Sustainability of egg production in the United States—The policy and market context

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ABSTRACT The US egg industry is being pressured from many directions to change its production practices, particularly to address concerns about hen welfare in conventional cage systems. Responding to similar pressures, in 1999, the European Union banned conventional laying cages starting in 2012. This now impending European ban has led to the development of several alternative housing systems. These include noncage systems like aviaries and modified (enriched or furnished) cages that include perches, areas in which the hens can forage and dustbathe, and nests. Understanding the European experience is valuable as the United States considers the future direction of the egg industry. In the United States, the proportion of eggs produced in alternative systems is small (less than 5% of output) but growing, in part due to market and political incentives for systems that provide hens with more behavioral freedom than conventional cages. Animal welfare, however, is only one element of a sustainable production system. Other elements include those related to public values, the environment, economics, worker health, and food safety and quality. Eggs are a primary source of animal protein globally, and the United States is the third largest producer of eggs in the world, behind China and the European Union. The national table egg flock comprises about 280 million hens housed in all regions but with approximately 60% of eggs produced in the 10 leading states. Adopting new housing systems will have substantial effects on costs and other aspects of egg production on both a regional and national scale, with some positive effects but also potential negative effects that need to be carefully considered. This paper discusses the US egg industry in the context of legislation and standards related to hen housing systems. It also addresses initiatives by retailers, nongovernmental organizations, and private certification organizations to shape production practices in the egg industry as well as how those initiatives might affect various aspects of the sustainability of egg production.

INTRODUCTION

Agricultural animal producers in the United States find themselves in a changing climate in which the social and environmental ramifications of their production practices are undergoing intense scrutiny. Egg producers in particular are being pressured from many directions to change the way in which they house hens, largely based on animal welfare concerns. This has led to increasing regulation of the egg industry at the state level, along with uncertainty and apprehension about the overall effects of this regulation on egg producers, retail markets, the public, and the hens themselves.

In this paper, we discuss the scope of the US and international egg industries and the pressures driving change. In addition, we discuss the importance of considering the sustainability of egg production in a broad context, to include not just hen welfare but the potential social, environmental, economic, and human health effects of different housing systems.

THE US AND INTERNATIONAL EGG INDUSTRY

Eggs are a primary source of animal protein in both developed and developing countries. In 2007, global egg production consisted of 65 tonnes of eggs, an increase of approximately 2% over the preceding year (IEC, 2007). The United States is the third largest egg producer in the world, after China and the European Union (EU)-
15 (consisting of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom). Other countries that are significant producers include India, Japan, the Russian Federation, Mexico, and Brazil (Table 1). Although US and EU production has grown slightly since the 1980s, production in China, India, and Mexico has grown significantly (FAOSTAT, 2009). In 2008, the United States produced over 76 billion table eggs (USDA-NASS, 2009; Sumner et al., 2011).

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The most common commercial housing system for egg-laying hens in the United States and worldwide is the conventional (battery) cage system (Figure 1). In most non-EU countries, including both developed and developing countries, more than 95% of commercial laying hens are housed in conventional cages (IEC, 2009; Figure 2). The conventional cage system was developed in the 1930s and began to be adopted on a large scale in the 1950s. The main advantage of this system was that the hens and their eggs were separated from feces, thus decreasing the likelihood of transmission of soilborne parasites like coccidiosis and improving egg cleanliness. This system also proved to be economically efficient because it allowed automation of feeding, watering, and egg collection and improved the ability to control environmental variables important for hen health and production performance. Although cages were initially designed to hold only 1 hen, larger cages were eventually adopted that permitted groups of hens (typically about 6 to 10) to be housed together, further increasing economic efficiency as a result of the higher hen stocking densities that could be accommodated in each building.

This housing system, however, began to be criticized in northern Europe in the 1960s due to the restrictions it imposed on the hens’ movement and behavior. This criticism was part of a larger concern about the growing intensification of European livestock and poultry farms and its effects on the health and welfare of the animals. This issue received widespread public attention due to the publication of Ruth Harrison’s book, Animal Machines (Harrison, 1964), as well as a resulting UK government report on farm animal welfare known as the Brambell Report (Brambell, 1965). It ultimately led to sweeping legislative changes in the EU affecting

<table>
<thead>
<tr>
<th>Country</th>
<th>Egg production (tonnes)</th>
<th>Approximate share world production (%)</th>
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<tbody>
<tr>
<td>China</td>
<td>24,348,250</td>
<td>50.45</td>
</tr>
<tr>
<td>United States</td>
<td>4,403,475</td>
<td>9.12</td>
</tr>
<tr>
<td>India</td>
<td>2,492,000</td>
<td>5.16</td>
</tr>
<tr>
<td>Japan</td>
<td>2,465,000</td>
<td>5.11</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>2,654,000</td>
<td>4.26</td>
</tr>
<tr>
<td>Mexico</td>
<td>1,906,476</td>
<td>3.95</td>
</tr>
<tr>
<td>Brazil</td>
<td>1,560,000</td>
<td>3.23</td>
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<tr>
<td>France</td>
<td>1,045,000</td>
<td>2.17</td>
</tr>
<tr>
<td>Indonesia</td>
<td>876,000</td>
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<tr>
<td>Turkey</td>
<td>830,000</td>
<td>1.72</td>
</tr>
<tr>
<td>Germany</td>
<td>798,000</td>
<td>1.65</td>
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<tr>
<td>Ukraine</td>
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</tr>
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<td>Spain</td>
<td>725,000</td>
<td>1.5</td>
</tr>
<tr>
<td>Italy</td>
<td>700,000</td>
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</tr>
<tr>
<td>Iran</td>
<td>610,000</td>
<td>1.26</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>595,000</td>
<td>1.23</td>
</tr>
<tr>
<td>Korea</td>
<td>570,000</td>
<td>1.18</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>551,999</td>
<td>1.14</td>
</tr>
<tr>
<td>Poland</td>
<td>520,000</td>
<td>1.08</td>
</tr>
<tr>
<td>Nigeria</td>
<td>476,000</td>
<td>0.99</td>
</tr>
<tr>
<td>Total</td>
<td>48,261,101</td>
<td>100</td>
</tr>
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multiple facets of farm animal production, including the housing of laying hens.

**EUROPEAN DEVELOPMENTS**

One of the first developments that would ultimately affect hen housing in the EU was the introduction by the Council of Europe of the 1976 Convention on the Protection of Animals Kept for Farming Purposes, which had been ratified by 10 of the member states by 1981 (Appleby, 2003). Among other things, the Convention stated the following: “The freedom of movement appropriate to an animal, having regard to its species and in accordance with established experience and scientific knowledge, shall not be restricted in such a manner as to cause it unnecessary suffering or injury. Where an animal is continuously tethered or confined it shall be given the space appropriate to its physiological and ethological needs” (Council of Europe, 1976, p. 2).

This emphasis on meeting the ethological (behavioral) needs of animals was a direct outgrowth of the recommendations in the Brambell Report (Brambell, 1965) and shaped much of the subsequent European legislation. It also shaped the scientific agenda for animal welfare research, which is discussed in detail with regard to laying hens elsewhere in this volume (Lay et al., 2011).

Initially, in keeping with the wording of the Convention, the EU adopted standards for conventional cages that stipulated the minimum number of drinkers per cage and the feeder space and floor area to be provided per hen, as well as certain other aspects of cage design (CEC, 1986, 1998). This was based at least in part on research that was underway in Sweden (Tauson, 1998) to improve conventional cages by evaluating the hen health effects of various aspects of cage design, including flooring type, floor slopes, and cage door configuration. In 1999, however, the EU decided to ban conventional cages, with the ban to take effect in 2012 and with no new conventional cages to be installed after January 1, 2003 (CEC, 1999). Several European countries also independently passed legislation that affected hen housing, either by banning conventional cages (although in Sweden there were hen health conditions attached to the ban that could not be met, requiring it be deferred) or requiring cage or stocking density modifications; these laws are summarized elsewhere (Appleby, 2003; Jendral, 2005).

**HOUSING SYSTEMS**

An outgrowth of the legislative activity in Europe was that a great deal of attention was directed toward developing alternatives to conventional cage housing. Funding for this effort came largely from national governments, with some contribution from animal welfare organizations (Appleby, 2003). Along the way, some systems were found to be unworkable and their development was discontinued, whereas others were found to be sufficiently promising for further investment and refinement. Current alternative systems that are acceptable under the EU legislation are noncage systems and enriched cages; these systems are described in greater detail elsewhere (Appleby et al., 2004; LayWel, 2006a).

Noncage systems are of 2 general types (Figure 3): floor systems (single-level systems) and aviaries (multi-tier systems), each typically housing thousands or tens of thousands of hens. In floor systems, the hens are housed on the floor of a building instead of in cages; the building contains nest boxes, which are typically configured to allow automatic egg collection. Aviaries
are similar to floor systems but have multi-tiered platforms that allow the hens to make use of the height of the building. The ground level is covered with litter material, and the perforated upper level platforms are arranged so that manure does not fall on the hens below. Aviaries permit hens to be kept at higher stocking densities than floor systems, making them more efficient economically.

Figure 3. Noncage systems. The top system is an aviary (multi-level) system. The floor is covered with litter material for foraging and dustbathing, and perches, nest boxes, feed, and water are provided on multiple levels, allowing higher stocking densities than in the single-level (floor) system shown in the second photograph. Outdoor or semi-outdoor access can be provided from either multiple or single-level systems via a veranda or range area, or both, as shown in the bottom photograph. Color version available in online PDF.

Hens kept in noncage systems can also be given access to the outdoors, either by providing a semi-enclosed and covered outdoor area (a veranda or winter garden) or by giving them access to range (free range) for all or a part of the day, or both. Hens may also be mainly raised on the range, although provided with shelter at night and during inclement weather. These latter systems are typically relatively small-scale systems and are called pastured or pasture-based systems in the United States. The shelter may be movable so that hens can be rotated among pastures, minimizing the buildup of soilborne parasites.

Furnished cages (also called enriched or modified cages, or enriched colony systems) are similar to conventional cages but are equipped with perches, nesting areas, and material that is designed to facilitate foraging and dustbathing behavior. The prototypes of these cages were the getaway cages developed in Germany in the 1980s. These tall cages included perches and had larger colony sizes than conventional cages but were not widely adopted because of problems with cannibalism (Tauson, 1998). The next developments, on an experimental rather than a commercial scale, were systems like the Edinburgh modified cage (Appleby, 1998), the general configurations of which were based on research evaluating the behavioral priorities of hens (Lay et al., 2011). The Edinburgh modified cage was a 4-hen cage containing a single perch, single nest box, and dustbath filled with litter.

As these types of systems were rolled out commercially, several different variants were evaluated in terms of group size and enrichment features such as perch placement, nest box design, and substrate material in the dusting and foraging areas. Currently, there are commercial systems in Europe made for small (up to 15 hens), medium (15 to 30 hens), and large (30 to 60 hens) group sizes (LayWel, 2006a). However, the system that appears most likely to be widely adopted is the enriched colony system (Figure 4), which can be configured to hold 20 to 60 hens at the EU-mandated maximum stocking density. These large cages provide additional freedom of movement and have a nesting area composed of a nest mat (often made of Astroturf) and nest curtains, one or more perches, and a scratching area. This latter is usually made of an Astroturf pad with feed dispensed onto the pad to stimulate pecking and scratching but can also comprise a box into which loose litter (like sand or wood shavings) is dispensed.

Despite the rapidly approaching deadline for the ban, the overwhelming majority of hens in most EU-15 countries are still kept in conventional cages (Figure 5). One obstacle deterring EU producers from converting their systems has been the European egg-labeling system. Although enriched cages are allowed as of 2012, eggs from this system must still be labeled only as cage eggs. Thus, consumers cannot distinguish eggs produced in enriched cages from those produced in conventional cages. This means that there is no market premium associated with eggs from enriched cages, making it dif-
ficult for the producers to recover the costs of installing them.

An additional issue creating uncertainty about the future egg market is that the major European animal welfare organizations have stated their opposition to enriched cages because they still restrict hen behavior more than noncage systems. As David Wilkins from the Eurogroup for Animals, a consortium of European animal welfare organizations, stated: “Let me make one thing very clear. We in Eurogroup, and I think I can speak on behalf of the whole animal welfare movement in Europe, are opposed to hens in cages…if the legislative debate is reopened, then we may seek to get enriched cages prohibited completely” (Wilkins, 2004). However, the opportunity to do so was greatly decreased when enriched cages were endorsed as an acceptable alternative to conventional cages in terms of hen welfare by the LayWel Project (see below) and when the EU confirmed that they would be legally acceptable as of 2012 and set minimum standards for their use. Thus, several of the animal protection groups, like Compassion in World Farming (http://www.ciwf.org.uk/) and the Royal Society for Prevention of Cruelty to Animals (http://rspca.org.uk), have instead turned their attention toward pressing individual member states to ban all cage systems.

**DEVELOPMENTS IN THE UNITED STATES**

In contrast to Europe, where the welfare of agricultural animals both on farm and during transport and slaughter is highly regulated, the United States has only minimal federal regulation. Only 2 major federal laws apply: the Twenty-Eight Hour Law and the Humane Methods of Slaughtering Act, the latter of which excludes poultry 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, which were authorized under the 1996 Farm Bill (Stull, 2001). This stands in contrast to the situation for some animals (including farm animals) used for 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 successfully prevented bills introduced into Congress from reaching the floor for a vote and so have forestalled on-farm animal welfare regulation (Garner, 1998). Instead, the primary drivers of improved farm animal welfare in the United States have been standards developed by producers, food retailers, and independent certification programs. All of these efforts are relatively recent (Mench, 2003, 2008). Animal advocates are also playing a pivotal role in driving changes in animal agriculture.

**Producers**

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 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 hens housed in conventional cages (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. These guidelines have undergone regular re-
view and revision by the scientific and producer committee and now also include standards for hens kept in noncage systems (UEP, 2010). The UEP guidelines are audited using a third-party (independent) auditing system. Producers who pass the audit can display the “UEP Certified” logo (which is process-verified by the USDA) on their egg cartons. They are required by UEP to have 100% of their production certified to pass the audit. Approximately 230 million hens, or 83% of the nation’s flocks, are covered under the UEP certification program (G. Gregory, United Egg Producers, personal communication).

Retailers

National and multi-national 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 their packing plants to ensure that the cattle were handled and killed humanely and according to the voluntary standards developed by the American Meat Institute. 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. 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. 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 FMI-NCCR endorsed the UEP guidelines in 2002 (http://www.fmi.org), and many retailers now require their suppliers either to be UEP certified or to meet the UEP standards.

Certification Programs

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 animal rearing conditions, this has to occur through niche marketing. Niche marketing in general is becoming important in the United States (Honeyman et al., 2006), with organic being the most significant market segment. Only a small percentage of US hens are raised under the National Organic Standards program (Sumner et al., 2010). The organic standards contain some provisions for hen housing, but these are very general and allow several broad exceptions, for example with regard to outdoor access. There are, however, several smaller certification programs that focus specifically on animal welfare. The 2 largest of these are the Certified Humane Raised and Handled program (http://www.certifiedhumane.org) and the American Humane Certified program (http://www.americanhumane.org). The first of these is an ISO-65 guide certified labeling program supported by 27 humane organizations, whereas the second is a program of the American Humane Association. Both have standards developed by scientists and other experts based initially on the Royal Society for the Prevention of Cruelty to Animals Freedom Foods standards (http://www.rspca.org.uk) and include third-party audits of certified producers. At present, the Certified Humane Raised and Handled program only permits certification of noncage production systems, whereas the American Humane
Certified program certifies both noncage systems and enriched colony systems.

**Animal Protection Organizations**

Perhaps because of a lack of effective political support to institute new federal regulation, there has been increasing emphasis on the introduction of state and local regulation by animal welfare and animal rights groups, which coincides with a burgeoning field of animal law in the United States (Wise, 2003). All states already have some form of animal cruelty legislation and enforcement is becoming stricter, with more significant fines imposed for violations. 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 practices considered unacceptable by animal protection groups (Mench, 2008). These mechanisms 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, Arizona, and Colorado) or producing (California) or serving (Chicago, under a ban passed by the city legislature in 2006 but overturned in 2008) foie gras. The potential effects of these initiatives on farm animal production was initially very small (e.g., Florida, Colorado, and Arizona are not major swine production states), but that changed with the passage of Proposition 2 in California in 2008.

Proposition 2, the Treatment of Farm Animals Act, was placed on the ballot by a coalition headed by 2 animal protection groups, The Humane Society of the United States (HSUS) and Farm Sanctuary. It passed with 64% of the vote in the November 2008 general election. Although the language of the initiative did not mention the word “cage,” the proposition effectively outlawed conventional cages for hens (as well as gestation stalls for sows and crates for veal calves) by requiring that “…a person shall not tether or confine any covered animal, on a farm, for all or the majority of any day, in a manner that prevents such animal from: (a) Lying down, standing up, and fully extending his or her limbs; and (b) Turning around freely.” For laying hens, there was additional language, stipulating that fully extending all limbs meant “fully spreading both wings without touching the side of an enclosure or other egg-laying hens.” Hens can lie down, stand up, and turn around in conventional cages, but they cannot fully extend both wings without touching one another or the enclosure, simply due to the small size of the cage. Therefore, it was this latter language that effectively outlawed conventional cages, as of 2015. As of December 2010, there has been no clarification of the language of the act, in terms of what kinds of systems or hen stocking densities will be permitted. The scale of the effect is likely large, however, given that California produces approximately 14% of the eggs in the United States and is the fifth largest egg-producing state (Summer et al., 2008, 2010).

Facing the prospect of a similar ballot initiative, the producers in Michigan came to an agreement with the HSUS to support a bill with language similar to that of Proposition 2, except that the law also specified a minimum space allowance of 1 ft²/hen. The bill was passed by the legislature and signed into law in October of 2009. In contrast, in Ohio, the legislature attempted to circumvent an HSUS-led initiative by crafting its own ballot initiative in 2009. This initiative proposed amending the state constitution to establish a state Livestock Care Standards Board to develop livestock and poultry housing standards. That initiative passed with a vote of approximately two-thirds. In 2010, still facing the prospect of a ballot initiative, Ohio producers, the governor, and the HSUS finalized a complex agreement. This agreement included (among other provisions) a moratorium on permits for the construction of new conventional cage facilities.

It is noteworthy that in 1996, well before any ballot activity in California, New Jersey became the first state to enact a requirement for their 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 when) the proposed regulations, which allow keeping hens in conventional cages, will be finalized and enforced.

Lawsuits are also becoming a more common tool. Several years before the California ballot initiative, the HSUS sued the California State Board of Equalization in an attempt to remove what were viewed as favorable tax provisions for egg producers who housed hens in cages. Currently, there is a lawsuit against several major egg producers, claiming that the UEP hen stocking density minimum standards (see below) were developed not to improve hen welfare but as a mechanism to decrease the national flock size to increase egg prices. In addition, the HSUS has sued the UEP and 2 large egg producers, alleging that they are “engaging in false and deceptive advertising to mislead consumers” that UEP-certified hens are well-cared for because although the certification program “touts that [it is] …an ‘animal welfare’ program, it permits factory farmers to confine hens in restrictive, barren cages.” An extensive list of
these and other lawsuits can be found on the Web site of the HSUS (http://www.hsus.org).

In parallel to these legal efforts, animal welfare groups are exerting increasing pressure on retailers to increase their purchases of noncage eggs. These groups recognize that US and multi-national retailers have enormous potential to effect changes in animal welfare because of their size and scope. For example, the top 5 supermarkets in the United States had grocery sales of approximately $200 billion in 2004, and 1 US-based supermarket, Wal-Mart, had worldwide sales of approximately $245 billion, 4 times greater than its nearest competitor, the French chain Carrefour (Hendrickson and Heffernan, 2005). Several animal protection groups have been successful in using shareholder’s resolutions (Singer, 1998), publicity campaigns, and exposés (generally video taken on commercial farms supplying to particular retailers) to pressure retailers to pledge to change their egg-purchasing specifications (see, for example, http://www.humanesociety.org). The HSUS alone now holds shares in more than 80 retail groups.

This kind of activity is part of a growing trend for social-cause activists to use pressure on marketers to accomplish political ends. It has been facilitated by several 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). The net economic effect on the US egg market of these much-touted announcements by retailers is unclear at this time, given that many of the retailers indicate that they will increase their purchases of noncage eggs only slightly, typically to levels similar to the current US market share of noncage eggs.

INTERNATIONAL STANDARDS AND ACTIVITY

These 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), a Paris-based intergovernmental organization which in the past has focused primarily on animal disease identification and control, highlighted animal welfare as one of its priorities. This has implications for the trade in animal products because the OIE has an official collaboration with the World Trade Organization to harmonize global standards with respect to animal health.

The OIE convened a working group on animal welfare in 2002 and held its first 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. 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 written by ad hoc expert groups and incorporated as appendices into the OIE Terrestrial Animal Health Code (http://www.oie.int/eng/bien_etre/_introduction.htm). Guidelines for beef cattle, broiler chickens, and dairy cattle are also in process. No date has been set for the guidelines development process for laying hens, which are a lower priority for the OIE because of the limited international trade in eggs. However, the International Egg Commission has global standards that are based in part on the UEP standards (IEC, 2003).

In addition to this OIE activity, the United Nations Food and Agriculture Organization recently produced an expert report on capacity building for animal welfare (Fraser et al., 2008). The report does not set specific standards for production systems but does emphasize the growing implications of the world trade in animal products on animal welfare. Its goal is to assist farmers in developing countries in accessing markets in developed countries that require adherence to particular animal welfare standards. The Food and Agriculture Organization also developed a Web portal for animal welfare-related information, including local regulations, standards, and guidelines, the Gateway to Farm Animal Welfare (http://www.fao.org/ag/againfo/themes/animal-welfare/en/).

SUSTAINABILITY OF EGG PRODUCTION

Although changes in laying hen production systems are being driven largely by animal welfare concerns, it is clear that other aspects of such changes must be considered to ensure sustainable egg production. Sustainability is a complex topic, and there is no agreed-upon definition of what constitutes a sustainable agricultural system for animal production. However, elements of sustainability include economics, environmental effects, human health and safety, and social values in addition to animal welfare.

Recognizing that there were many unanswered questions about sustainability in terms of the proposed alternative systems to conventional cages, the European Council decided to reconsider the conventional cage ban in 2008. It required the European Commission (EC) to submit a report by 2005 “based on an opinion from the Scientific Veterinary Committee [note: now called the Scientific Panel on Animal Health and Welfare]...of the pathological, zootechnical, physiological, and ethological aspects of the various systems and of their health and environmental impact,” as well as a study of the “socio-economic implications of the various systems and their effects on the Community’s economic partners” (CEC, 1999). Subsequently, the EU funded the LayWel Project, which provided funding for experts to write a series of reports, and to carry out targeted research projects, on laying hen welfare (http://www.LayWel.eu). The results of these efforts, as well as oth-
er research undertaken in Europe to address system sustainability, are discussed in detail in the companion papers in this symposium. Here, we provide a brief background overview of some of the European research efforts.

**Values**

The values of European consumers with respect to animal welfare have been assessed to a much greater extent than those of US consumers. Recent Eurobarometer (2005, 2006) surveys have assessed attitudes toward animal welfare in some detail. In addition, the EU funded a major 5-yr project in 2004 called the Welfare Quality Project. The goals were to understand public opinion about animal welfare and to develop on-farm welfare assessment schemes, with the ultimate goal of producing an EU-wide animal welfare labeling program for animal products (http://www.welfarequality.net). The surveys conducted as part of this project revealed a great deal of information about Europeans’ attitudes toward animal welfare and about their purchasing patterns for animal products (Roux and Miele, 2005; Thompson et al., in press).

**Environmental Effects**

There has been limited published research on the environmental effects of hen housing systems in Europe, with most of this conducted in the Netherlands. De Boer and Cornelissen (2002) stated that the main effects of concern in laying hen production systems were those related to ammonia emissions, nitrogen and phosphorous losses, energy use, and use of detergents, disinfectants, and pesticides. Ammonia is a particular concern because as of 2008 hens in the Netherlands can only be kept in systems that can meet an ammonia emissions target. Attempts to integrate information about Europeans’ attitudes toward animal welfare and about their purchasing patterns for animal products (Roux and Miele, 2005; Thompson et al., in press).

**Food Safety**

In their 2005 report, the European Food Safety Authority Scientific Panel on Animal Health and Welfare raised concerns about food safety in alternative systems. In particular, they noted that the potential for bacterial contamination was higher in systems in which hens laid their eggs in litter material, on the ground, or on nest mats rather than on wire. They concluded that “eggs produced in conventional cages still show the best quality from a microbiological point of view.” They also noted the potential for other food safety hazards associated with eggs from alternative systems but overall noted that data comparing systems were scarce. In response, the EC funded 2 projects, Safehouse and Rescape, in 2006. Safehouse focuses on epidemiological studies to assess factors affecting rates of microbial contamination of eggs in different systems, whereas Rescape aims to improve egg safety by developing new methods to reduce egg contamination, including by improving hen management, egg sorting during packing, and methods for shell decontamination. The results to date of these projects are reviewed elsewhere in these proceedings (Holt et al., 2011); regular newsletter updates are available on the Safehouse Web site (http://www.safehouse-project.eu/).

**Human Health and Safety**

In addition to food safety considerations, there can be human health and safety aspects of different production systems, including with respect to the health and safety of poultry workers and people living near poultry facilities and the potential for transmission of zoonotic diseases such as avian influenza. There has been very little research in these areas. In one of the few papers addressing worker health and safety issues, Whyte (2002) found that individuals working in barn systems were exposed to more dust than those working in conventional cage systems and that their inhalable dust exposure exceeded the United Kingdom occupational exposure standards. They were also exposed to higher ammonia concentrations than workers in cage systems; these concentrations exceeded the short-term exposure limits on several occasions but not the daily exposure standard. Assessing overall risk, workers in barns had a 67% risk of health problems due to dust
and ammonia, as compared with a 12% risk for workers in cage facilities. The author concluded that workers in barns should wear personal respiratory protection because the design of noncage facilities made it difficult to improve interior air quality. In a study conducted on 61 commercial farms in the Netherlands (van der Zijpp et al., 2006) evaluating various aspects of sustainability in different laying hen production systems, workers were asked to self-report physical complaints; no differences were found between workers in conventional cage, aviary, or single-level systems. Data from self-reports have to be treated with caution, however, and it would be important to have independent verification of worker health status in different systems.

**Economics**

There have been several significant studies of economic aspects of the scheduled ban of conventional cages in Europe. A 2004 report submitted to the EC (Agra CEAS, 2004) was based on data that are now old. However, the study projected that a 2012 ban could cost the EU-15 egg industry as much as €160 million if producers shifted to floor or aviary housing systems, the most practicable alternative housing system after a cage ban. The study projected that if producers in the EU were to switch entirely to noncage systems, consumers would lose roughly €28 million (Agra CEAS, 2004, p.92). In that report, the costs of furnished cage production were judged to be roughly similar to those of conventional cages as used in Europe, and the report did not indicate industry-wide costs associated with a mandated switch from conventional cages to furnished cages. Barn production was projected to increase variable costs by an average of 12% and total costs by 26%. Free-range production was the most expensive alternative, with variable costs about 22% higher and total costs 45% higher than conventional cages.

Other studies also indicate that conventional cage bans will significantly raise costs of producing eggs (Van Horne and Bondt, 2003; Sumner et al., 2008). Because international trade in fresh eggs is limited, most of the cost increase resulting from a European cage ban will translate into higher prices for consumers. But where some countries have moved more rapidly, eggs have often been shipped in from nearby suppliers. In most cases, egg production has decreased in European countries like Germany that have enacted stricter housing standards or banned cages altogether (Sumner et al., 2008). The German situation is complex, involving both legislative action and retailer decisions regarding shell egg purchases, but illustrates the general pattern of effects on production of reducing or eliminating the use of conventional cages before the EU ban. Egg production in Germany declined by approximately 13% from 2000 to 2007. Although Germany exports eggs mainly for further-processed products, it now has a shell egg deficit that is larger than the EU egg surplus, which means that eggs will need to be imported from non-EU countries to meet consumer demand (IEC, 2009, 2010b).

**THE FUTURE**

After reviewing the commissioned reports and other submitted documentation (CEC, 2008a), the EC decided in 2008 to proceed on schedule with the conventional cage ban. They cited the following as important factors influencing their decision (CEC, 2008b):

- Consumers’ attitudes: Eurobarometer (2005, 2006) surveys showed that animal welfare is a core value for European consumers, that they generally pay attention to the husbandry system when they purchase eggs and are willing to pay more for eggs sourced from an animal welfare-friendly production system, and that they consider poultry production to be a priority area of action in terms of welfare.
- Environment: “a study…concluded in 2005 that the expansion of all intensive egg production systems had a significant negative impact on the quality of water, air and landscape. However, it is becoming more evident that in the future any aspect related to sustainability will have to be taken into account in further development of husbandry systems for laying hens.”
- Hen welfare: The LayWel summary report (LayWel, 2006b) concluded that, with the exception of conventional cages, “alternative systems [NB: this included both non-cage systems and enriched cages] had the potential to produce satisfactory welfare for laying hens although further research was still needed.”
- Socioeconomic implications: Production in enriched cages would increase the cost of eggs by only about 1 cent per egg, although costs would be higher in noncage systems and overall production per farm might decrease.

In other words, the EC proceeded despite a significant amount of uncertainty about the sustainability characteristics of several aspects of the different production systems. It has been suggested that 2 factors played a particularly important role in driving the conventional cage ban: the strength of European public opinion and the likely success of enriched cage systems in terms of their economic performance (Appleby, 2003; Savory, 2004). That the LayWel committee also endorsed enriched cages as promoting acceptable hen welfare further strengthened this decision. In making their decision, the EC did recognize (CEC, 2008b) that
there were potentially important increased risks to the economic security of their egg producers by stating that although it would be “extremely difficult for European farmers to compete with their counterparts in certain third countries on production costs alone... [they could] have a competitive advantage by applying better animal welfare standards and delivering high quality goods.” Regardless, the EU in the past has pressed for animal welfare standards to be incorporated as part of World Trade Organization negotiations, a move strongly opposed by the non-EU egg-producing countries.

CONCLUSIONS

As the United States moves forward to consider the implications of this information, there is an opportunity (indeed an imperative) to consider sustainability issues in more depth and to conduct the necessary research before making decisions that might have unacceptably negative effects on one or more sustainability components. Efforts to do so are underway. The papers in this volume represent part of this process. In addition, the Coalition for Sustainable Egg Supply (http://www.sustainableeggonline.org) has been established to conduct research on the sustainability of laying hen production systems. The Coalition is composed of retailers and processors (e.g., McDonald’s, Bob Evans, Dine Equity, Cracker Barrel Country Stores, Cargill Kitchen Solutions, and Michael Foods), universities (e.g., Iowa State, Michigan State, and University of California, Davis), professional societies and trade organization (e.g., the American Veterinary Medical Association, Poultry Science Association, and UEP), egg producers, government agencies (e.g., USDA-Agricultural Research Service), and nongovernmental organizations (e.g., the American Humane Association and the Environmental Defense Fund). The major goal of this group is to collect data from commercial conventional cage, enriched colony, and noncage systems to evaluate the hen welfare, environmental, worker health and safety, and egg safety and quality effects of these systems and to develop methods to mitigate problems. As this issue evolves, it will be important to continuously refine our understanding of the perspectives of stakeholders and also to conduct research that promotes the development and implementation of scientifically and ethically sustainable egg production systems.

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