An HSUS Report: The Welfare of Animals in the Chicken Industry

Abstract

The overwhelming majority of the more than 9 billion chickens slaughtered for meat in the United States each year are raised in industrial production systems that severely impair their welfare. These animals experience crowded confinement, unnatural lighting regimes, poor air quality, stressful handling and transportation, and inadequate stunning and slaughter procedures. Selectively bred for rapid growth, broiler chickens are prone to a variety of skeletal and metabolic disorders that can cause suffering, pain, and death. Broiler breeders, the parent stock of chickens raised for meat, are subjected to severe feed restriction, and males may undergo painful toe and beak amputations, mutilations performed without pain relief. Rapid and immediate reform is needed to improve the welfare of chickens raised for meat.

Introduction

Chickens raised for meat are the most numerous of any land animal farmed in the world. In a single year in the United States, more than 9 billion chickens, termed "broilers" by industry, are slaughtered for human consumption.[1] Over the last several decades, the broiler chicken industry has adopted the industrial model of farm animal production. As explained by the U.S. Department of Agriculture's National Agricultural Statistics Service, "The broiler industry has evolved from millions of small backyard flocks, where meat was a by-product of egg production, to less than 50 highly specialized, vertically integrated agribusiness firms."[2] These commercial corporate producers raise chickens exclusively indoors, confined in large, warehouse-like buildings, often referred to as "grower" or "grow-out" houses or sheds, each typically 121.9-152.0 m (400-499 ft) by 12.1-14.0 m (40-46 ft).[3,4] Each building may house up to 20,000 birds,[5] and 150,000-300,000 birds may be raised on one site.[6] Grower houses are commonly artificially lit, force-ventilated, and completely barren except for litter material on the floor and long rows of feeders and drinkers.

Rapid Growth*

Broiler chickens have been selectively bred for rapid growth to market weight.[7] In 1920, a chicken reached 1 kg (2.2 lb) in 16 weeks, but today's broiler chicken strains may now reach 2.27 kg (5 lb) in only 7 weeks.[8] Daily growth rates have increased from 25 g (0.88 oz) to 100 g (3.52 oz) in the past 50 years—an increase of more than 300%.[9] Genetic selection is so intense that the age by which broiler chickens reach market weight and are slaughtered has decreased by as much as one day every year.[10] Ongoing selection for rapid growth is a severe welfare problem as it has resulted in leg disorders, including deformities, lameness, tibial dyschondroplasia (TD), and ruptured tendons, and has been correlated with metabolic disorders such as ascites and sudden death syndrome.[11,12,13] Broiler chickens selected for faster growth also suffer from weakened immune systems, making them more susceptible to a variety of additional diseases.[14]

Due in part to genetic selection for unnaturally fast growth, muscle outpaces bone development during the early life of chickens, leading to problems with skeletal weakness. As a result, broiler chickens often suffer from leg deformities and lameness.[15,16,17,18,19] Skeletal deformity can result in difficulty walking and, in some cases, birds who are non-ambulatory.[20] Studies consistently show that approximately 26-30% of broiler chickens suffer from

* For more information, see: "An HSUS Report: Welfare Issues with Selective Breeding for Rapid Growth in Broiler Chickens and Turkeys" at www.hsus.org/farm/resources/research/practices/fast_growth_chickens_turkeys.html.

gait defects severe enough to impair walking ability,[21,22,23] and additional research strongly suggests that birds at this level of lameness are in pain.[24,25] Extrapolating these percentages to the U.S. broiler chicken flock finds that 2.34-2.7 billion chickens have difficulty walking and experience pain. Severe leg deformities are fatal if birds can no longer stand to reach food or water;[26] about 1% of broiler chickens die or are culled due to leg problems.[27,28]

Tibial dyschondroplasia (TD), an abnormal mass of cartilage at the growth plate of a bone, usually the tibia, is the cause of some leg problems. The end of the tibia may become enlarged and weakened, and the bone may bend backward as it grows. Lesions can become necrotic and may lead to spontaneous fracture, severe lameness, and, in some cases, the complete inability to stand.[29] Sources differ broadly on the prevalence of TD in broiler chicken flocks, with percentages reaching 30-40% in extreme cases.[30] Aviagen, a leading breeding company, has worked to reduce the incidence of TD, and a 2001 report estimated that the incidence of TD would fall from approximately 8% in 1989 to a projected level of less than 2% by 2005.[31] However, studies published in 2001 and 2003 report elevated cases in common commercial chicken strains, with a mean prevalence of approximately 45-57%.[32,33] While TD may be relatively common in chickens raised for meat, it is rare or absent in other types of birds.[34]

Rupture of the gastrocnemius tendon that runs along the back of the leg is a common problem in heavy broiler chickens. It is caused by excessive weight on tendons with inadequate strength. If one leg is affected, the added stress may cause rupture of the tendon in the other leg. Discoloration may be seen on the back of the legs due to hemorrhage. A ruptured tendon is a chronic, debilitating, and painful condition.[35]

Between 5-7 weeks of age, broiler chickens spend 76-86% of their time lying down, depending on the degree to which they suffer from lameness. This unusually high level of time spent lying down is thought to be related to fast growth and heavy body weight,[36] and, in turn, leads to breast blisters, hock burns, and foot-pad dermatitis.[37] Because sheds are sometimes cleared of litter and accumulated excrement only after several consecutive flocks have been reared,[38,39,40] the birds often must stand and lie in their own waste and that of previous flocks.

Increased body weight can also lead to sudden death syndrome (SDS),[41] which is associated with acute heart failure caused by dysrhythmias, common in broiler chickens.[42] Young birds die from SDS after sudden convulsions and wing-beating, and are frequently found lying on their backs.[43] Between approximately 1-4% of broiler chickens may die from this condition,[44] which has been linked to their unnaturally rapid growth rate.[45]

Ascites is a condition in which rapidly growing broiler chickens do not have the heart and lung capacity needed to distribute oxygen throughout the body[46] and is a leading cause of mortality as the birds reach market weight.[47] Characteristic symptoms include accumulation of fluid in the abdominal cavity, an enlarged flaccid heart, the appearance of a shrunken liver, and heart failure. For commercial broiler chickens, most cases are the result of pulmonary hypertension, elevated pressure in the arteries that supply blood to the lungs. The high metabolic demand for oxygen and relatively low capacity for blood flow through the lungs of rapidly growing birds increase the workload of the heart, leaving them susceptible to mortality caused by ascites.[48,49,50]

Historically, poultry breeding companies have not adequately addressed broiler chicken health or overall welfare. Despite the many problems associated with rapid growth rate, growth has consistently been the top selection trait since the 1950s, followed only by other economically important traits, such as breast muscle (meat) yield and feed efficiency.[51,52]

Indeed, even though leg disorders, ascites, and many other health problems are common among chickens raised for meat, producers are economically inclined to use fast-growing birds. According to Scott Beyer, a Kansas State University poultry scientist, “Although a small percentage of birds may be predisposed to leg problems, use of highly selected fast-growing strains is recommended because savings in feed costs and time far outweigh the loss of a few birds.”[53]

Overcrowding

Stocking density, the number of birds per unit of floor space, indicates the level at which the animals are crowded together in a grower house. For a chicken nearing market weight (2.27 kg or 5 lb), the average industry stocking density is slightly larger than the area of a single sheet of letter-sized paper, 628-762 cm^2 (97.3-118.1 in^2) per bird.[†]

Crowding at this level may cause poor walking ability,[54] thigh sores and scabs, and scratches on the back[55] from birds walking over one another.[56] Hock and foot-pad dermatitis, lesions on the back of the legs and feet, respectively, which may be superficial or progress into deep ulcers,[57] may also develop indirectly by deteriorating litter quality.[58,59] At stocking densities exceeding the industry average, litter wetness due to greater fecal content, poor ventilation, and spilled water from the automated drinking system may become more problematic.[60] When birds lie in wet litter, ammonia produced by the decomposing organic material may irritate the skin.[61] Air quality continues to deteriorate at even higher stocking densities, and, when overcrowded, broiler chickens may experience more bruising[62] and heightened fearfulness.[63] Rest is important for young, growing animals,[64] and crowding also increases the frequency with which birds disturb and walk over each other, interrupting resting patterns.[65,66]

Despite the clear health and behavioral problems associated with high stocking density, broiler chicken producers have an economic incentive to overcrowd birds. Since the total kilograms produced per unit of space will increase with stocking density, profit margins will also increase to a point, as birds are raised in increasingly crowded environments.[67] As two poultry industry specialists write, "[L]imiting the floor space gives poorer results on a bird basis, yet the question has always been and continues to be: What is the least amount of floor space necessary per bird to produce the greatest return on investment?"[68]

Although reducing stocking density is important for improving the well-being of animals, large-scale studies under commercial conditions suggest that attention to this one factor alone is insufficient to ensure the welfare of broiler chickens, as other management features including litter quality, temperature changes, ventilation, and humidity are critical and may overshadow the effects of stocking density.[69,70]

Artificial Lighting

Although there are a wide variety of artificial lighting regimes,[71] broiler chickens are commonly reared under nearly continuous lighting.[72,73] A lighting schedule with 23 hours of light and 1 hour of darkness per 24 hours is known to hasten growth compared to a more natural photoperiod.[74] However, reduced nightly periods of darkness are detrimental, because they reduce the opportunity for sleep and resting behavior, which is important for all animals, and promote feeding behavior, further enhancing growth and exacerbating problems with leg disorders, sudden death syndrome, higher mortality, and ascites.[75,76,77,78,79,80]

These problems have not gone unnoticed by poultry scientists, and increasing the period of darkness to slow early growth is now recommended.[81] Long, uninterrupted dark periods early in their lives may reduce growth by curbing feeding activity and subsequently reduce leg problems, sudden death syndrome, and mortality.[82,83,84,85,86]

In the United States, 95% of chickens come from producers who adhere to guidelines of the National Chicken Council,[87] an industry group that currently recommends 4 hours of darkness, given in increments of 1, 2, or 4 hours, per 24-hour period.[88] However, a 4-hour period of uninterrupted darkness has been described by scientists working at the Silsoe Research Institute as an "absolute minimum" requirement.[89] Studies show that a longer period of darkness could further improve gait score (an indicator of leg problems)[90] and reduce mortality and culls due to such health challenges as leg abnormalities and sudden death syndrome.[91]

[†] Calculated from values given in: Estevez I. 2007. Density allowances for broilers: where to set the limits? Poultry Science 86:1265-72.

Although the lighting in broiler chicken sheds is nearly continuous, the light intensity is extremely dim. A typical business office may have a light level of 23.2 footcandle (250 lux),[92] but a broiler chicken shed's light intensity is often less than 1 footcandle (10 lux). Because light intensities greater than this level stimulate activity, which can decrease growth rates, many producers gradually and increasingly dim the lighting below this intensity as the birds grow.[93] Dim, near-continuous lighting may result in uncomfortable, eventually painful changes in the eye morphology of chickens due to abnormal eye development.[94]

Air Quality

Rapid deterioration of air quality within the sheds is another common result of overcrowded confinement typical of U.S. broiler chicken production systems. As successive flocks are sometimes kept on the same litter,[95,96,97,98] as mentioned above, excrement from tens of thousands of birds accumulates on the floors. Bacteria break down the litter and droppings, causing the air to become polluted with dust, bacteria, fungal spores, and ammonia. Excessive ammonia levels in the litter and air can lead to skin and respiratory problems, as well as pulmonary congestion, swelling, hemorrhage, and even blindness.[99,100,101,102]

U.K. standards require that broiler chicken sheds not exceed ammonia levels of 20 parts per million (ppm),[103] while U.S. standards permit 25 ppm.[104] However, data published in 2006 report that ammonia levels in U.S. broiler chicken sheds may reach 80 ppm, especially in the winter months when ventilation rates slow. These results show that ammonia levels can quickly become excessive as birds grow, even when they are placed initially on new litter.[105]

Ammonia fumes also inhibit chickens' acute sense of smell that they use to perceive their environment. Wrote Christopher Wathes, Professor of Animal Welfare and head of the Centre for Animal Welfare at the Royal Veterinary College, University of London, "For a bird with an acute sense of olfaction the polluted atmosphere of a poultry house may be the olfactory equivalent of looking through dark glasses."[106]

Broiler "Breeders"

In such vertically integrated industries as broiler chicken production, sectors of the system are compartmentalized. One sector produces fertile eggs from breeding birds, also known as parent stock or simply "breeders." These eggs are collected, incubated, and hatched separately to supply chicks to the meat production sector. Broiler breeders, like their progeny, are confined in large, warehouse-like sheds with littered floors, but the buildings in which they're housed also contain long rows of nest boxes that facilitate the collection of fertilized, hatching eggs. Typically, nest boxes are elevated above floor level. Wooden or plastic slatted areas in front of the nest boxes and below the drinkers allow manure and water to pass into a pit below.

Approximately 56 million broiler chicken hens are used for breeding each year in the United States;[107] statistics on the number of broiler breeding males are not available via the U.S. Department of Agriculture's National Agricultural Statistics Service.

Unlike broiler chickens, who are usually slaughtered between 6-7 weeks of age,[108] mature parent stock are kept for one or, if force-molted, two years.[109] For birds, molting is a natural process of feather loss and re-growth, and results in reproductive quiescence during which hens cease egg-laying for several months. Because the time period during which females stop laying can be lengthy, commercial hatching egg producers speed up the molting process by stressing the birds with complete feed withdrawal for 10-14 days, until they lose 25% of their body weight.[110] This process is viewed by producers as "recycling" the flock,[111] as the chickens would otherwise be slaughtered and replaced by younger birds. Although male broiler breeders are typically killed and replaced after one breeding cycle (after approximately one year), some are "recycled."[112]

Broiler breeders can suffer from the same welfare problems endured by their offspring, such as skeletal and metabolic disorders, which arise as a consequence of genetic selection for rapid growth rate. Parent stock additionally suffer from frustration and stress due to severe feed restriction, which causes an additional welfare

concern.[113] If allowed to feed to satiety, broiler breeders would show health and reproductive problems[114,115,116] due in part to their unnaturally rapid growth rate and size. As such, parent stock are feed-restricted. In many parts of the world, including the United States, broiler breeders may be fed on a "skip-a-day" regimen in which the animals are fed every other day[117,118,119]—though this practice has been outlawed in several European countries.[120] In some cases, water may also be restricted in order to reduce litter moisture.[121]

Experimental studies suggest that artificial selection for increased body weight may have altered the brain mechanism controlling satiety and appetite,[122] and evidence from behavioral studies suggests that feed restriction causes stress, frustration, boredom, and chronic hunger.[123,124] Breeders receive only 25-50% of the amount of feed they would otherwise eat if given free access.[125] Feed restriction is believed to cause undernourishment, nutritional deficiency, and frustration.[126] After an extensive scientific review, the European Commission's Scientific Committee on Animal Health and Animal Welfare concluded that "current commercial food restriction of breeding birds causes poor welfare."[127]

To prevent males from dominating access to the feed, male broiler breeders may be fed separately from females. Several methods of excluding males from the hens' feeders are in practice. One technique uses a metal grill with partitions spaced too close together for roosters, who have slightly larger heads than breeding hens, to access the feed. However, when the birds are young, males may be small enough to reach into the feeder. To prevent the young roosters from accessing the females' feed, their nasal septums may be pierced horizontally with a plastic stick inserted into the nares (nasal openings) of their beaks, blocking them from passing their heads through the bars of the grill. These "Noz Bonz"™[128,129] undoubtedly impair welfare.

Unlike other chicken breeds,[130,131] broiler breeding males may display uncharacteristically aggressive behavior, including aberrant sexual aggression toward females during breeding, including chasing, grabbing and pulling the comb, forced copulation, and pecking the hen while mounted.[132] There have been reports of males injuring and even killing hens.[133,134,135] Studies disagree on whether or not aggression is a consequence of frustrated feeding motivation due to feed restriction,[136,137] but at least one study suggests that the problem of female-directed aggression is somehow a consequence of genetic traits and may be associated with breeding birds for meat production.[138]

Male broiler breeders are commonly beak-trimmed, "dubbed" (their combs are cut off), and de-toed at the hatchery,[139,140,141] physical mutilations performed without anaesthesia or analgesia.[142,143] Beak-trimming is the removal of one-third to one-half of the beak tip,[144,145,146] an alteration meant to prevent injurious pecking. Commonly performed with a heated blade,[147,148,149] beak-trimming causes tissue damage and nerve injury, including open wounds and bleeding, resulting in inflammation, as well as acute and possibly chronic pain[150,151,152,153,154] that results from the formation of a neuroma (a tangled nerve mass) in the healed stump of the beak.[155,156,157] De-toeing mutilations involve cutting off the hallux (the inner-most toe on each foot) to prevent the growth of claws, which can severely scratch hens during mating. Neuromas may also form during toe amputation, however the degree to which these are painful is less certain.[158]

Catching and Crating

When broiler chickens have reached market weight, usually between 6-7 weeks of age,[159] they are caught and crated for transport to slaughter. The birds are typically caught by the legs, inverted, and carried in groups of 3-4 birds per hand to transport crates.[160] During an average shift, a single catcher will lift 5-10 tons of birds at a rate of 1,000-1,500 animals per hour.[161,162] Catching and crating are difficult for the birds, who experience fear, stress,[163,164,165] and, due to skeletal defects associated with leg problems that commonly afflict broiler chickens, likely pain during the process.[166] Handling can become even rougher as crews become fatigued. Based on their own experience catching chickens in field tests, one team of researchers concluded that "as fatigue sets in, one's primary motivation becomes just getting the job over with. Catching and crating the birds as quickly as possible with the minimum effort possible becomes the major focus. Careful handling becomes secondary."[167]

Indeed, birds may be injured and bruised in the process, suffering dislocated and broken bones, as well as internal hemorrhages.[168,169,170] One study noted:

> Hip dislocation occurs as birds are carried in the broiler sheds and loaded into the transport crates. Normally the birds are held by one leg as a bunch of birds in each hand. If one or more birds start flapping they twist at the hip, the femur detaches, and a subcutaneous haemorrhage is produced which kills the bird….Dead birds that have a dislocated hip often have blood in the mouth, which has been coughed up from the respiratory tract. Sometimes this damage is caused by too much haste on the part of the catchers.[171]

Transportation

Once the crates are loaded onto trucks, the chickens are transported to the slaughter plant. Transport is stressful,[172,173] as birds experience noise, vibration, motion, overcrowding, feed and water deprivation, social disruption, and temperature extremes.[174,175,176]

Some chickens do not survive the trip. Birds may die en route from infectious disease, heart and circulatory disorders, and trauma experienced during catching and crating.[177] Dead on arrival (DOA) estimates range from 0.19-0.46%,[178,179,180,181,182] which, when applied to the more than 9 billion broiler chickens slaughtered in the United States annually, indicate that approximately 17-41 million birds die during transport every year.

Slaughter[‡]

At the slaughter plant, transport crates are unloaded from the trucks and the chickens are dumped onto conveyors and hung upside-down in shackles by their legs. There is evidence that shackling is painful for chickens,[183,184] and this pain is likely to be worse in birds suffering from diseases or abnormalities of leg joints or leg bones,[185,186] especially those with dislocated joints or bone fractures induced by rough handling during catching, crating, and uncrating.[187] Moreover, hanging upside-down is a physiologically abnormal posture for chickens. Handling, inversion, and shackling are traumatic and stressful, as reported in multiple studies that measured physiological indicators of stress.[188,189,190,191] Because of this, approximately 90% of birds flap their wings vigorously,[192] which may lead to additional dislocated joints and broken bones.[193]

Despite the fact that birds make up more than 95% of all land animals slaughtered for food in the United States,[194,195] at present, the U.S. Department of Agriculture (USDA) does not include them under the protections of the Humane Methods of Slaughter Act.[196] Thus, there is no legal requirement that chickens must be rendered unconscious before they are slaughtered. Most chickens are stunned before slaughter in an electrified water bath, which immobilizes them before they are killed by an automated knife. Following throat-cutting, the birds die from exsanguination (blood loss). After the bleed-out process, birds enter the scald tank in preparation for the next step, mechanical feather plucking. Line speeds may be as fast as 140-180 birds per minute.[197]

It is well-documented in the scientific and trade literature that some birds experience painful electric shocks prior to being stunned in the electrified water bath.[198,199,200,201,202] This can happen when a bird's leading wing makes contact with the water before the head does or if wing-flapping occurs at the entrance to the stunner.[203] Newer designs in stunners may, however, prevent overflow of electrically charged brine onto the entry ramp,[204] and can lower the incidence of pre-stun electrical shocks.[205]

Scientific studies suggest that the electrical stunning process may not be instantaneous or effective. Although it is theoretically possible to induce immediate unconsciousness using electricity of sufficient magnitude, evidence that this occurs in commercial practice is lacking, and research published in 2006 suggests that the electrical

[‡] This section is drawn from "An HSUS Report: The Welfare of Birds at Slaughter," co-authored by Sara Shields, Ph.D., and Mohan Raj, BVSc, MVSc, Ph.D. For more information, see: www.hsus.org/farm/resources/research/practices/welfare_of_birds_slaughter.html.

settings currently in use in U.S. slaughter plants may not render all birds immediately unconscious.[206,207] The precise settings needed to produce an instantaneous state of unconsciousness and insensibility are not easily achieved as control of all the biological and electrical variables in water-bath stunners is difficult.[208]

Of further concern is that some birds are conveyed through the stunner without ever making contact with the electrified water bath. This can happen if birds struggle and lift their heads, the height of the stunner is not correctly adjusted, or birds are too short to reach the water-bath.[209,210,211] In 2007, one of the top disease challenges facing poultry veterinarians in the United States was Runting Stunting Syndrome (RSS). RSS-affected flocks have poor uniformity, hindering processability,[212] possibly worsening the problem of small birds missing the stunner.

Occasionally, live birds who were not adequately stunned and/or who missed the killing machine, or recovered from the stun due to poor neck-cutting practices are conscious when entering the scald tank.[213,214,215,216] Although a worker is present on the slaughter line to manually cut the throats of birds who miss the automated blade, in high-throughput processing plants, rapid line speeds can prevent the detection of live birds exiting the killing machine.[217] In U.S. plants with improper supervision, the rate at which birds enter the scald tank while still alive may be as high as 3%.[218] According to the USDA's Food Safety and Inspection Service "Poultry Slaughter Inspection Training" guide, "Poultry that die from causes other than slaughter are condemned under the cadaver category. These birds are not dead when they enter the scald vat. When submerged in the hot water, they drown…."[219] In 2007, more than 1.5 million chickens were condemned under this category.[220]

More effective and less aversive alternatives to electrified water-bath stunning slaughter are Controlled Atmosphere Stunning (CAS) and Controlled Atmosphere Killing (CAK) systems. In these systems, animals are not handled while they are still conscious, avoiding the problems associated with dumping,[§] handling, and shackling live birds, and the systems do not risk pre-stun shocks and/or ineffective stunning. In CAS and CAK systems, birds are conveyed through a tunnel filled with carbon dioxide (CO_2), inert gases (argon or nitrogen), or a mixture of these gases. With CAK, birds are exposed to lethal concentrations of gases long enough that they are actually killed, rather than simply stunned,[221] whereas with CAS, the gas or gases induce unconsciousness as the birds pass through before they are hung on shackles, while insensible, and conveyed to the killing machine for slaughter. In both systems, hanging operators do not shackle the birds until after they exit the gas stunning system, so the animals do not endure the pain, fear, and stress associated with this step in the procedure, and there is no potential for pre-stun electric shock or birds missing the stunner.

Conclusion

Many standard practices in the broiler chicken industry are in dire need of reform, as they are simply inhumane. Housing, breeding, transport, and slaughter must be reevaluated in light of bird welfare concerns in an effort to reduce suffering and enhance quality of life. There are many new innovations in technology for catching,[222,223] transporting,[224] and slaughtering chickens that could greatly improve the welfare of these animals if more widely adopted within the industry.

While all welfare problems of broiler chickens are important, selective breeding for growth without due attention to animal health and well-being, which has resulted in animals who are chronically in pain, is wholly unacceptable. Broiler chickens grow so quickly that they are "on the verge of structural collapse."[225] According to John Webster, Emeritus Professor of Animal Husbandry at the University of Bristol, "[T]his must constitute, in both magnitude and severity, the single most severe, systematic example of man's inhumanity to another sentient animal."[226] Poultry geneticists must address this problem swiftly, and support is needed from producers, retailers, and consumers to encourage this change.

[§] Some gas systems are designed in such a way that birds must still be dumped from their transport crates prior to entering the gas-filled chamber on a conveyer belt. While still retaining many of the welfare advantages of CAS and CAK systems, those that move birds through the gaseous atmosphere while they are still in their transport crates are considered optimal.

Chickens are living, sentient individuals and must be recognized as such, rather than commodified and viewed simply as "products"[227,228] or "breeders." Scientists are increasingly recognizing the complex cognitive abilities of birds,[229,230] their capacity to suffer,[231] and the ethical implications that these findings carry. Billions of birds in the United States and globally will continue to suffer in industrial production if scientifically documented welfare problems continue to be minimized and left unaddressed by the meat industry.

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[1] U.S. Department of Agriculture National Agricultural Statistics Service. 2008. Poultry slaughter: 2007 annual summary. http://usda.mannlib.cornell.edu/usda/current/PoulSlauSu/PoulSlauSu-02-28-2008.pdf. Accessed September 8, 2008.
[2] U.S. Department of Agriculture National Agricultural Statistics Service. 2002. U.S. broiler industry structure. Agricultural Statistics Board. http://usda.mannlib.cornell.edu/reports/nassr/poultry/industry-structure/specpo02.pdf. Accessed September 8, 2008.
[3] Watt Poultry USA. 2005. Housing expansion plans. Watt Poultry USA, June, pp. 24-8.
[4] National Chicken Council. 2007. About the industry: animal welfare. www.nationalchickencouncil.com/aboutIndustry/detail.cfm?id=11. Accessed September 8, 2008.
[5] National Chicken Council. 2007. About the industry: animal welfare. www.nationalchickencouncil.com/aboutIndustry/detail.cfm?id=11. Accessed September 8, 2008.
[6] Lacy MP. 2002. Management of large broiler farms. The University of Georgia College of Agricultural and Environmental Sciences, Cooperative Extension Service. http://pubs.caes.uga.edu/caespubs/pubcd/L419.htm. Accessed September 8, 2008.
[7] Boersma S. 2001. Managing rapid growth rate in broilers. World Poultry 17(8):20-1.
[8] Aho PW. 2002. Introduction to the US chicken meat industry. In: Bell DD and Weaver WD Jr (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[9] Knowles TG, Kestin SC, Haslam SM, et al. 2008. Leg disorders in broiler chickens: prevalence, risk factors and prevention. PLoS ONE 3(2):e1545. doi:10.1371/journal.pone.0001545.
[10] Weeks C. 2004. Introduction. In: Weeks C and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CABI Publishing, p. xiii).
[11] Boersma S. 2001. Managing rapid growth rate in broilers. World Poultry 17(8):20-1.
[12] Julian RJ. 2004. Evaluating the impact of metabolic disorders on the welfare of broilers. In: Weeks C and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CABI Publishing).
[13] Bessei W. 2006. Welfare of broilers: a review. World's Poultry Science Journal 62:455-66.
[14] Rauw WM, Kanis E, Noordhuizen-Stassen EN, and Grommers FJ. 1998. Undesirable side effects of selection for high production efficiency in farm animals: a review. Livestock Production Science 56:15-33.
[15] Leeson S, Diaz G, and Summers JD. 1995. Poultry Metabolic Disorders and Mycotoxins (Guelph, Canada: University Books, p. 140).
[16] Mench JA. 2004. Lameness. In: Weeks C and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CABI Publishing).
[17] Bessei W. 2006. Welfare of broilers: a review. World's Poultry Science Journal 62:455-66.
[18] Sanotra GS, Lund JD, Ersbøll AK, Petersen JS, and Vestergaard KS. 2001. Monitoring leg problems in broilers: a survey of commercial broiler production in Denmark. World's Poultry Science Journal 57:55-69.
[19] Scientific Committee on Animal Health and Animal Welfare. 2000. The welfare of chickens kept for meat production (broilers). For the European Commission. http://ec.europa.eu/food/fs/sc/scah/out39_en.pdf. Accessed September 8, 2008.
[20] Julian RJ. 1998. Rapid growth problems: ascites and skeletal deformities in broilers. Poultry Science 77:1773-80.
[21] Knowles TG, Kestin SC, Haslam SM, et al. 2008. Leg disorders in broiler chickens: prevalence, risk factors and prevention. PLoS ONE 3(2):e1545. doi:10.1371/journal.pone.0001545.
[22] Kestin SC, Knowles TG, Tinch AE, and Gregory NG. 1992. Prevalence of leg weakness in broiler chickens and its relationship with genotype. The Veterinary Record 131:190-4.
[23] Sanotra GS, Lund JD, Ersbøll AK, Petersen JS, and Vestergaard KS. 2001. Monitoring leg problems in broilers: a survey of commercial broiler production in Denmark. World's Poultry Science Journal 57:55-69.

[24] Danbury TC, Weeks CA, Chambers JP, Waterman-Pearson AE, and Kestin SC. 2000. Self-selection of the analgesic drug carprofen by lame broiler chickens. The Veterinary Record 146:307-11.
[25] McGeown D, Danbury TC, Waterman-Pearson AE, and Kestin SC. 1999. Effect of carprofen on lameness in broiler chickens. The Veterinary Record 144:668-71.
[26] Sørensen P, Su G, and Kestin SC. 1999. The effect of photoperiod: scotoperiod on leg weakness in broiler chickens. Poultry Science 78:336-42.
[27] Riddell C and Springer R. 1985. An epizootiological study of acute death syndrome and leg weakness in broiler chickens in Western Canada. Avian Diseases 29:90-102.
[28] Morris MP. 1993. National survey of leg problems. Broiler Industry, May, pp. 20-4.
[29] Julian RJ. 2004. Evaluating the impact of metabolic disorders on the welfare of broilers. In: Weeks C and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CABI Publishing).
[30] Leeson S, Diaz GJ, and Summers JD. 1995. Poultry Metabolic Disorders and Mycotoxins (Guelph, Canada: University Books, p. 140).
[31] Aviagen. 2001. Ross Tech 01/40. Leg health in broilers. www.aviagen.com/docs/ross tech leg.pdf. Accessed September 8, 2008.
[32] Sanotra GS, Lund JD, Ersbøll AK, Petersen JS, and Vestergaard KS. 2001. Monitoring leg problems in broilers: a survey of commercial broiler production in Denmark. World's Poultry Science Journal 57:55-69.
[33] Sanotra GS, Berg C, and Lund JD. 2003. A comparison between leg problems in Danish and Swedish broiler production. Animal Welfare 12:677-83.
[34] Julian RJ. 1998. Rapid growth problems: ascites and skeletal deformities in broilers. Poultry Science 77:1773-80.
[35] Julian RJ. 2004. Evaluating the impact of metabolic disorders on the welfare of broilers. In: Weeks C and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CABI Publishing).
[36] Weeks CA, Danbury TD, Davies HC, Hunt P, and Kestin SC. 2000. The behaviour of broiler chickens and its modification by lameness. Applied Animal Behaviour Science 67:111-25.
[37] Estevez I. 2002. Poultry welfare issues. Poultry Digest Online 3(2):1-12. www.ansc.umd.edu/extension/poultry/Poultry_Welfare_Behavior/publications/Poultry Welfare Issues, Poultry Digest Onine Volume 3 Number 2.pdf. Accessed September 8, 2008.
[38] Dozier WA III, Lacy MP, and Vest LR. 2001. Broiler production and management. The University of Georgia College of Agricultural and Environmental Sciences, Cooperative Extension Service. http://pubs.caes.uga.edu/caespubs/pubcd/B1197.htm. Accessed September 8, 2008.
[39] Carlile FS. 1984. Ammonia in poultry houses: a literature review. World's Poultry Science Journal 40:99-113.
[40] Lacy MP. 2002. Broiler management. In: Bell DD and Weaver WD Jr (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[41] Gardiner EE, Hunt JR, Newberry RC, and Hall JW. 1988. Relationships between age, body weight, and season of the year and the incidence of sudden death syndrome in male broiler chickens. Poultry Science 67:1243-9.
[42] Riddell C and Springer R. 1985. An epizootiological study of acute death syndrome and leg weakness in broiler chickens in Western Canada. Avian Diseases 29:90-102.
[43] Julian RJ. 2004. Evaluating the impact of metabolic disorders on the welfare of broilers. In: Weeks C and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CABI Publishing).
[44] Olkowski AA and Classen HL. 1997. Malignant ventricular dysrhythmia in broiler chickens dying of sudden death syndrome. The Veterinary Record 140:177-9.
[45] Riddell C and Springer R. 1985. An epizootiological study of acute death syndrome and leg weakness in broiler chickens in Western Canada. Avian Diseases 29:90-102.
[46] Duncan IJH. 2001. Animal welfare issues in the poultry industry: is there a lesson to be learned? Journal of Applied Animal Welfare Science 4(3):207-21.
[47] Boersma S. 2001. Managing rapid growth rate in broilers. World Poultry 17(8):20-1.
[48] Balog JM. 2003. Ascites syndrome (pulmonary hypertension syndrome) in broiler chickens: are we seeing the light at the end of the tunnel? Avian and Poultry Biology Reviews 14(3):99-126.
[49] Julian RJ. 2000. Physiological, management and environmental triggers of the ascites syndrome: a review. Avian Pathology 29(6):519-27.

[50] Boersma S. 2001. Managing rapid growth rate in broilers. World Poultry 17(8):20-1.
[51] Rauw WM, Kanis E, Noordhuizen-Stassen EN, and Grommers FJ. 1998. Undesirable side effects of selection for high production efficiency in farm animals: a review. Livestock Production Science 56(1):15-33.
[52] Arthur JA and Albers GAA. 2003. Industrial perspective on problems and issues associated with poultry breeding. In: Muir WM and Aggrey SE (eds.), Poultry Genetics, Breeding and Biotechnology (Wallingford, U.K.: CAB International).
[53] Beyer RS. 2002. Leg problems in broilers and turkeys. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, June. www.oznet.ksu.edu/library/lvstk2/ep113.pdf. Accessed September 8, 2008.
[54] Sørensen P, Su G, and Kestin SC. 2000. Effects of age and stocking density on leg weakness in broiler chickens. Poultry Science 79(6):864-70.
[55] Bilgili SF and Hess JB. 1995. Placement density influences broiler carcass grade and meat yields. Journal of Applied Poultry Research 4:384-9.
[56] Estevez I. 2007. Density allowances for broilers: where to set the limits? Poultry Science 86:1265-72.
[57] McMullin P. 2004. A Pocket Guide to Poultry Health and Disease, First Edition (Sheffield, U.K.: 5M Enterprises Limited, pp.111-2).
[58] Arnould C and Faure JM. 2003. Use of pen space and activity of broiler chickens reared at two different densities. Applied Animal Behaviour Science 84(4):281-96.
[59] Dozier WA III, Thaxton JP, Branton SL, et al. 2005. Stocking density effects on growth performance and processing yields of heavy broilers. Poultry Science 84:1332-8.
[60] Estevez I. 2002. Poultry welfare issues. Poultry Digest Online 3(2):1-12. www.ansc.umd.edu/extension/poultry/Poultry_Welfare_Behavior/publications/Poultry Welfare Issues, Poultry Digest Onine Volume 3 Number 2.pdf. Accessed September 8, 2008.
[61] Estevez I. 2002. Poultry welfare issues. Poultry Digest Online 3(2):1-12. www.ansc.umd.edu/extension/poultry/Poultry_Welfare_Behavior/publications/Poultry Welfare Issues, Poultry Digest Onine Volume 3 Number 2.pdf. Accessed September 8, 2008.
[62] Hall AL. 2001. The effect of stocking density on the welfare and behaviour of broiler chickens reared commercially. Animal Welfare 10:23-40.
[63] Sanotra GS, Lawson LG, Vestergaard KS, and Thomsen MG. 2001. Influence of stocking density on tonic immobility, lameness, and tibial dyschondroplasia in broilers. Journal of Applied Animal Welfare Science 4(1):71-87.
[64] Duncan IJH. 2004. Welfare problems of poultry. In: Benson GJ and Rollin BE (eds.), The Well-Being of Farm Animals: Challenges and Solutions (Ames, IA: Blackwell Publishing).
[65] Hall AL. 2001. The effect of stocking density on the welfare and behaviour of broiler chickens reared commercially. Animal Welfare 10:23-40.
[66] Febrer K, Jones TA, Donnelly CA, and Dawkins MS. 2006. Forced to crowd or choosing to cluster? Spatial distribution indicates social attraction in broiler chickens. Animal Behaviour 72(6):1291-300.
[67] Puron D, Santamaria R, Segura JC, and Alamilla JL. 1995. Broiler performance at different stocking densities. Journal of Applied Poultry Research 4:55-60.
[68] North MO and Bell DD. 1990. Commercial Chicken Production Manual, 4th Edition (New York, NY: Van Nostrand Reinhold, p. 456).
[69] Jones TA, Donnelly CA, and Dawkins MS. 2005. Environmental and management factors affecting the welfare of chickens on commercial farms in the United Kingdom and Denmark stocked at five densities. Poultry Science 84:1155-65.
[70] Dawkins MS, Donnelly CA, and Jones TA. 2004. Chicken welfare is influenced more by housing conditions than by stocking density. Nature 427:342-4.
[71] Knowles TG, Kestin SC, Haslam SM, et al. 2008. Leg disorders in broiler chickens: prevalence, risk factors and prevention. PLoS ONE 3(2):e1545. doi:10.1371/journal.pone.0001545.
[72] Hester PY. 1994. The role of environment and management on leg abnormalities in meat-type fowl. Poultry Science 73:904-15.
[73] Duncan IJH. 2004. Welfare problems of poultry. In: Benson GJ and Rollin BE (eds.), The Well-Being of Farm Animals: Challenges and Solutions (Ames, IA: Blackwell Publishing).

[74] Lacy MP. 2002. Broiler management. In: Bell DD and Weaver WD Jr (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[75] Prescott NB, Kristensen HH, and Wathes CM. 2004. Light. In: Weeks CA and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CAB International).
[76] Gordon SH and Tucker SA. 1997. Effect of light programme on broiler mortality, leg health and performance. British Poultry Science 38:S6-7.
[77] Knowles TG, Kestin SC, Haslam SM, et al. 2008. Leg disorders in broiler chickens: prevalence, risk factors and prevention. PLoS ONE 3(2):e1545. doi:10.1371/journal.pone.0001545.
[78] Lott BD, Branton SL, and May JD. 1996. The effect of photoperiod and nutrition on ascites incidence in broilers. Avian Diseases 40:788-91.
[79] Lewis P and Morris T. 2006. Poultry lighting: the theory and practice (Hampshire, U.K.: Northcot, p. 38).
[80] Gordon SH. 1994. Effects of daylength and increasing daylength programmes on broiler welfare and performance. World's Poultry Science Journal 50:269-82.
[81] Alabama Cooperative Extension System. 2000. Controlling light in broiler production. The Alabama Poultry Engineering and Economics Newsletter, No. 6. www.aces.edu/dept/poultryventilation/documents/Nwsltr-6.pdf. Accessed September 8, 2008.
[82] Knowles TG, Kestin SC, Haslam SM, et al. 2008. Leg disorders in broiler chickens: prevalence, risk factors and prevention. PLoS ONE 3(2):e1545. doi:10.1371/journal.pone.0001545.
[83] Gordon SH. 1994. Effects of daylength and increasing daylength programmes on broiler welfare and performance. World's Poultry Science Journal 50:269-82.
[84] Prescott NB, Kristensen HH, and Wathes CM. 2004. Light. In: Weeks CA and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CAB International).
[85] Lewis P and Morris T. 2006. Poultry lighting: the theory and practice (Hampshire, U.K.: Northcot, p. 39), citing: Lewis PD. 2001. Lighting regimes for broiler and egg production. In: Proceedings of XVII Latin American Poultry Congress, pp. 326-35.
[86] Classen HL and Riddell C. 1989. Photoperiodic effects on performance and leg abnormalities in broiler chickens. Poultry Science 68:873-9.
[87] Personal correspondence with Stephen Pretanik, director of Science and Technology, National Chicken Council, Washington, DC, June 11, 2008.
[88] National Chicken Council. 2005. National Chicken Council animal welfare guidelines and audit checklist. www.nationalchickencouncil.com/files/AnimalWelfare2005.pdf. Accessed September 8, 2008.
[89] Prescott NB, Kristensen HH, and Wathes CM. 2004. Light. In: Weeks CA and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CAB International).
[90] Knowles TG, Kestin SC, Haslam SM, et al. 2008. Leg disorders in broiler chickens: prevalence, risk factors and prevention. PLoS ONE 3(2):e1545. doi:10.1371/journal.pone.0001545.
[91] Gordon SH and Tucker SA. 1995. Effect of daylength on broiler welfare. British Poultry Science 36(5):844-5.
[92] Prescott NB, Kristensen HH, and Wathes CM. 2004. Light. In: Weeks CA and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CAB International).
[93] Lacy MP. 2002. Broiler management. In: Bell DD and Weaver WD Jr (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers, p. 856).
[94] Prescott NB, Kristensen HH, and Wathes CM. 2004. Light. In: Weeks CA and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CAB International).
[95] Dozier WA III, Lacy MP, and Vest LR. 2001. Broiler production and management. The University of Georgia College of Agricultural and Environmental Sciences, Cooperative Extension Service. http://pubs.caes.uga.edu/caespubs/pubcd/B1197.htm. Accessed September 8, 2008.
[96] Lacy MP. 2002. Broiler management. In: Bell DD and Weaver WD Jr (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[97] Carlile FS. 1984. Ammonia in poultry houses: a literature review. World's Poultry Science Journal 40:99-113.
[98] Bermudez AJ and Stewart-Brown. 2003. In: Saif YM, Barnes HJ, Glisson JR, Fadly AM, McDougald LR, and Swayne DE (eds.), Diseases of Poultry, 11th Edition (Ames, IA: Iowa State Press, p. 39).

[99] Berg CC. 1998. Foot-pad dermatitis in broilers and turkeys: prevalence, risk factors and prevention. Doctor's dissertation. Department of Animal Environment and Health, SLU. Acta Universitatis agriculturae Sueciae. Veterinaria 36, p. 16.
[100] Wathes CM. 1998. Aerial emissions from poultry production. World's Poultry Science Journal 54:241-51.
[101] Muirhead S. 1992. Ammonia control essential to maintenance of poultry health. Feedstuffs, April 13, p. 11.
[102] Kristensen HH and Wathes CM. 2000. Ammonia and poultry welfare: a review. World's Poultry Science Journal 56:235-45.
[103] Department for Environment, Food and Rural Affairs. 2002. Code of recommendations for the welfare of livestock: meat chickens and breeding chickens. www.defra.gov.uk/animalh/welfare/farmed/meatchks/meatchkscode.pdf. Accessed September 8, 2008.
[104] National Chicken Council. 2005. National Chicken Council animal welfare guidelines and audit checklist. www.nationalchickencouncil.com/files/AnimalWelfare2005.pdf. Accessed September 8, 2008.
[105] Wheeler EF, Casey KD, Gates RS, et al. 2006. Ammonia emissions from twelve U.S. broiler chicken houses. Transactions of the American Society of Agricultural and Biological Engineers 49(5):1495-512.
[106] Wathes CM. 1998. Aerial emissions from poultry production. World's Poultry Science Journal 54:241-51.
[107] U.S. Department of Agriculture National Agricultural Statistics Service. 2008. Chickens and eggs: 2007 summary. http://usda.mannlib.cornell.edu/usda/current/ChickEgg/ChickEgg-02-28-2008.pdf. Accessed September 8, 2008.
[108] Scanes CG, Brant G, and Ensminger ME. 2004. Poultry Science, 4th Edition (Upper Saddle River, NJ: Pearson Prentice Hall, p. 260).
[109] Bell DD. 2002. Flock replacement programs and flock recycling. In: Bell DD and Weaver WD Jr (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[110] Bell DD. 2002. Flock replacement programs and flock recycling. In: Bell DD and Weaver WD Jr (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[111] Bell DD. 2002. Flock replacement programs and flock recycling. In: Bell DD and Weaver WD Jr (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[112] Bell DD. 2002. Flock replacement programs and flock recycling. In: Bell DD and Weaver WD Jr (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[113] Savory CJ, Maros K, and Rutter SM. 1993. Assessment of hunger in growing broiler breeders in relation to a commercial restricted feeding programme. Animal Welfare 2:131-52.
[114] Savory CJ, Maros K, and Rutter SM. 1993. Assessment of hunger in growing broiler breeders in relation to a commercial restricted feeding programme. Animal Welfare 2:131-52.
[115] Hocking PM. 2004. Measuring and auditing the welfare of broiler breeders. In: Weeks CA and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CABI Publishing).
[116] De Jong IC and Jones B. 2006. Feed restriction and welfare in domestic birds. In: Bels V (ed.), Feeding in Domestic Vertebrates: From Structure to Behaviour (Wallingford, U.K.: CAB International, pp. 120-35).
[117] Shane SM. 2007. Progress in refining standards, audits. Watt Poultry USA, October, pp. 34-7.
[118] Coon CN. 2002. Feeding broiler breeders. In: Bell DD and Weaver WD Jr (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[119] Mench JA. 1993. Problems associated with broiler breeder management. In: Savory CJ and Hughes BO (eds.), Proceedings of the 4th European Symposium on Poultry Welfare (Edinburgh, U.K., pp. 195-207).
[120] Hocking PM. 2004. Measuring and auditing the welfare of broiler breeders. In: Weeks CA and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CABI Publishing).
[121] Hocking PM. 2004. Measuring and auditing the welfare of broiler breeders. In: Weeks CA and Butterworth A (eds.), Measuring and Auditing Broiler Welfare (Wallingford, U.K.: CABI Publishing).
[122] Burkhart CA, Cherry JA, Van Krey HP, and Siegel PB. 1983. Genetic selection for growth rate alters hypothalamic satiety mechanisms in chickens. Behavior Genetics 13(3):295-300.
[123] Savory CJ, Maros K, and Rutter SM. 1993. Assessment of hunger in growing broiler breeders in relation to a commercial restricted feeding programme. Animal Welfare 2:131-52.
[124] De Jong IC and Jones B. 2006. Feed restriction and welfare in domestic birds. In: Bels V (ed.), Feeding in Domestic Vertebrates: From Structure to Behaviour (Wallingford, U.K.: CAB International, pp. 120-35).

[125] Savory CJ, Maros K, and Rutter SM. 1993. Assessment of hunger in growing broiler breeders in relation to a commercial restricted feeding programme. Animal Welfare 2:131-52.
[126] Savory CJ and Maros K. 1993. Influence of degree of food restriction, age and time of day on behaviour of broiler breeder chickens. Behavioural Processes 29:179-90.
[127] Scientific Committee on Animal Health and Animal Welfare. 2000. The welfare of chickens kept for meat production (broilers). For the European Commission, p. 84. http://ec.europa.eu/food/fs/sc/scah/out39_en.pdf. Accessed September 8, 2008.
[128] Brake J. 1998. Equipment design for breeding flocks. Poultry Science 77:1833-41.
[129] Wilson JL. 1999. Hatchery/breeder tip: managing roosters for hatchability. The University of Georgia College of Agricultural and Environmental Sciences, Cooperative Extension Service. www.poultry.uga.edu/tips/05 1999 HB tip J L W.pdf. Accessed September 8, 2008.
[130] Millman ST, Duncan IJH, and Widowski TM. 2000. Male broiler breeder fowl display high levels of aggression toward females. Poultry Science 79:1233-41.
[131] Millman ST and Duncan IJH. 2000. Effect of male-to-male aggressiveness and feed-restriction during rearing on sexual behaviour and aggressiveness towards females by male domestic fowl. Applied Animal Behaviour Science 70:63-82.
[132] Millman ST, Duncan IJH, and Widowski TM. 2000. Male broiler breeder fowl display high levels of aggression toward females. Poultry Science 79:1233-41.
[133] Millman ST, Duncan IJH, and Widowski TM. 2000. Male broiler breeder fowl display high levels of aggression toward females. Poultry Science 79:1233-41, citing: Mench JA. 1993. Problems associated with broiler breeder management. In: Savory CJ and Hughes BO (eds.), Proceedings of the 4th European Symposium on Poultry Welfare (Potters Bar, U.K.: Universities Federation for Animal Welfare, pp. 195-207).
[134] Brake J. 1998. Equipment design for breeding flocks. Poultry Science 77:1833-41.
[135] Mench JA. 1993. Problems associated with broiler breeder management. In: Savory CJ and Hughes BO (eds.), Proceedings of the 4th European Symposium on Poultry Welfare (Edinburgh, U.K., pp. 195-207).
[136] Mench JA. 1988. The development of aggressive behavior in male broiler chicks: a comparison with laying-type males and the effects of feed restriction. Applied Animal Behaviour Science 21:233-42.
[137] Millman ST and Duncan IJH. 2000. Effect of male-to-male aggressiveness and feed-restriction during rearing on sexual behaviour and aggressiveness towards females by male domestic fowl. Applied Animal Behaviour Science 70:63-82.
[138] Millman ST and Duncan IJH. 2000. Effect of male-to-male aggressiveness and feed-restriction during rearing on sexual behaviour and aggressiveness towards females by male domestic fowl. Applied Animal Behaviour Science 70:63-82.
[139] Mauldin JM and Morrison T III. 2002. Equipment for hatcheries. In: Bell DD and Weaver WD Jr (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[140] Duncan IJH. 2004. Welfare problems of poultry. In: Benson GJ and Rollin BE (eds.), The Well-Being of Farm Animals: Challenges and Solutions (Ames, IA: Blackwell Publishing).
[141] Meijerhof R. 2002. Managing the breeding flock. In: Bell DD and Weaver WD (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[142] Duncan IJH. 2004. Welfare problems of poultry. In: Benson GJ and Rollin BE (eds.), The Well-Being of Farm Animals: Challenges and Solutions (Ames, IA: Blackwell Publishing).
[143] Gentle MJ and Hunter LH. 1988. Neural consequences of partial toe amputation in chickens. Research in Veterinary Science 45:374-6.
[144] Fraser D, Mench J, and Millman S. 2001. Farm animals and their welfare in 2000. In: Salem DJ and Rowan AN (eds.), The State of the Animals: 2001 (Washington, DC: Humane Society Press).
[145] Cheng H. 2006. Morphopathological changes and pain in beak trimmed laying hens. World's Poultry Science Journal 62:41-52.
[146] Duncan IJH. 2004. Welfare problems of poultry. In: Benson GJ and Rollin BE (eds.), The Well-Being of Farm Animals: Challenges and Solutions (Ames, IA: Blackwell Publishing).
[147] Gentle MJ and McKeegan DEF. 2007. Evaluation of the effects of infrared beak trimming in broiler breeder chicks. The Veterinary Record 160:145-8.

[148] Cheng H. 2006. Morphopathological changes and pain in beak trimmed laying hens. World's Poultry Science Journal 62:41-52.
[149] Mauldin JM and Morrison T III. 2002. Equipment for hatcheries. In: Bell DD and Weaver WD Jr (eds.), Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers).
[150] Mench JA. 1992. The welfare of poultry in modern production systems. Poultry Science Reviews 4:107-28.
[151] Duncan IJH. 2001. Animal welfare issues in the poultry industry: is there a lesson to be learned? Journal of Applied Animal Welfare Science 4(3):207-21.
[152] Gentle MJ, Waddington D, Hunter LN, and Jones RB. 1990. Behavioural evidence for persistent pain following partial beak amputation in chickens. Applied Animal Behaviour Science 27:149-57.
[153] Hughes BO and Gentle MJ. 1995. Beak trimming of poultry: its implications for welfare. World's Poultry Science Journal 51:51-61.
[154] Cheng H. 2006. Morphopathological changes and pain in beak trimmed laying hens. World's Poultry Science Journal 62:41-52.
[155] Gentle MJ. 1986. Neuroma formation following partial beak amputation (beak trimming) in the chicken. Research in Veterinary Science 41:383-5.
[156] Gentle M and Wilson S. 2004. Pain and the laying hen. In: Perry GC (ed.), Welfare of the Laying Hen (Wallingford, U.K.: CABI Publishing).
[157] Cheng H. 2006. Morphopathological changes and pain in beak trimmed laying hens. World's Poultry Science Journal 62:41-52.
[158] Gentle MJ and Hunter LH. 1988. Neural consequences of partial toe amputation in chickens. Research in Veterinary Science 45:374-6.
[159] Scanes CG, Brant G, and Ensminger ME. 2004. Poultry Science, 4th Edition (Upper Saddle River, NJ: Pearson Prentice Hall, p. 260).
[160] Bayliss PA and Hinton MH. 1990. Transportation of broilers with special reference to mortality rates. Applied Animal Behaviour Science 28:93-118.
[161] Nijdam E, Arens P, Lambooij E, Decuypere E, and Stegeman JA. 2004. Factors influencing bruises and mortality of broilers during catching, transport, and lairage. Poultry Science 83:1610-5.
[162] Ramasamy S, Benson ER, and Van Wicklen GL. 2004. Efficiency of a commercial mechanical chicken catching system. Journal of Applied Poultry Research 13:19-28.
[163] Jones RB. 1992. The nature of handling immediately prior to test affects tonic immobility fear reactions in laying hens and broilers. Applied Animal Behaviour Science 34:247-54.
[164] Knowles TG and Broom DM. 1990. The handling and transport of broilers and spent hens. Applied Animal Behaviour Science 28:75-91, citing: Duncan IJH and Kite VG. 1987. Report for 1986-1987. AFRC Institute of Animal Physiology and Genetics Research, Edinburgh Research Station, Edinburgh, pp. 30-6.
[165] Kannan G and Mench JA. 1996. Influence of different handling methods and crating periods on plasma corticosterone concentrations in broilers. British Poultry Science 37:21-31.
[166] Weeks CA. 2007. Poultry handling and transport. In: Grandin T (ed.), Livestock Handling and Transport, 3rd Edition (Wallingford, U.K.: CAB International).
[167] Lacy MP and Czarick M. 1998. Mechanical harvesting of broilers. Poultry Science 77:1794-7.
[168] Metheringham J and Hubrecht R. 1996. Poultry in transit—a cause for concern? British Veterinary Journal 152:247-9.
[169] Gregory NG and Wilkins LJ. 1992. Skeletal damage and bone defects during catching and processing. In: Whitehead CC (ed.), Bone Biology and Skeletal Disorders in Poultry (Abingdon, U.K.: Carfax Publishing).
[170] Sams AR. 2001. Preslaughter factors affecting poultry meat quality. In: Sams AR (ed.), Poultry Meat Processing (Washington, DC: CRC Press, p. 14).
[171] Gregory NG. 1998. Animal Welfare and Meat Science (Wallingford, U.K.: CABI Publishing, pp. 183-94).
[172] Mitchell MA, Kettlewell PJ, and Maxwell MH. 1992. Indicators of physiological stress in broiler chickens during road transportation. Animal Welfare 1:91-103.
[173] Freeman BM, Kettlewell PJ, Manning ACC, and Berry PS. 1984. Stress of transportation for broilers. The Veterinary Record 114:286-7.
[174] Mench JA. 1992. The welfare of poultry in modern production systems. Poultry Science Reviews 4:107-28.

[175] Weeks CA. 2007. Poultry handling and transport. In: Grandin T (ed.), Livestock Handling and Transport, 3rd Edition (Wallingford, U.K.: CAB International).
[176] Duncan IJH. 1989. The assessment of welfare during the handling and transport of broilers. In: Faure JM and Mills AD (eds.), Proceedings of the Third European Symposium on Poultry Welfare (Tours, France: French Branch of the World Poultry Science Association, pp. 93-107).
[177] Nijdam E, Zailan ARM, van Eck JHH, Decuypere E, and Stegeman JA. 2006. Pathological features in dead on arrival broilers with special reference to heart disorders. Poultry Science 85:1303-8.
[178] Warriss PD, Bevis EA, Brown SN, and Edwards JE. 1992. Longer journeys to processing plants are associated with higher mortality in broiler chickens. British Poultry Science 33:201-6.
[179] Bayliss PA and Hinton MH. 1990. Transportation of broilers with special reference to mortality rates. Applied Animal Behaviour Science 28:93-118.
[180] Gregory NG and Austin SD. 1992. Causes of trauma in broilers arriving dead at poultry processing plants. The Veterinary Record 131:501-3.
[181] Nijdam E, Arens P, Lambooij E, Decuypere E, and Stegeman JA. 2004. Factors influencing bruises and mortality of broilers during catching, transport, and lairage. Poultry Science 83:1610-5.
[182] Ekstrand C. 1998. An observational cohort study of the effects of catching method on carcase rejection rates in broilers. Animal Welfare 7:87-96.
[183] Gentle MJ and Tilston VL. 2000. Nociceptors in the legs of poultry: implications for potential pain in pre-slaughter shackling. Animal Welfare 9:227-36.
[184] Gentle MJ. 1992. Ankle joint (artc. intertarsalis) receptors in the domestic fowl. Neuroscience 49(4):991-1000.
[185] European Food Safety Authority. 2004. Scientific report of the Scientific Panel for Animal Health and Welfare on a request from the Commission related to welfare aspects of animal stunning and killing methods, pp. 125-6. www.efsa.europa.eu/cs/BlobServer/Scientific_Opinion/opinion_ahaw_02_ej45_stunning_report_v2_en1,1.pdf. Accessed September 8, 2008.
[186] Danbury TC, Weeks CA, Chambers JP, Waterman-Pearson AE, and Kestin SC. 2000. Self-selection of the analgesic drug carprofen by lame broiler chickens. The Veterinary Record 146(11):307-11.
[187] Raj ABM. 2004. Stunning and slaughter of poultry. In: Mead GC (ed.), Poultry Meat Processing and Quality (Cambridge, U.K.: Woodhead Publishing Ltd.).
[188] Kannan G and Mench JA. 1996. Influence of different handling methods and crating periods on plasma corticosterone concentrations in broilers. British Poultry Science 37(1):21-31.
[189] Debut M, Berri C, Arnould C, et al. 2005. Behavioural and physiological responses of three chicken breeds to pre-slaughter shackling and acute heat stress. British Poultry Science 46(5):527-35.
[190] Kannan G, Heath JL, Wabeck CJ, and Mench JA. 1997. Shackling of broilers: effects on stress responses and breast meat quality. British Poultry Science 38(4):323-32.
[191] Bedanova I, Voslarova E, Chloupek P, et al. 2007. Stress in broilers resulting from shackling. Poultry Science 86(6):1065-9.
[192] Kannan G, Heath JL, Wabeck CJ, and Mench JA. 1997. Shackling of broilers: effects on stress responses and breast meat quality. British Poultry Science 38(4):323-32.
[193] European Food Safety Authority. 2004. Opinion of the Scientific Panel on Animal Health and Welfare (AHAW) on a request from the Commission related to welfare aspects of the main systems of stunning and killing the main commercial species of animals. www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1178620775454.htm. Accessed September 8, 2008.
[194] U.S. Department of Agriculture National Agricultural Statistics Service. 2008. Livestock slaughter: 2007 summary. http://usda.mannlib.cornell.edu/usda/current/LiveSlauSu/LiveSlauSu-03-07-2008_revision.pdf. Accessed September 8, 2008.
[195] U.S. Department of Agriculture National Agricultural Statistics Service. 2008. Poultry slaughter: 2007 annual summary. http://usda.mannlib.cornell.edu/usda/current/PoulSlauSu/PoulSlauSu-02-28-2008.pdf. Accessed September 8, 2008.
[196] U.S. Department of Agriculture Food Safety and Inspection Service. 2005. Treatment of live poultry before slaughter; notice. September 28. Federal Register 70(187):56624-26.

[197] Bilgili SF. 1999. Recent advances in electrical stunning. Poultry Science 78:282-6.
[198] Gregory NG and Bell JC. 1987. Duration of wing flapping in chickens shackled before slaughter. The Veterinary Record 121:567-9.
[199] European Food Safety Authority. 2004. Opinion of the Scientific Panel for Animal Health and Welfare on a request from the Commission related to welfare aspects of animal stunning and killing the main commercial species of animals. The EFSA Journal 45:1-29. www.efsa.europa.eu/cs/BlobServer/Scientific_Opinion/opinion_ahaw_02_ej45_stunning_report_v2_en1,1.pdf. Accessed September 8, 2008.
[200] Sparrey JM, Kettlewell PJ, Paice MER, and Whetlor WC. 1993. Development of a constant current water bath stunner for poultry processing. Journal of Agricultural Engineering Research 56:267-74.
[201] Schütt-Abraham I, Wormuth HJ, and Fessel J. 1983. Electrical stunning of poultry in view of animal welfare and meat production. In: Eikelenboom G (ed.), Stunning of Animals for Slaughter (The Hague: Martinus Nijhoff Publishers).
[202] Gazdziak S. 2007. Kill floor improvements: automation on the poultry kill and eviscerating lines is increasing efficiency and product quality. The National Provisioner, December, pp. 66, 68.
[203] Raj ABM. 2004. Stunning and slaughter of poultry. In: Mead GC (ed.), Poultry Meat Processing and Quality (Cambridge, U.K.: Woodhead Publishing Ltd.).
[204] Bilgili SF. 1999. Recent advances in electrical stunning. Poultry Science 78:282-6.
[205] Raj ABM. 2004. Stunning and slaughter of poultry. In: Mead GC (ed.), Poultry Meat Processing and Quality (Cambridge, U.K.: Woodhead Publishing Ltd.).
[206] Raj ABM, O'Callaghan M, and Hughes SI. 2006. The effects of amount and frequency of pulsed direct current used in water bath stunning and of slaughter methods on spontaneous electroencephalograms in broilers. Animal Welfare 15:19-24.
[207] Raj ABM, O'Callaghan M, and Knowles TG. 2006. The effects of amount and frequency of alternating current used in water bath stunning and of slaughter methods on electroencephalograms in broilers. Animal Welfare 15:7-18.
[208] Boyd F. 1994. Humane slaughter of poultry: the case against the use of electrical stunning devices. Journal of Agricultural and Environmental Ethics 72(2):221-36.
[209] Raj ABM. 2004. Stunning and slaughter of poultry. In: Mead GC (ed.), Poultry Meat Processing and Quality (Cambridge, U.K.: Woodhead Publishing Ltd.).
[210] Heath GBS, Watt DJ, Waite PR, and Ormond JM. 1981. Observations on poultry slaughter. The Veterinary Record 108:97-9.
[211] Shane SM. 2005. Future of gas stunning. Watt Poultry USA, April, pp. 16-23.
[212] National Institute for Animal Agriculture. 2007. U.S. broiler health shows slight decline. Poultry Health Report, Fall/Winter, p. 2. www.animalagriculture.org/publications/poultry/2007PHR/Poultry Fall-Winter 2007.pdf. Accessed September 8, 2008.
[213] Gregory NG. 1986. The physiology of electrical stunning and slaughter. In: Humane Slaughter of Animals for Food Symposium (Hertfordshire, U.K.: Universities Federation for Animal Welfare).
[214] Raj ABM. 2004. Stunning and slaughter of poultry. In: Mead GC (ed.), Poultry Meat Processing and Quality (Cambridge, U.K.: Woodhead Publishing Ltd.).
[215] Heath GBS, Watt DJ, Waite PR, and Ormond JM. 1981. Observations on poultry slaughter. The Veterinary Record 108:97-9.
[216] Heath GBS, Watt DJ, Waite PR, and Meakins PA. 1983. Further observations on the slaughter of poultry. British Veterinary Journal 139:285-90.
[217] Raj ABM. 2004. Stunning and slaughter of poultry. In: Mead GC (ed.), Poultry Meat Processing and Quality (Cambridge, U.K.: Woodhead Publishing Ltd.).
[218] Shane SM. 2005. Future of gas stunning. Watt Poultry USA, April, pp. 16-23.
[219] U.S. Department of Agriculture Food Safety and Inspection Service. 2005. Poultry Slaughter Inspection Training. Poultry postmortem inspection, p. 15. www.fsis.usda.gov/PDF/PSIT_PostMortem.pdf. Accessed September 8, 2008.

[220] U.S. Department of Agriculture National Agricultural Statistics Service. 2008. Poultry slaughter: 2007 annual summary. http://usda.mannlib.cornell.edu/usda/current/PoulSlauSu/PoulSlauSu-02-28-2008.pdf. Accessed September 8, 2008.
[221] Raj M. 1998. Welfare during stunning and slaughter of poultry. Poultry Science 77:1815-9.
[222] Lacy MP and Czarick M. 1998. Mechanical harvesting of broilers. Poultry Science 77:1794-7.
[223] Delezie E, Lips D, Lips R, and Decuypere E. 2005. Mechanical catching of broiler chickens is a viable alternative for manual catching from an animal welfare point of view. Animal Science Papers and Reports 23(Supplement 1):257-64.
[224] Kettlewell PJ and Mitchell MA. 2001. Comfortable ride: Concept 2000 provides climate control during poultry transport. Resource: Engineering & Technology for a Sustainable World, September, pp. 13-4.
[225] Wise DR and Jennings AR. 1972. Dyschondroplasia in domestic poultry. The Veterinary Record 91:285-6.
[226] Webster J. 1995. Animal Welfare: A Cool Eye Towards Eden (Cambridge, MA: Blackwell Science, p. 156).
[227] Cobb. 2008. Products: overview. www.cobb-vantress.com/Products/Default.aspx. Accessed September 8, 2008.
[228] Ross. Product overview. www.aviagen.com/output.aspx?sec=2102&con=410&siteId=2&region=Na. Accessed September 8, 2008.
[229] Rogers LJ. 1995. The Development of Brain and Behaviour in the Chicken (Wallingford, U.K.: CAB International, pp. 213-21).
[230] Griffin DR. 1992. Animal Minds (Chicago, IL: The University of Chicago Press, pp.162-4).
[231] Dawkins, MS. 2005. The science of suffering. In: McMillan FD (ed.), Mental Health and Well-Being in Animals (Ames, IA: Blackwell Publishing).