An HSI Report: Adopting a Cage-Free Production Policy for Animal Products in Brazil

Abstract

Farm animal welfare is becoming an important concern for governments, producers, and consumers worldwide. In particular, intensive confinement systems, such as battery cages and gestation crates, have been acknowledged as severely impairing to the physical comfort and expression of natural behaviors of animals. The European Union and select states in the United States have already passed bills eliminating these housing systems over the next several years. Numerous international retail and food production companies, including *Burger King* (North America), *Smithfield Foods*, and *McDonald's* (Europe) are committed to gradually eliminating the use and sale of eggs and pork produced via intensive confinement systems. This trend has also influenced Brazil, where surveys already indicate that 88% of consumers believe that the treatment of farm animals needs to be improved. As a result, cage-free housing technology for commercial operations of egg-laying hens and breeding sows is proving to be a business opportunity of great potential in Brazil. Although producers may encounter obstacles when adopting the new system, most of the difficulties may be solved with certain adaptations to facilities, animal breeds, and management practices. In this article, we show that it is possible to neutralize these obstacles in a way that ensures low mortality rates, a commercial production scale, a high level of food safety, and affordable costs. Producers are thus able to adequately care for the animals, meeting consumers' expectations, remain competitive, and even conquer new markets.

Introduction

The breadth of scientific evidence demonstrating that intensively confined animals are frustrated, distressed, and suffering under modern production schemes is extensive,[1,2,3,4,5,6] substantiating that battery cages for egg-laying hens and crates for pregnant sows and calves are not appropriate environments. Some of the principal Brazilian associations representing livestock producers, such as Brazilian Poultry Union (UBA, in Portuguese), already acknowledge that animal welfare constitutes a very important concern in the agribusiness, in addition to environmental preservation, food safety, and salubrious working conditions.[7]

A widely accepted definition of farm animal welfare, proposed by the Farm Animal Welfare Council (FAWC), an advisory body of the British government, involves five essential freedoms, which must be met in order for an animal to "be protected from unnecessary suffering". An animal must be (a) free from hunger and thirst, (b) free from discomfort, (c) free from pain, injury, or disease, (d) free to express normal behavior, and (e) free from fear and distress.[8]

Industrial animal housing systems may have particularly severe implications on animal welfare. The welfare of intensively confined hens, sows, and calves is significantly compromised, as the animals are denied the ability to exercise, fully extend their limbs or simply turn their bodies, or perform other integral, instinctual, and natural behaviors.[9] The forced near-immobilization may take a serious physical and psychological toll, leading both to physiological problems and psychosis, resulting from extreme boredom and frustration.[10]

World Trend

We have seen a striking increase in the ethical demands of consumer markets of Europe and North America in recent years. Media and non-governmental organizations are increasingly providing citizens with information about the industrial methods of animal agriculture. This leads to consumers refusing to purchase

foods produced inhumanely. The increase in the amount of information available to consumers has consequently put pressure on all supply chains and governments to adopt more animal friendly policies, namely those which seriously consider the importance of providing proper animal welfare.

Legislation

Due to the high standards of ethical demands from consumers in the 1990s, the European Union (UE) passed the Directive 1999/74/CE, which foresees the complete prohibition of barren battery cages beginning in 2012.[11] The routine use of gestation crates will also be banned in 2013.[12] As for veal crates (form of intensive confinement of calves), the prohibition is already under law.[13] These directives apply to all 27 EU member states; however, some European countries have preferred to adopt stricter legislations, taking animal welfare even more seriously. The United Kingdom has already banned gestation crates for sows,[14] in addition to having rigorous codes of animal welfare for other farm animals.[15,16,17] In Switzerland, battery cages and the continuous intensive confinement of pigs have been prohibited since 1992.[18] Belgium, in turn, has already set terms for any kind of cage to be forbidden in egg production.[19]

In the United States, seven states have already enacted similar laws. From 2015 onwards, California will no longer allow any manner of confinement that prevents animals from lying down, standing up, turning around freely, and fully extending their limbs.[20] The parliamentarians of the state of Michigan passed a very similar law in October 2009, banning the intensive confinement of calves in October 2010 and of pigs and laying hens in 2019.[21]

Companies

In addition to legislators and the government, private companies have also been affected by public pressure to improve animal welfare. This can be illustrated by the increase in the sales of cage-free eggs in the United States by approximately 150% between 2000 and 2008.[22,23,24] Public disapproval of intensive confinement raising systems has thus reached a level which is forcing large producers and food retail chains to adopt significant animal welfare policies, in order not to lose customers.

To meet this demand, an increasing number of retail food companies in Europe are already offering meat and eggs produced in cage-free systems. A similar trend is taking place in the United States, where major restaurant and supermarket chains are adopting purchasing policies favoring producers who do not use cages or crates.

In March 2007, *Burger King*, the second largest fast-food restaurant chain in the United States, announced a policy to gradually reduce products originating from caged animals, for all of its franchise locations in North America. It also implemented a purchase preference for swine producers who do not confine breeding sows in gestation crates. The company announced that this decision was made not only to keep *Burger King* ahead of the industry trends, but also to encourage producers to adopt more humane production systems.[25] Other large restaurant chains in the United States, such as *Wendy's*, *Red Robin*, *Hardee's*, and *Carl's Jr.*,[26] have moved in the same direction.

In the United States, *Walmart* and *McDonald's* began to put the pressure on their supplier, *Smithfield Foods*—the largest swine producer in the world—to adopt a program for the elimination of gestation crates.[27] *Maple Leaf Foods*, the largest swine producer in Canada, also committed to gradually ending its use of intensive confinement systems.[28] Similarly, the American Veal Association voted to end the use of veal crates in 2017 to stimulate the American veal industry.[29]

On the supermarket shelves, the trend is clear. *Safeway*, a giant in the industry with 1,743 units in the United States and Canada, alleged in 2008 the plan of achieving a 6% cage-free share of its overall egg volume by 2010, in addition to giving preference to pork suppliers who do not intensively confine their breeding sows.[30,31] *Whole Foods Market*, world leader in natural and organic retail, currently buys 100% of its eggs from producers who do not use cages, in addition to implementing other animal welfare standards.[32] Similarly, other North American supermarket chains, such as *Wild Oats*, *Andronico's*, *Jimbo's*, and *Mother's*, no longer purchase animal products originating from intensive confinement systems.[33]

In the United Kingdom, animal welfare policies are present in many food chains. Examples of this include *Marks and Spencer*, *Sainsbury's*, and *Waitrose*, which no longer sell cage eggs or crate pork.[34,35,36,37,38] *McDonald's* in the EU ordered over 95% of its eggs from cage-free systems in 2008 and committed to increasing that number to 100% by 2010.[39] Other retail food companies in Germany, Italy, and the Netherlands have also been gradually eliminating cage eggs from their shelves.[40]

In addition to producers, supermarkets, and restaurants, offices of companies with high numbers of employees have begun to supply their cafeterias exclusively with cage-free products, generating a significant financial and educational impact. This is the case for *America Online*, *Google*, and *Yahoo!*, among others. Moreover, hundreds of university cafeterias in the United States are following suit, significantly raising the demand for cage-free eggs and encouraging many students to adhere to this trend.[41]

In Brazil, some commercial-scale producers have already reacted to the market trend and are expanding their cage-free facilities. There is now a national certificate called *Certified Humane Brasil*, available to those farms that do not practice intensive confinement and that adhere to other basic animal welfare standards.[42]

Opportunity for Cage-free Systems in Brazil

The ethical demands from consumers have been continuously increasing worldwide, accompanied by a growing activity of animal advocacy and environmentalist NGOs. Such mobilization in the direction of more humane animal agriculture presents a business opportunity of great potential for farmers, wholesalers, and retailers alike.

In Brazil, there are already several commercial-scale producers transitioning to more humane systems. Some of these producers have also been requesting welfare certifications (such as *Certified Humane Brasil*). Moreover, the government has already been adopting policies on certain animal welfare concerns, such as humane slaughter.[43] Intensive confinement systems, however, which constitute some of the worst practices in terms of animal welfare, remain untouched, raising concerns for many consumers. A 2007 survey by the World Society of the Protection of Animals (WSPA) indicates that 74% of Brazilian consumers believe that the treatment of farm animals in Brazil needs to improve.[44] A 2008 study carried out by the Brazilian Institute of Public Opinion and Statistics (IBOPE, in Portuguese) indicates that 85% of Brazilian consumers are willing to pay more for environmentally friendly products.[45]

Arguably, those who invest in products that are serious about animal welfare (especially with respect to reducing the chronic stress inherent to intensive confinement) will certainly find a market. Unfortunately, many Brazilian producers still believe that cage-free housing is not feasible. However, we can already predict that, in the foreseeable future, cage-free production will no longer be only feasible, but also necessary for the long-term success of the producer.

Cage-free Egg Production

There are numerous alternatives to battery cages. Thus, producers have a variety of options available to them that may work best for both themselves and the birds. The various systems can be grouped into three basic categories: single-level barns, aviary systems, and free-range systems.[46]

Single-level Barns

Single-level barns may be "deep-litter" systems (see below), similar to those in which broiler chickens are raised, or designed with perforated flooring. In either case, these systems provide nest boxes and, in contrast to battery cages, allow birds to move about freely. In the case of deep-litter, the floor area is solid with a litter of straw, wood shavings, sand, or turf. Manure and litter should preferably be removed as often as possible. In the case of perforated flooring, there is no bedding and the mesh floor allows manure to drop onto a pit below, similarly to what happens in cage systems.

Aviary Systems

Aviaries, or multi-tiered barn systems, have litter floors for exercise and dustbathing, raised nest boxes for laying eggs, and perches at higher tiers for roosting. Placing drinking and feeding stations at every tier encourages the birds to use the entire system. This also ensures that the majority of the manure falls into manure pits or manure collection belts below higher tiers, and not into the litter or in nesting areas. Stocking density is usually higher than in single-level barns. In the United States, the majority of commercial cage-free egg production employs this type of aviary system.

Free-Range Systems

These systems combine a barn system (deep-litter or aviary) with continuous daytime access to the outdoors. The outdoor areas should contain a large amount of vegetation and areas with overhead cover to protect birds from predators. Though resting, nesting, and feeding may still typically take place indoors, free-range systems give birds the opportunity to exercise in fresh air and enjoy a higher level of environmental stimulation.

General Features of Cage-Free Egg Production

Cage-free systems should minimally contain separate areas for perching, nesting, and dustbathing. Stocking density should be low enough to avoid overcrowding and to ensure that all birds have access to the different sections of the housing system.

The availability of a separate area for laying eggs, preferably covered nesting boxes, is critical to hen welfare. Several leading animal scientists and veterinarians have concluded that a significant source of frustration for battery-caged hens is the lack of nesting opportunity. Hens crave seclusion during oviposition.[47] Indeed, birds in battery cages are often seen trying to hide beneath their cage-mates at this time.

The hens will almost exclusively lay in nesting boxes, which makes both automated and manual egg collection easier. Cage-free hens may lay 5% of their eggs on the litter ("floor eggs") instead of in nesting boxes,[48] although our research shows that there are Brazilian producers who adopt good management practices and are able to achieve rates below 1%.[49,50] Measures which discourage such behavior include: collecting previously laid floor eggs and immediately placing them into nesting boxes, eliminating dark, shadowed areas that may attract the hens, providing hens with early access to perches, and placing water and feed systems near the nesting sites so that the birds are not drawn away from the nest boxes when they are ready to lay their eggs.[51,52,53]

Providing increased ground scratching and foraging opportunity for the birds can mitigate abnormal behaviors. If chickens do not have the opportunity to peck and scratch the ground, a natural foraging tendency, they may be more likely to exhibit feather-pecking behaviors. By providing diverse substrate to keep the birds engaged and fulfilled, a producer can minimize negative interactions. For example, grains can be mixed into the litter to promote scratching and pecking at the ground. Limestone blocks and straw also make the litter more interesting to birds, thereby diverting them from destructive behaviors.[54,55] Injurious pecking behavior and mortality rate are extremely variable among existing cage-free commercial producers. Low mortality rates can be achieved through proper management[56,57,58,59] and breed choice.[60,61,62,63,64] Furthermore, since cage-free egg production is becoming an international trend, breeding companies are beginning to select hens on the basis of their performance and survival *in cage-free environments*,[65] which will likely improve the adaptability of industrial strains to these environments even more.

The housing structure for brooders should mirror those in which they will live as layers, as this provides an opportunity for them to learn to use the different sections of the housing system.[66]

Economics of Cage-Free Egg Production

Comparisons between cage-free and battery-cage operations in Europe and the United States suggest that cage-free systems have higher feed and labor costs.[67,68] A study found that aviaries have production costs of

about 21% above conventional cages.[69] However, producers may receive a premium for cage-free eggs. A survey of retail prices from a major retail chain across 15 U.S. cities in April 2008 indicates an average retail price of about $3.07 per dozen large grade A brown eggs versus $3.59 for non-organic, non-cage brown eggs—an average premium of about 17%.[70]

Although furnished cages have some welfare advantages over non-cage systems, U.S. consumers do not recognize a larger, modified cage as a significant improvement over conventional battery cages.[71,72] Eggs from hens confined in furnished cages thus do not enjoy the market premium of cage-free eggs.[73]

Brazilian cage-free producers interviewed by Humane Society International (HSI) stated that the eggs produced at their farms enjoy such a premium.[74,75] A commercial scale free-range producer claimed that the retail value of his product is twice that of conventional eggs and stressed that he has never been short on demand.[76] Other data from the interviews provide evidence of similar building costs per square meter for cage-free aviaries and battery cage buildings. The total area required for a commercial scale cage-free aviary may be greater, but the basic building and cage-free furnishing costs are similar to the costs associated with a conventional shed with battery cages. Yet, it is worth noting that the cost of converting a conventional building for egg-laying hens to a cage-free aviary may be significant, due to their very different physical structures. However, better options are available, including building completely new cage-free aviaries or converting broiler facilities into cage-free egg aviaries.[77] As for acquiring cage-free furnishings, producers say that they have not encountered any difficulties, as the materials are identical to those commonly used for breeder flocks.[78]

Concerning other economical aspects, such as the laying rate and the age of replacement, Brazilian cage-free producers have no evidence of significant variation between caged and non-caged hens. The peak laying rate for cage-free hens can be as high as 95%, although this rate may sometimes be slightly lower than the rate for caged hens.[79] Floor eggs constitute only a small proportion of the eggs laid: from less than 1% to 5%, depending on the management of the birds and their environment.[80,81,82] Moreover, the age of replacing the flock in cage-free systems is not necessarily younger, varying from 16-24 months, and the stocking density may vary between 5-8.5 hens per square meter.[83,84]

Although the choice of animal strain may have an influence on mortality rates and resistance to diseases, the interviewed cage-free producers in Brazil have successfully used a number of different strains, including Label Rouge, ISA Brown, and Hisex Brown, and others. This shows that highly productive strains can be used in cage-free systems without any difficulty.[85,86,87]

The labor force currently seems to be a key concern in cage-free farms in Brazil. Although the automated collection of eggs is already a reality among commercial cage-free egg producers in the United States, interviewed Brazilian producers currently use no such mechanism, relying on manual collection of their eggs, a much slower process. This is a main reason for their need for at least twice the number of employees for each flock of a given size.[88,89,90]

Hen Mortality

Scientists have shown that mortality in the laying period is generally low and similar in all kinds of housing.[91] Studies are beginning to reveal that the differences in mortality between systems are not due to the housing system *per se*, but to management decisions, such as choice of hen strain. Indeed, husbandry practices and production methods are critical to hen welfare. A 2005 systematic review of 14 different studies showed that mortality rate does not necessarily differ between cages and aviaries. Mortality can be reduced in cage-free systems by choosing a suitable hen strain,[92] taking necessary steps to prevent feather-pecking and cannibalism, and by protecting free-range flocks from predators.[93]

Management seems to be an important factor in determining mortality rate. In a 2007 study of free-range farms, the estimated losses from culling and death ranged from 1.8% to 21.4% at the end of the laying cycle (70 weeks).[94] This result shows that mortality may vary widely between farms using the same type of facilities, thus suggesting that mortality rate differences are generated by other characteristics such as management. Given that at least one farm had a mortality rate of only 1.8%, it is suggested that producers

may have a very acceptable mortality rate in a cage-free operation, as long as they use good management practices. On the other hand, poor management may lead to mortality rates as high as 20% or more.

The Brazilian cage-free producers we interviewed claimed that the mortality of hens was not a significant problem, that is, at least not any more so than for caged hens.[95,96] In fact, one producer stated that mortality rate was very similar to the expected mortality curve for the strain used.[97]

Hen Health and Food Safety

Egg-laying hens may suffer from parasitic and reproductive, as well as metabolic and anatomic diseases, both within or without cages. However, the kind of housing may have an effect on the types and likelihood of these diseases.

When one compares free-range and more intensive systems, advantages and disadvantages are found between them. Whereas free-range flocks that have access to external areas have more contact with wild animals, insects, and other potential infectious agents, these systems provide fresh air, which can lower frequency of airborne disease.[98] Additionally, a number of diseases show similar prevalence between different housing systems, such as *Campylobacter jejuni*, which has been recently shown not to occur more often in outdoor flocks, as it was once thought.[99]

Stocking density represents an important factor in determining the risk of occurrence of certain diseases. High densities increase the frequency of protozoal infections with short, direct life cycles, such as coccidiosis and cryptosporidiosis.[100] Moreover, overcrowding has been identified as a relevant factor in the emergence of highly pathogenic strains of avian influenza.[101]

The risk of enteric disease is heightened by contact with droppings, which can occur in deep-litter and free range systems, not only for laying hens, but for all birds reared on litter, including broilers and breeding birds used to produce hatching eggs. However, disease risk in a barn system can be reduced by preventing the environment from being too moist, stopping leaks in drinkers, and removing water vapor from the barn.[102,103] Additional measures which further reduce the occurrence of enteric diseases in aviaries include: removing some of the droppings (e.g., via a belt in aviary and perchery systems); placing drinkers on a slatted platform above a manure pit; using dewormers;[104] stocking hardy laying hen strains resistant to intestinal parasites;[105] introducing only parasite-free, healthy pullets;[106] and feeding diets that improve resistance.[107] In order to prevent ammonia build-up, litter depth should be kept at a minimum so that it remains dry and friable. Encouraging scratching and foraging behaviors also helps dry the litter. For free-range systems, disease risk can also be reduced by utilizing pasture rotation to regenerate soil, regularly mowing or grazing to keep short vegetation on pasture, using only land with good drainage, removing heavily contaminated soil around the barn before introducing a new flock, and installing fencing and bird mesh to exclude wild birds and other animals.[108,109,110]

Interviews with Brazilian cage-free producers show that they have no difficulty in keeping the litter dry and hygienic throughout the life of a flock of laying hens. In fact, based on their experiences with cage-free egg farms, they state that, as long as hens are provided a common, high-quality feed, their droppings are not sufficiently moist to compromise the quality of the deep-bed during that period.[111,112] Furthermore, simple management practices, such as mixing the substrate[113,114] and adding small quantities of fresh litter,[115] help maintain bedding quality.

Most of the parasitic diseases of the intestinal tract, such as coccidiosis, are not normally problematic in cage-free systems with adequate management. Measures such as the health control of pullets entering the aviary, anticoccidial medication, and biosecurity precautions prevent coccidiosis outbreaks,[116,117] allowing for good sanitary conditions in these systems.

Concerning non-parasitic diseases, however, cage systems may have a more frequent occurrence than in other systems. Some of these diseases severely impair the hens' welfare and may generate considerable financial losses to the farmer. Examples include: Fatty Liver Hemorrhagic Syndrome (FLHS), common in caged laying hens on high energy diets;[118,119] toe pad hyperkeratosis;[120,121] osteoporosis, often related to the

lack of movement in battery cages;[122,123,124,125,126,127] and cage layer fatigue, which also causes bone weakness and consequent fractures.[128]

In Brazil, interviews with alternative producers indicate that health problems are no more frequent in cage-free operations. With proper vaccinations and routine sanitary control to prevent contamination of flocks, the occurrence of most diseases is low and similar to that of cage systems. Cannibalism and feather pecking also occur at a low frequency in cage-free production and debeaking is still practiced on birds once at an early age.[129,130,131]

Alternatives to Gestation Crates

Alternatives to gestation crate production methods include free-range, pasture-based systems, and most commonly, indoor group housing.

In free-range systems, sows are afforded access to the outdoors and, optimally, given the freedom and materials to express natural behaviors like nest-building and rooting. Sows are raised outdoors in pasture-based production and are typically provided with portable housing or shelters to allow for sustainable rotational practice. This is the case for the Free-Range Pig Production Intensive System (*Sistema intensivo de produção de suínos criados ao ar livre*, or SISCAL in Portuguese), which is already practiced among several producers in Brazil and has proven to be an excellent alternative.

As the main alternative to gestation-crate systems, groups of up to several dozen sows are housed together in indoor pens, sometimes with deep litter allowing for access to bedding materials, and given the freedom to move and the opportunity to socialize.

Feeding practices in group-housing systems vary. The most effective alternative to date is likely the electronic sow feeder (ESF) system, which allows entry of one sow at a time, identifies her through an electronic tag or collar, and distributes the appropriate ration. When the sow finishes eating, she leaves through a separate exit. In the ESF system, feeding aggression is eliminated because sows do not have to compete for food. In several countries, ESF systems are being widely adopted and their welfare advantages are well documented in scientific reviews.[132,133]

Higher sow productivity is possible in group housing compared with individual crate housing, resulting from reduced rates of confinement injuries and urinary tract infections (UTIs),[134] earlier first estrus,[135,136] larger litter size, and lower stillbirth incidence.[137] Commenting on the increased litter size in group versus crated housing systems, Iowa State University animal science Professor Mark Honeyman was quoted as saying it is "a large difference….It's significant from an economic value and productivity value viewpoint."[138]

In its review, the Scientific Veterinary Committee (SVC) in the European Commission reported that sows in groups "have more exercise, more control over their environment, more opportunity for normal social interactions and better potential for the provision of opportunities to root or manipulate materials… Group-housed sows show less abnormality of bone and muscle development, much less abnormal behaviour, less likelihood of extreme physiological responses, less incidence of urinary tract infections associated with inactivity, and better cardiovascular fitness."[139] In 2000, more than 4 million sows in Europe were raised in either group or outdoor housing.[140]

Animal Health and Well-Being

Virtually immobilized in barren, restrictive gestation crates, the welfare of breeding sows is severely compromised. Jeremy Marchant-Forde, now a research animal scientist with the U.S. Department of Agriculture (USDA), and Donald Broom, professor of Animal Welfare at the University of Cambridge, have posited that difficulty performing the simple movements of standing and lying is indicative of poor sow welfare. They describe that commercial stalls were not designed with the understanding of these movements and note: "With these dynamic space requirements taken into account, the vast majority of gestation stalls and farrowing crates are too small in width and length, to allow standing and lying to be carried out without spatial restriction."[141]

Other animal scientists have made similar claims and also have suggested that crated sows experience increasingly severe discomfort as pregnancy advances.[142] Indeed, welfare concerns were not the "primary consideration in the design of many current housing systems".[143] A survey of manufacturers revealed that engineers did not use sow measurements during the design of the first gestation crates.[144]

Discomfort can be compounded by problems associated with barren crates. Without any bedding materials, sows have no thermal protection, which can cause systemic and local cold stress and may contribute to or exacerbate injuries to skin and limbs.[145] Because gestation crates are barely larger than a sow's body, the animals must urinate and defecate where they stand. As such, the concrete floors of the crates are often partially or fully slatted to allow waste to fall into a pit below. Housing the sows directly above their own excrement has been shown to expose the animals to adversely high levels of ammonia,[146] and respiratory disease has been found to be a significant health issue for pigs kept in confinement.[147]

Foot and leg disorders, urinary tract infections, and cardiovascular problems are also of concern for crated sows, who additionally suffer traumatic injuries and body sores often caused by being forced to stand and lie on unnatural flooring or in residual feces and urine. A 1995 study by Broom, Mendel, and Zanella found that 33% of crated sows required removal from production as a result of health problems, compared with less than 4% of group-housed sows.[148]

Space restriction in gestation crates is a significant cause of injury to pregnant sows. Intensively confined, crated sows experience soreness and injuries from rubbing against the bars of their enclosures and from standing or lying on barren flooring. As gestation crates are narrow and typically placed side by side within pig production facilities, when lying down, sows must extend their limbs into adjacent stalls where they may be stepped on. The slatted floors often have sharp corners that can injure exposed limbs and sows who slip in the crates.[149]

Food-deprived sows can also suffer head and snout injuries from attempting to access a feeder in an adjacent stall.[150] Research has shown that rates of injury increase with time spent in the gestation stall.[151]

In their natural habitat, pigs evolved to walk in woodlands and scrub. Putting sows in gestation crates with unnatural flooring changes the stresses on their feet[152] and is considered to significantly contribute to toe lesions.[153] Some reports find up to 80% of stall-housed sows suffer from this condition.[154]

Gestation crate confinement has also been found to excessively[155] cause damage to joints[156] and lameness.[157,158] Erosion of the cement floor from water and feed may leave rocks and sharp edges that can contribute to foot and leg problems and shoulder sores.[159] Furthermore, bolts which fix the crates in place can contribute to similar injuries.[160]

Reduced Muscle Mass and Bone Strength

The health and welfare of breeding sows housed in gestation crates has been determined to be negatively affected by their inability to turn around or exercise. The restriction of movement can lead to a "reduction of muscle weight and considerable reduction of bone strength," making the most basic movements difficult and leading to a "greater chance of the sow slipping during lying and standing and incurring physical damage." Successive pregnancies exacerbate the problems of diminished muscle mass and bone strength.[161]

Urinary Tract Infections

Gestation-crated sows suffer from a higher rate of UTIs than do uncrated sows,[162] apparently due to their inactivity, decreased water consumption, infrequency of urination,[163] and possible contact with their own waste.[164] These infections can result in a high mortality rate, with one study estimating that half of breeding sow mortalities was caused by UTIs.[165] In comparison, group-housed sows suffer a lower incidence of UTIs associated with inactivity.[166] Increasing water intake at one commercial operation using group pens rather than gestation crates nearly eliminated UTIs.[167]

Mortality in Group Housing Systems

Sows confined in gestation crates have been found to suffer from dramatic weight loss after successive pregnancies and a high incidence of health problems requiring the animals to be "removed from the [production] system."[168] Research on crate-free production has found that both outdoor,[169] and loose-housing[170] systems offer benefits to sow health and longevity. Compared with typical U.S. crate production methods, deep-bedded, loose-housing systems in Sweden result in lower cull rates and greater sow longevity.[171] Commercial operations have also recorded better reproductive performance and lower mortality rates for sows housed in pens rather than confined in crates.[172]

Compared to group-housed sows, gestation-crated sows show increased resting heart rates, likely due to decreased muscle fitness from chronic lack of exercise,[173] and are more likely to suffer decreased cardiovascular fitness.[174] The deaths of many pigs during transport can be traced to cardiovascular problems.[175]

Economics of Group Housing Systems

Although there is no comprehensive study that fully details the economic effects of sow housing alternatives, various studies suggest that they are at least competitive with, if not economically preferable to, the gestation crate systems.[176,177]

Most studies focus on sow performance under the different systems. One study reviewed various others and "found that in 15 studies reviewed, 8 showed better reproduction in group-housed pigs, whereas only 4 showed better reproduction with individual housing."[178] Another recent study indicates that "gestating sows can be housed in deep-bedded hoop barns equipped with individual feeding stalls and achieve results comparable or superior to gestating sows housed in individual crated gestation systems."[179] Furthermore, research shows that the overall farrowing rate was not different between systems.[180]

The financial expense may be less in the group housing system: "The versatility, production flexibility, and low capital costs may result in reduced financial risk."[181] Even if the production performance in alternatives is not at or above that of gestation crates, low initial costs for the farmer may make the alternatives economically viable. Therefore, one may conclude that alternatives to gestation crates are economically competitive.

Economics of Free-range Systems

SISCAL is the principal free-range commercial housing system used in Brazil, and receives technical support from the Brazilian Agency of Agricultural Research (*Empresa Brasileira de Pesquisa Agropecuária*, or EMPRAPA in Portuguese). SISCAL has high technical performance, low implantation and upkeep costs, and ease in expanding facilities, as compared to confinement systems. According to EMBRAPA researcher Osmar Dalla Costa, although implantation costs are 30% higher than that of the conventional system, production costs are nearly the same. [182]

In Brazil, other studies indicate that total costs are between $156 and $312 per housed sow when using SISCAL,[183] whereas the costs at confinement operations are as high as $700 per sow.[184]

In a 2001 study, the total SISCAL implantation costs for fourteen sows and one boar, during reproduction, lactation, and nursery, was $490.20 for each sow. This cost includes all materials, equipment, and labor required for the implantation. The greatest expenses were due to equipment acquisition and construction of the feed plant and storage barn, adding up to 49.03% of the total expenditure. Thus, if a farmer already possesses these items, the cost per sow falls to $240.35. In the same study, the production costs equaled $0.617 for each kilogram of piglet produced, resulting in a profit of 18.81% per kilogram. [185]

Conclusion

Brazilian agriculture is beginning to transform,[186] gradually eliminating those practices which are most harmful to animal welfare. Due to consistent efforts from the media and from non-governmental organizations, consumer awareness continues to grow with respect to the welfare implications concerning the industrial farming of animals, especially those raised in intensive confinement systems. Combined with the

modern concept of "consumption awareness" and co-responsibility, consumers have been motivated to refuse to support certain animal production practices, generating an increased pressure upon the government and the industry. This is evidenced by the recent constitution of a technical commission within the Brazilian Department of Agriculture, dedicated to animal welfare. Such pressure is also made visible in the recent introduction of the before-mentioned animal welfare certificate, *Certified Humane Brasil*.

The difficulties usually encountered in the implementation of cage-free housing systems for hens and crate-free housing systems for sows are expected, given that the facilities, animal strains, and management practices are adapted to the outdated intensive confinement systems. However, difficulties may be overcome through improvements and adjustments to those elements. One cannot expect that by simply eliminating the cages and leaving the rest of the system unchanged, one can overcome all of the obstacles. It is necessary to consider other factors and to make some adaptations—often at a low cost—in order for the new system to succeed. One thing however, is certain: from now on, producers who wish to conquer new markets, and not lose the old ones, must take animal welfare more seriously into account and work to eliminate those housing systems that prevent animals from performing their most basic natural behaviors.

References

[1]WSPA. 2007. World Society for the Protection of Animals. International Farm Animal Survey. Conducted by Ipsos MORI in November, 2007.

[1] Špinka M. 2006. How important is natural behaviour in animal farming systems? Applied Animal Behaviour Science 100:117-28.

[2] Baxter MR. 1994. The welfare problems of laying hens in battery cages. The Veterinary Record 134(24):614-9.

[3] Dawkins MS. 1990. From an animal's point of view: Motivation, fitness, and animal welfare. Behavioral and Brain Sciences 13:1-61.

[4] Vestergaard K. 1984. An evaluation of ethological criteria and methods in the assessment of wellbeing in sows. Annales de Recherches Vétérinaires (Annals of Veterinary Research) 15(2):227-35.

[5] Broom DM, Mendl MT, and Zanella AJ. 1995. A comparison of the welfare of sows in different housing conditions. Animal Science 61:369-85.

[6] European Commission, Scientific Veterinary Committee, Animal Welfare Section. 1995. Report on the Welfare of Calves. Adopted November 9. http://ec.europa.eu/food/fs/sc/oldcomm4/out35_en.pdf. Accessed January 25, 2008.

[7] UBA (União Brasileira de Avicultura). 2008. Protocolo de Bem-Estar para Frangos e Perus, p. 10. http://www.uba.org.br/site3/arquivos/protocolo_de_bem_estar_para_frangos_e_perus_14_07_08.pdf. Accessed January 25, 2010.

[8] FAWC (Farm Animal Welfare Council). 2009. Five Freedoms. http://www.fawc.org.uk/freedoms.htm. Accessed January 25, 2010.

[9] Špinka M. 2006. How important is natural behaviour in animal farming systems? Applied Animal Behaviour Science 100(1-2):117-28.

[10] Mendl MT. 1991. The effects of alternative forms of intensive pig husbandry on measures of pig welfare. In: Bradley A and Sckofield WL (eds.), Proceedings of the First Association of Veterinary Students Animal Welfare Symposium (Cambridge, U.K.: Association of Veterinary Students)

[11] European Commission. 1999. Council Directive 1999/74/EC of 19 July 1999 laying down minimum standards for the protection of laying hens. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1999:203:0053:0057:EN:PDF. Accessed January 25, 2010.

[12] Commission of the European Communities. 2001. Council Directive 2001/88/EC of 23 October 2001 amending Directive 91/630/EEC laying down minimum standards for the protection of pigs. Official Journal of the European Communities L316:1-4.

[13] Council of the European Union. 1997. Council Directive 97/2/EC of 20 January 1997 amending Directive 91/629/EEC laying down minimum standards for the protection of calves. http://ec.europa.eu/food/fs/aw/aw_legislation/calves/97-2-ec_en.pdf. Accessed January 25, 2010.

[14] Department for Environmental Food and Rural Affairs. Code of Recommendations for the Welfare of Livestock: Pigs. 2003. Available at: http://www.defra.gov.uk/foodfarm/farmanimal/welfare/onfarm/documents/pigcode.pdf. Accessed April 10, 2010.

[15] Department for Environmental Food and Rural Affairs. Code of Recommendations for the Welfare of Livestock: Cattle. 2003. Available at: http://www.defra.gov.uk/foodfarm/farmanimal/welfare/onfarm/documents/cattcode.pdf Accessed April 10, 2010.

[16] Department for Environmental Food and Rural Affairs. Code of Recommendations for the Welfare of Livestock: Meat Chickens and Breeding Chickens. 2002. Available at: http://www.defra.gov.uk/foodfarm/farmanimal/welfare/onfarm/documents/meatchkscode.pdf. Accessed April 10, 2010.

[17] Department for Environmental Food and Rural Affairs. Code of Recommendations for the Welfare of Livestock: Laying Hens. 2002. Available at: http://www.defra.gov.uk/foodfarm/farmanimal/welfare/onfarm/documents/layerscode.pdf. Accessed April 10, 2010.
[18] Landwirtschaftlicher Informationsdienst. 2010. Haltung von Hühner. http://www.landwirtschaft.ch/de/wissen/tiere/gefluegelhaltung/haltung. Accessed April 10, 2010.
[19] Avicultura Industrial. 2009. Bélgica proíbe gaiolas. August 14. http://www.aviculturaindustrial.com.br/PortalGessulli/WebSite/Noticias/belgica-proibe-gaiolas,20090814140742_P_831,20081118090935_B_868.aspx. Accessed January 25, 2010.
[20] Poultry Press. 2008. California Voters Pass Proposition 2 with 63 % of the Vote. Winter 2008-2009, 18(4). http://www.upc-online.org/winter2008/california-voters.html. Accessed January 25, 2010.
[21] Saúde & Lazer. 2009. O Mundo Contra o Confinamento Intensivo Animal. October 16. http://www.saudelazer.com/index.php?option=com_content&task=view&id=8832&Itemid=49. Accessed January 25, 2010.
[22] The Poultry Site. 2008. Choosing a Good Egg. December 1. http://www.thepoultrysite.com/poultrynews/16580/choosing-a-good-egg. Accessed January 25, 2010.
[23] World Poultry. 2007. The new US trend: the cage-free egg. August 13. http://www.worldpoultry.net/news/the-new-us-trend-the-cage-free-egg-id1619.html. Accessed January 25, 2010.
[24] Henry F. 2008. 'Cage-free' living isn't always equal. The Plain Dealer, June 17. Available at http://www.allbusiness.com/government/government-bodies-offices/12116999-1.html. Accessed January 25, 2010.
[25] Martin A. 2007. Burger King Shifts Policy on Animals. The New York Times, March 28. www.nytimes.com/2007/03/28/business/28burger.html?ei=5124&en=71042316311193l0&ex=1332734400&pagewanted=print. Accessed January 25, 2010.
[26] Henry F. 2008. 'Cage-free' living isn't always equal. The Plain Dealer, June 17. Available at http://www.allbusiness.com/government/government-bodies-offices/12116999-1.html. Accessed January 25, 2010.
[27] Smithfield Foods. 2007. Smithfield Foods makes landmark decision regarding animal management. http://www.prnewswire.com/news-releases/smithfield-foods-makes-landmark-decision-regarding-animal-management-53754097.html. Accessed January 25, 2010.
[28] The Pig Site. 2007. Maple Leaf Endorses U.S. Industry direction On Sow Stalls. February 1. http://www.thepigsite.com/swinenews/13284/maple-leaf-endorses-us-industry-direction-on-sow-stalls. Accessed January 25, 2010.
[29] Smith R. 2007. Veal group housing approved. Feedstuffs, August 6, p. 3.
[30] Dowling BG. (Vice-president, External Affairs, Safeway Inc.) Personal communication, February 7, 2008. http://www.hsus.org/web-files/PDF/farm/safeway-02-07-08-letter-to-hsus.pdf. Accessed April 10, 2010.
[31] Safeway. 2008. Animal Welfare. http://www.safeway.com/ifl/grocery/CSR-Animal-Welfare. Accessed January 25, 2010.
[32] Whole Foods Market. 2008. Guide to Eggs. http://www.wholefoodsmarket.com/recipes/guides/eggs.php. Accessed January 25, 2010.
[33] The Humane Society of the United States. Andronico's Market Puts the Chicken Before the Egg. Press release issued October 4, 2006. http://www.hsus.org/farm/news/pressrel/andronicos_market_cage_free.html. Accessed January 25, 2010.
[34] The Poultry Site. 2009. UK Supermarkets Halfway to Ending Cage Egg Sales. April 30. http://www.thepoultrysite.com/poultrynews/17639/uk-supermarkets-halfway-to-ending-cage-egg-sales. Accessed January 25, 2010.
[35] Sainsbury's. 2010. Freedom Food Endorsed Pork – a better deal for pigs. http://www2.sainsburys.co.uk/food/foodandfeatures/safety_quality/articles/pork.htm. Accessed January 25, 2010.
[36] Sainsbury's. 2010. Eggs from cage-free hens. http://www2.sainsburys.co.uk/food/foodandfeatures/safety_quality/articles/cage-free_hens-eggs.htm. Accessed January 25, 2010.
[37] Waitrose. 2010. Waitrose pork. http://www.waitrose.com/food/productranges/meat/pork.aspx. Accessed January 25, 2010.
[38] Waitrose. 2010. Good Eggs. http://www.waitrose.com/food/celebritiesandarticles/ingredients/9903s04f01.aspx. Accessed January 25, 2010.
[39] McDonald's Europe. 2008. McDonald's Europe receives 'Good Egg' award from Compassion in World Farming as a result of its action on 'cage-free eggs'. Press release issued April 16. http://www.mcdpressoffice.eu/downloads/pr/Good%20Egg_press_release.pdf. Accessed April 14, 2010.
[40] CIWF. 2009. One billion eggs now from cage-free hens as leading UK companies win 2009 good egg awards. Press release issued May 14. http://www.ciwf.org.uk/includes/documents/cm_docs/2009/n/nr4708.pdf. Accessed April 14, 2010.
[41] The Humane Society of the United States. 2007. 2006 HSUS Annual Report: Charging Forward for Animals. http://www.humanesociety.org/assets/pdfs/2006_annual_report.pdf. Accessed April 13, 2010.

[42] Ecocert Brasil. 2009. Bem estar animal. http://www.ecocert.com.br/bem_estar_animal.html. Accessed January 25, 2010.
[43] BRASIL. 2000. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. Instrução Normativa nº 3, de 17 de janeiro de 2000. *Diário Oficial da República Federativa do Brasil.* Poder Executivo, Brasília, DF, 24 jan. 2000. Seção 1. p. 14. http://extranet.agricultura.gov.br/sislegis-consulta/consultarLegislacao.do?operacao=visualizar&id=1793. Accessed January 25, 2009.
[44] WSPA. 2007. World Society for the Protection of Animals. International Farm Animal Survey. Conducted by Ipsos MORI in November, 2007.
[45] IBOPE. II Fórum IBOPE negócios sustentáveis. Sustentabilidade: Hoje ou Amanhã? 2008. http://www.ibope.com.br/forumibope/pesquisa/Forum_oficial_Mar08.pdf. Accessed January 25, 2010.
[46] Pickett, H. 2007. Alternatives to the Barren Battery Cage For the Housing of Laying Hens in the European Union. Compassion in World Farming (CIWF). http://www.ciwf.org.uk/includes/documents/cm_docs/2008/a/alternatives_to_the_barren_battery_cage_in_the_eu.pdf. Accessed January 25, 2010.
[47] The Humane Society of the United States, Scientists and Experts on Battery Cages and Laying Hen Welfare. http://www.humanesociety.org/assets/pdfs/farm/HSUS-Synopsis-of-Expert-Opinions-on-Battery-Cages-and-Hen-Welfare.pdf. Accessed January 25, 2010.
[48] LayWel. 2006. Welfare implications of changes in production systems for laying hens. 2005. http://www.laywel.eu/web/pdf/deliverable%2062.pdf. Accessed January 25, 2010.
[49] Demattê Filho LC. Telephone interview. January 11, 2010.
[50] Rodrigues LC. Personal interview. July 1, 2010.
[51] Appleby MC, Duncan IJH, and McRae HE. 1988. Perching and floor laying by domestic hens: experimental results and their commercial implications. In: European Food Safety Authority. 2005. Welfare aspects of various systems for keeping laying hens, p. 53. http://www.efsa.europa.eu/EFSA/Scientific_Opinion/lh_scirep_final1.pdf. Accessed January 25, 2010.
[52] Gunnarsson S, Keeling LJ, and Svedberg J. 1999. Effect of rearing factors on the prevalence of floor eggs, cloacal cannibalism and feather pecking in commercial flocks of loose housed laying hens. In: European Food Safety Authority. 2005. Welfare aspects of various systems for keeping laying hens, p. 53. http://www.efsa.europa.eu/EFSA/Scientific_Opinion/lh_scirep_final1.pdf. Accessed January 25, 2010.
[53] Jendral M. 2005. Alternative Layer Hen Housing Systems in Europe: Executive Summary. Report prepared for Alberta Egg Producers and Alberta Farm Animal Care Association. http://www.afac.ab.ca/reports/exechenhousing.pdf. Accessed January 7, 2010.
[54] Jendral M. 2005. Alternative Layer Hen Housing Systems in Europe: Executive Summary. Report prepared for Alberta Egg Producers and Alberta Farm Animal Care Association. http://www.afac.ab.ca/reports/exechenhousing.pdf. Accessed January 7, 2010.
[55] Blokhuis HJ. 1989. The effect of a Sudden Change in Floor Type on Pecking Behaviour in Chicks. Applied Animal Behaviour Science 22(1):65-73.
[56] Scientific Panel on Animal Health and Welfare. 2005. Opinion of the Scientific Panel on Animal Health and Welfare on a request from the Commission related to the welfare aspects of various systems of keeping laying hens. The EFSA Journal 197:1-23. www.efsa.europa.eu/EFSA/Scientific_Opinion/lh_opinion1.pdf. Accessed March 25, 2008.
[57] Blokhuis HJ. 1989. The effect of a sudden change in floor type on pecking behaviour in chicks. Applied Animal Behaviour Science 22(1):65-73.
[58] Newberry RC. 2004. Cannibalism. In: Perry GC (ed.), Welfare of the Laying Hen. Poultry Science Symposium Series 27 (Wallingford, U.K.: CABI Publishing).
[59] Scheideler SE and Shields SJ. 2007. Cannibalism by poultry. NebGuide. University of Nebraska-Lincoln Extension, Institute of Agriculture and Natural Resources. www.ianrpubs.unl.edu/epublic/live/g1670/build/g1670.pdf. Accessed March 25, 2008.
[60] Appleby MC and Hughes BO. 1991. Welfare of laying hens in cages and alternative systems: environmental, physical and behavioural aspects. World's Poultry Science Journal 47(2):109-28.
[61] Appleby MC, Hughes BO, and Hogarth GS. 1989. Behaviour of laying hens in a deep litter house. British Poultry Science 30(3):545-53.
[62] European Food Safety Authority, Animal Health and Animal Welfare. 2005. Scientific report on the welfare aspects of various systems for keeping laying hens. EFSA-Q-2003-92, p. 80. Annex to The EFSA Journal 197, 1-23. www.efsa.europa.eu/EFSA/Scientific_Opinion/lh_scirep_final1.pdf. Accessed March 25, 2008.
[63] Flock DK, Laughlin KF, and Bentley J. 2005. Minimizing losses in poultry breeding and production: how breeding companies contribute to poultry welfare. World's Poultry Science Journal 61(2):227-37.
[64] Ellen ED, Visscher J, van Arendonk JA, and Bijma P. 2008. Survival of laying hens: genetic parameters for direct and associative effects in three purebred layer lines. Poultry Science 87(2):233-9.
[65] O'Sullivan NP. 2009. Genomics, physiology, and well-being: Layer industry breeder's perspective. In: Abstracts of the 98th Annual Meeting of the Poultry Science Association (Raleigh, North Carolina, p. 2).
[66] Van Emous, R. 2003. From cages to alternative systems. World Poultry. 19(6): 24-27

[67] Scientific Veterinary Committee. 1996. Animal Welfare Section. Report on the Welfare of Laying Hens. For the European Commission; Doc VI/B/II.2. http://ec.europa.eu/food/fs/sc/oldcomm4/out33_en.pdf. Accessed January 25, 2010.
[68] European Commission. 2004. Study on the socio-economic implications of the various systems to keep laying hens. Submitted by Agra CEAS Consulting. http://ec.europa.eu/food/animal/welfare/farm/socio_economic_study_en.pdf: p.45. Accessed January 25, 2010.
[69] Van Horne PLM and Bondt N. 2003. Impact of EU Council Directive 99/74/EC "welfare of laying hens" on the competitiveness of the EU egg industry. The Hague: Agricultural Economics Research Institute (LEI), p.25.
[70] Sumner DA, Rosen-Molina JT, Matthews WA, Mench JA, and Richter KR. 2008. Economic Effects of Proposed Restrictions on Egg-laying Hen Housing in California. University of California Agricultural Issues Center. http://aic.ucdavis.edu/publications/eggs/egginitiative.pdf. Accessed April 10, 2010.
[71] Tacken GML, Cotteleer G, and van Horne PLM. 2003. The future of the Dutch egg processing industry. Agricultural Economics Research Institute, The Hague.
[72] Appleby MC. 2003. The European Union Ban on Conventional Cages for Laying Hens: History and Prospects. Journal of Applied Animal Welfare Science 6(2):103-21.
[73] European Commission. 2004. Study on the socio-economic implications of the various systems to keep laying hens. Submitted by Agra CEAS Consulting. http://ec.europa.eu/food/animal/welfare/farm/socio_economic_study_en.pdf: p.45. Accessed January 25, 2010.
[74] De Morais AB. Telephone interview. January 11, 2010.
[75] Rodrigues LC. Personal interview. July 1, 2010.
[76] Rodrigues LC. Personal interview. July 1, 2010.
[77] Dematthê Filho LC. Telephone interview. January 11, 2010.
[78] De Morais AB. Telephone interview. January 11, 2010.
[79] De Morais AB. Telephone interview. January 11, 2010.
[80] Dematthê Filho LC. Telephone interview. January 11, 2010.
[81] De Morais AB. Telephone interview. January 11, 2010.
[82] Rodrigues LC. Personal interview. July 1, 2010.
[83] Dematthê Filho LC. Telephone interview. January 11, 2010.
[84] De Morais AB. Telephone interview. January 11, 2010.
[85] Dematthê Filho LC. Telephone interview. January 11, 2010.
[86] De Morais AB. Telephone interview. January 11, 2010.
[87] Rodrigues LC. Personal interview. July 1, 2010.
[88] Dematthê Filho LC. Telephone interview. January 11, 2010.
[89] De Morais AB. Telephone interview. January 11, 2010.
[90] Rodrigues LC. Personal interview. July 1, 2010.
[91] Appleby MC. 1991. Do hens suffer in battery cages? A review of the scientific evidence commissioned by the Athene Trust. http://www.ciwf.org.uk/includes/documents/cm_docs/2008/d/do_hens_suffer_in_battery_cages_1991.pdf. Accessed January 25, 2010.
[92] Aerni V, Brinkhof MWG, Wechsler B, Oester H, and Fröhlich E. 2005. Productivity and mortality of laying hens in aviaries: a systematic review. World's Poultry Science Journal 61(1):130-42.
[93] Fanatico A. 2006. Alternative Poultry Production Systems and Outdoor Access. National Sustainable Agriculture Information Service. http://www.attra.ncat.org/attra-pub/PDF/poultryoverview.pdf. Accessed January 25, 2010.
[94] Whay RH, Main DCJ, Green LE, et al. 2007. Assessment of the behaviour and welfare of laying hens on free-range units. The Veterinary Record 161:119-28.
[95] Dematthê Filho LC. Telephone interview. January 11, 2010.
[96] De Morais AB. Telephone interview. January 11, 2010.
[97] Dematthê Filho LC. Telephone interview. January 11, 2010.
[98] Scientific Panel on Animal Health and Welfare. 2005. Opinion of the Scientific Panel on Animal Health and Welfare on a request from the Commission related to the welfare aspects of various systems of keeping laying hens. The EFSA Journal 197:1-23. http://www.efsa.europa.eu/EFSA/Scientific_Opinion/lh_opinion1.pdf. Accessed January 25, 2010.
[99] WorldPoultry.net. 2008. Free-range chickens at 'no increased infection risk.' April 16. http://www.worldpoultry.net/news/free-range-chickens-at-no-increased-infection-risk-id2430.html. Accessed January 25, 2010.
[100] McDougald LR. 2003. Protozoal infections. In: Saif YM, Barnes HJ, Gilsson JR, Fadly AM, McDougald LR, and Swayne DE (eds.), Diseases of Poultry, 11th Edition (Ames, IA: Iowa State Press, p. 973).
[101] Greger M. 2007. The Human/Animal Interface: Emergence and Resurgence of Zoonotic Infectious Diseases. Critical Reviews in Microbiology 33(4):243-99.
[102] Scientific Panel on Animal Health and Welfare. 2005. Opinion of the Scientific Panel on Animal Health and Welfare on a request from the Commission related to the welfare aspects of various systems of keeping laying hens. The EFSA Journal 197:1-23. www.efsa.europa.eu/EFSA/Scientific_Opinion/lh_opinion1.pdf. Accessed January 25, 2010.

[103] Häne M, Huber-Eicher B, and Fröhlich E. 2000. Survey of laying hen husbandry in Switzerland. World's Poultry Science Journal 56:21-31.
[104] Hy-Line Variety. 2007-2008. W-36 Commercial Management Guide. www.hy-line.com/userdocs/library/W-36_Eng_indd.pdf. Accessed January 25, 2010.
[105] McDougald LR. 2003. Internal parasites. In: Saif YM, Barnes HJ, Gilsson JR, Fadly AM, McDougald LR, and Swayne DE (eds.), Diseases of Poultry, 11th Edition (Ames, IA: Iowa State Press, p. 944).
[106] Shingleton D. 2004. Disease control. In: Perry GC (ed.), Welfare of the Laying Hen. Poultry Science Symposium Series 27: 279-282 (Wallingford, U.K.: CABI Publishing).
[107] McDougald LR. 2003. Internal parasites. In: Saif YM, Barnes HJ, Gilsson JR, Fadly AM, McDougald LR, and Swayne DE (eds.), Diseases of Poultry, 11th Edition (Ames, IA: Iowa State Press, p. 944).
[108] Shingleton D. 2004. Disease control. In: Perry GC (ed.), Welfare of the Laying Hen (Wallingford, U.K.: CABI Publishing).
[109] Hy-Line®. 2007-2008. W-36 commercial management guide. www.hy-line.com/userdocs/library/W-36_Eng_indd.pdf. Accessed April 10, 2010.
[110] Fanatico A. 2006. Alternative poultry production systems and outdoor access. National Sustainable Agriculture Information Service. www.attra.ncat.org/attra-pub/PDF/poultryoverview.pdf. Accessed April 10, 2010.
[111] Dematté Filho LC. Telephone interview. January 11, 2010.
[112] De Morais AB. Telephone interview. January 11, 2010.
[113] De Morais AB. Telephone interview. January 11, 2010.
[114] Rodrigues LC. Personal interview. July 1, 2010.
[115] Rodrigues LC. Personal interview. July 1, 2010.
[116] Appleby MC and Hughes BO. 1991. Welfare of laying hens in cages and alternative systems: environmental, physical and behavioural aspects. World's Poultry Science Journal 47(2):109-28.
[117] McDougald LR. 2003. Coccidiosis. In: Saif YM, Barnes HJ, Gilsson JR, Fadly AM, McDougald LR, and Swayne DE (eds.), Diseases of Poultry, 11th Edition (Ames, IA: Iowa State Press, p. 976).
[118] The Merck Veterinary Manual. 2008. Fatty Liver Syndrome: Introduction, The Merck Veterinary Manual Online, 8th Edition. www.merckvetmanual.com/mvm/index.jsp?cfile=htm/bc/202400.htm. Accessed January 25, 2010.
[119] McMullin P. 2004. A Pocket Guide to Poultry Health and Disease (Sheffield, U.K.: 5M Enterprises Ltd., p. 123).
[120] Bell DD. 2002. Cage management for layers. In: Bell DD and Weaver WD (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[121] Tauson R, Wahlstrom A, and Abrahamsson P. 1999. Effect of two floor housing systems and cages on health, production, and fear response in layers. Journal of Applied Poultry Research 8(2):152-9.
[122] Fanatico A. 2006. Alternative Poultry Production Systems and Outdoor Access. National Sustainable Agriculture Information Service. www.attra.ncat.org/attra-pub/PDF/poultryoverview.pdf. Accessed January 25, 2010.
[123] Nørgaard-Nielsen G. 1990. Bone strength of laying hens kept in an alternative system, compared with hens in cages and on deep-litter. British Poultry Science 31(1):81-9.
[124] Fleming RH, McCormack HA, McTeir L, and Whitehead CC. 2006. Relationships between genetic, environmental and nutritional factors influencing osteoporosis in laying hens. British Poultry Science 47(6):742-55.
[125] Leyendecker M, Hamann H, Hartung J, et al. 2005. Keeping laying hens in furnished cages and an aviary housing system enhances their bone stability. British Poultry Science 46(5):536-44.
[126] Fleming RH, Whitehead CC, Alvey D, Gregory NG, and Wilkins LJ. 1994. Bone structure and breaking strength in laying hens housed in different husbandry systems. British Poultry Science 35(5):651-62.
[127] Webster AB. 2004. Welfare Implications of Avian Osteoporosis. Poultry Science 83:184-92.
[128] Riddell C, Helmboldt CF, Singsen EP, and Matterson LD. 1968. Bone Pathology of Birds Affected with Cage Layer Fatigue. Avian Diseases 12(2):285-97.
[129] Dematté Filho LC. Telephone interview. January 11, 2010.
[130] De Morais AB. Telephone interview. January 11, 2010.
[131] Rodrigues LC. Personal interview. July 1, 2010.
[132] Broom DM, Mendl MT, and Zanella AJ. 1995. A comparison of the welfare of sows in different housing conditions. Animal Science 61:369-85.
[133] Hodgkiss NJ, Eddison JC, Brooks PH, and Bugg P. 1998. Assessment of the injuries sustained by pregnant sows housed in groups using electronic feeders. Veterinary Record 143(22):604-7.
[134] European Commission. 1997. Report of the Scientific Veterinary Committee, Animal Welfare Section. The welfare of intensively kept pigs. Doc XXIV/B3/ScVC/0005/1997, p. 93.
http://ec.europa.eu/food/fs/sc/oldcomm4/out17_en.html. Accessed January 25, 2010.
[135] Mavrogenis AP and Robison OW. 1976. Factors affecting puberty in swine. Journal of Animal Science 42(5):1251-5.
[136] Jensen AH, Yen JT, Gehring MM, Baker DH, Becker DE, and Harmon BG. 1970. Effects of space restriction and management on pre- and post-puberal response of female swine. Journal of Animal Science 31:745-50.
[137] Anil L, Anil SS, and Deen J. 2002. Evaluation of the relationship between injuries and size of gestation stalls relative to size of sows. Journal of the American Veterinary Medical Association 221(6):834-6.

[138] Arnot C and Gauldin C. 2007. Hoop barn study yields 'surprise.' Feedstuffs, May 7.
[139] Scientific Veterinary Committee. 1997. Animal Welfare Section. The welfare of intensively kept pigs. For the European Commission, Doc XXIV/B3/ScVC/0005/1997, p. 100. http://ec.europa.eu/food/fs/sc/oldcomm4/out17_en.pdf. Accessed January 25, 2010.
[140] Turner J. 2000. The welfare of Europe's sows in close confinement stalls (Hampshire, U.K.: Compassion in World Farming Trust, p. 33). http://www.ciwf.org.uk/includes/documents/cm_docs/2008/w/welfare_of_europes_sows_in_close_confinement_stalls.pdf. Accessed January 25, 2010.
[141] Marchant JN and Broom DM. 1996. Factors affecting posture-changing in loose-housed and confined gestating sows. Animal Science 63:477-85.
[142] Anil L, Anil SS, and Deen J. 2002. Evaluation of the relationship between injuries and size of gestation stalls relative to size of sows. Journal of the American Veterinary Medical Association 221(6):834-6.
[143] Morris JR, Hurnik JF, Friendship RM, Buhr MM, and Allen OB. 1993. The Behavior of Gestating Swine Housed in the Hurnik-Morris System. Journal of Animal Science 71:3280-4.
[144] Baxter MR and Schwaller CE. 1983. Space requirements for sows in confinement. In: Baxter SH, Baxter MR, and MacCormack JAC (eds.), Farm Animal Housing and Welfare (Boston, MA: Artinus Nijhoff).
[145] Webster J. 1994. Animal Welfare: A Cool Eye Towards Eden (Oxford, U.K.: Blackwell Science Ltd., pp. 148-9).
[146] Smith JH, Wathes CM, and Baldwin BA. 1996. The preference of pigs for fresh air over ammoniated air. Applied Animal Behaviour Science 49:417-24.
[147] Tillon JP and Madec F. 1984. Diseases affecting confined sows: data from epidemiological observations. Annales de Recherches Vétérinaires (Annals of Veterinary Research) 15(2):195-9.
[148] Broom DM, Mendl MT, and Zanella AJ. 1995. A comparison of the welfare of sows in different housing conditions. Animal Science 61:369-85.
[149] Lammers PJ, Honeyman MS, Mabry JW, and Harmon JD. 2007. Performance of gestating sows in bedded hoop barns and confinement stalls. Journal of Animal Science 85(5):1311-7.
[150] Lammers PJ, Honeyman MS, Mabry JW, and Harmon JD. 2007. Performance of gestating sows in bedded hoop barns and confinement stalls. Journal of Animal Science 85(5):1311-7.
[151] Anil L, Bhend KMG, Baidoo SK, Morrison R, and Deen J. 2003. Comparison of injuries in sows housed in gestation stalls versus group pens with electronic sow feeders. Journal of the American Veterinary Medical Association 223(9):1334-8.
[152] Mouttotou N, Hatchell FM, and Green LE. 1999. Foot lesions in finishing pigs and their associations with the type of floor. Veterinary Record 144(23):629-32.
[153] Kornegay ET, Bryant KL, and Notter DR. 1990. Toe Lesion Development in Gilts and Sows Housed in Confinement as Influenced by Toe Size and Toe Location. Applied Agricultural Research 5(4):327-34.
[154] Tillon JP and Madec F. 1984. Diseases affecting confined sows: data from epidemiological observations. Annales de Recherches Vétérinaires (Annals of Veterinary Research) 15(2):195-9, citing: Le Denmat M, Saulnier J, and Le Meur D. 1982. Lesions des pieds et boiteries chez le porc. Pointe Elev. Novembre 19-22.
[155] Scientific Veterinary Committee. 1997. Animal Welfare Section. The welfare of intensively kept pigs. For the European Commission; Report nr Doc XXIV/B3/ScVC/0005/1997, p. 98. http://ec.europa.eu/food/fs/sc/oldcomm4/out17_en.pdf. Accessed January 25, 2010, citing: Bäckström L. 1973. Environment and animal health in piglet production: a field study of incidences and correlations. Acta Veterinaria Scandinavica (Supplementum) 41:1-240.
[156] Fredeen HT and Sather AP. 1978. Joint damage in pigs reared under confinement. Canadian Journal of Animal Science 58:759-73.
[157] Marchant JN and Broom DM. 1996. Effects of dry sow housing conditions on muscle weight and bone strength. Animal Science 62:105-13.
[158] Sather AP and Fredeen HT. 1982. The effect of confinement housing upon the incidence of leg weakness in swine. Canadian Journal of Animal Science 62:1119-28.
[159] Miller D. 2004. Sows Flourish in Pen Gestation. National Hog Farmer, March 15.
[160] Stalder K and Baas T. 2005. Screen Gilts for Feet and Leg Disorders. National Hog Farmer, February 15.
[161] Marchant JN and Broom DM. 1996. Effects of dry sow housing conditions on muscle weight and bone strength. Animal Science 62:105-13.
[162] European Commission. 1997. Report of the Scientific Veterinary Committee, Animal Welfare Section. The welfare of intensively kept pigs. Doc XXIV/B3/ScVC/0005/1997, p. 93. http://ec.europa.eu/food/fs/sc/oldcomm4/out17_en.html. Accessed January 25, 2010.
[163] Tillon JP and Madec F. 1984. Diseases affecting confined sows: data from epidemiological observations. Annales de Recherches Vétérinaires (Annals of Veterinary Research) 15(2):195-9.
[164] Sather AP and Fredeen HT. 1982. The effect of confinement housing upon the incidence of leg weakness in swine. Canadian Journal of Animal Science 62:1119-28.
[165] Tillon JP and Madec F. 1984. Diseases affecting confined sows: data from epidemiological observations. Annales de Recherches Vétérinaires (Annals of Veterinary Research) 15(2):195-9.

[166] Commission of the European Communities. 2001. COM(2001) 20 final 2001/0021 (CNS) Communication from the Commission to the Council and the European Parliament on the welfare of intensively kept pigs in particularly taking into account the welfare of sows reared in varying degrees of confinement and in groups. Proposal for a Council Directive amending Directive 91/630/EEC laying down minimum standards for the protection of pigs.
[167] Miller D. 2004. Sows flourish in pen gestation. National Hog Farmer, March 15.
[168] Broom DM, Mendl MT, and Zanella AJ. 1995. A comparison of the welfare of sows in different housing conditions. Animal Science 61:369-85.
[169] Honeyman M. 1996. Swine System Options for Iowa: Outdoor pig production: an approach that works. Iowa State University. http://www.leopold.iastate.edu/pubs/other/files/SA9.pdf. Accessed January 25, 2010.
[170] Broom DM, Mendl MT, and Zanella AJ. 1995. A comparison of the welfare of sows in different housing conditions. Animal Science 61:369-85.
[171] Honeyman MS. 1995. Västgötmodellen: Sweden's sustainable alternative for swine production. American Journal of Alternative Agriculture 10(3):129-32.
[172] Miller D. 2004. Sows Flourish In Pen Gestation. National Hog Farmer, March 15.
[173] Marchant JN, Rudd AR, and Broom DM. 1997. The effects of housing on heart rate of gestating sows during specific behaviours. Applied Animal Behaviour Science 55:67-78.
[174] Commission of the European Communities. 2001. COM(2001) 20 final 2001/0021 (CNS) Communication from the Commission to the Council and the European Parliament on the welfare of intensively kept pigs in particularly taking into account the welfare of sows reared in varying degrees of confinement and in groups. Proposal for a Council Directive amending Directive 91/630/EEC laying down minimum standards for the protection of pigs.
[175] Scientific Veterinary Committee. 1997. Animal Welfare Section. The welfare of intensively kept pigs. For the European Commission; Report Doc XXIV/B3/ScVC/0005/1997, p. 98.
http://ec.europa.eu/food/fs/sc/oldcomm4/out17_en.pdf. Accessed January 25, 2010.
[176] Perkins J. The Confinement Question. Des Moines Register, November 17, 2002.
[177] The Humane Society of the United States. Election '06: Animals Win in Arizona and Michigan. Press release issued November 7, 2006. http://www.hsus.org/legislation_laws/ballot_initiatives/election_06_animals_win_.html. Accessed January 25, 2010.
[178] Barnett JL and Hemsworth PH (1991) The effects of individual and group housing on sexual behaviour and pregnancy in pigs. Animal Reproduction Science 25, 265–273.
[179] Lammers PJ, Honeyman MS, Mabry J, and Harmon J. 2006. Sow and Litter Performance for Individual Crate and Group Hoop Barn Gestation Housing Systems: Progress Report III, 2006 Iowa State U. Animal Industry Report. http://www.ans.iastate.edu/report/air/2006pdf/R2171.pdf. Accessed January 25, 2010. In: Evans GE. To what extent does wealth maximization benefit farm animals? p.191.
[180] Lundeen T. 2003. Sow Housing System May Not Influence Animal Performance. Feedstuffs 9, July 28. In: Evans GE. To what extent does wealth maximization benefit farm animals? p.192.
[181] Harmon JD et al. 2004. Hoop Barns for Gestating Swine. Agricultural Engineers Digest, 44, 18. In: Evans GE. To what extent does wealth maximization benefit farm animals? p.192.
[182] Dalla Costa OA (interviewed). (2009, October 7). Conheça a Nova Forma de Criar Porcos. Globo Rural [Television program]. São Paulo: Globo Comunicação e Participações S.A. Available at:
http://video.globo.com/Videos/Player/Noticias/0,,GIM1137300-7823-CONHECA+A+NOVA+FORMA+DE+CRIAR+PORCOS,00.html. Accessed January 25, 2010.
[183] Edwards SA and Zanella AJ. 1996. Produção de suínos ao ar livre, bem estar e considerações ambientais. A Hora Veterinária, (93):88-93. In: Leite DMG, Dalla Costa OA, Vargas GA, Milleo RGS, and Silva A. Análise Econômica do Sistema Intensivo de Suínos Criados ao Ar Livre. Rev. Bras. Zootec., 30(2):482-486, 2001.
[184] Dalla Costa OA, Girotto AF, and Girotto AD. 1995. Análise econômica dos sistemas intensivos de suínos criados ao ar livre (SISCAL) e confinados (SISCON), nas fases de gestação e lactação. R. Soc. Bras. Zootec., 24(4):615-622. In: Leite DMG, Dalla Costa OA, Vargas GA, Milleo RGS, and Silva A. Análise Econômica do Sistema Intensivo de Suínos Criados ao Ar Livre. Rev. Bras. Zootec., 30(2):482-486, 2001.
[185] Leite DMG, Dalla Costa OA, Vargas GA, Milleo RGS, and Silva A. Análise Econômica do Sistema Intensivo de Suínos Criados ao Ar Livre. Rev. Bras. Zootec., 30(2):482-486, 2001. http://www.scielo.br/pdf/rbz/v30n2/5491.pdf. Accessed 25 january 2010.
[186] Silva IJO and Silva KJO. 2008. Impactos do Bem-estar na Produção de Ovos. VI Congresso de Produção e Comercialização e Consumo de Ovos (Associação paulista de Avicultura), March 2008, São Paulo.