* 29(2): 187–206.

- Rollin, B.E. n.d. Farm factories. *The Christian Century*. www.religion-online.org/showarticle.asp?title=2194.
- Scientific Committee on Animal Health and Animal Welfare (SCAHAW). 1998. The use of mixtures of the gases CO₂, O₂, and N₂ for stunning or killing poultry. europa.eu.int/comm/food/fs/sc/scaw/out08_en.html.
- . 2000. The welfare of chickens kept for meat production (broilers). Report for the European Commission, Health and Consumer Protection Directorate-General. SCAHAW.
- Shane, S. 2005. Future of gas stunning. *WATT PoultryUSA* 6(4): 16–23.
- Sullivan, T.W. 1994. Skeletal problems in poultry: Estimated annual cost and descriptions. *Poultry Science* 73: 879–882.
- Thornton, G.E. 1994. The race to automate broiler harvesting. *Broiler Industry* 57(12): 52–66.
- United Egg Producers. 2006. Industry history. uepcertified.com/industryhistory.html.
- United States Department of Agriculture (USDA), National Agricultural Statistics Service. 1998. Poultry production and value final estimates, 1994–97. Statistical Bulletin 958. jan.manlib.cornell.edu/usda/reports/general/sb/b9580399.txt.
- . 2005a. Chickens and eggs: 2004 summary. February. usda.manlib.cornell.edu/reports/nassr/poultry/pec-bbl/lyegan05.pdf.
- . 2005b. Poultry: Production and value, 2004 summary. usda.manlib.cornell.edu/reports/nassr/poultry/pbh-bbp/plca0405.txt.
- van Hoorne, P.L.M. 2005. Impact of EU Council Directive 99/74 “Welfare of Laying Hens” on the competitiveness of the EU egg industry: Update base year 2003. LEI, The Hague: The Netherlands, June.
- Webster, A.B. 2004. Welfare implications of avian osteoporosis. *Poultry Science* 83: 184–192.
- Zogby International. 2003. Nationwide views on the treatment of farm animals. Poll for the Animal Welfare Trust.