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Relationship between Environmental Conditions and Animal Welfare in Cage Free Housing for Egg-Laying Hens

Introduction

The industry-wide transition to cage-free housing for egg-laying hens can have significant, positive impacts on animal welfare by giving the birds an opportunity to express natural behaviors, such as dust bathing, nesting, wing flapping, and foraging. However, housing systems that provide litter and other matter to carry out these activities and increase the amount of bird movement may contribute to an increased level of dust that can worsen air quality and impact hen health and welfare. In addition to increased levels of dust, recent scientific studies comparing the aerial environment of cage-free housing to that of conventional cage and enriched colony cage housing consistently shows elevated indoor gaseous and particulate matter concentrations and overall poorer indoor air quality in cage-free housing.

A sample of scientific studies and industry media articles drawing these conclusions are outlined below. This research demonstrates the need to address the environmental conditions in cage-free housing, so that the welfare benefits that derived from hens being provided the opportunity to perform natural behaviors are not diminished by the impacts of poor indoor air quality.

Annotated Scientific Bibliography

David, Bruce, et al. "Air quality in alternative housing systems may have an impact on laying hen welfare. Part I—Dust." Animals 5.3 (2015): 495-511.

> To determine the potential impacts of air quality within cage-free housing on hen welfare, this article provides an overview of the scientific literature on dust levels found in different housing systems. The review found that dust levels are consistently much higher in cage-free—referred to in the text as ‘loose housing’—systems where hens have access to litter and increased movement than caged housing where they have little or no access to litter. The dust consists of both organic matter, including feather and skin particles, feed components, bacteria, viruses, molds, fungi and dried fecal matter, and inorganic matter that originates from building materials or is brought into the facility through the air supply. Among the potential health impacts of elevated dust levels are impaired lung function, pulmonary lesions, lung damage, and depressed immune system response to infections. According to the article, dust may also serve as a pathogen disseminator in hen houses.

David, Bruce, et al. "Air quality in alternative housing systems may have an impact on laying hen welfare. Part II—Ammonia." Animals 5.3 (2015): 886-896.

This review, which is the second of two that focus on air quality in alternative hen housing systems, provides information on ammonia levels in cage-free housing and enriched colony cage housing and the potential impacts on hens. According to the review, ammonia levels are typically higher in cage-free housing than conventional cage or enriched colony cage housing.

Three studies highlighted in the review found that ammonia levels in particular aviary houses far exceeded 25 ppm, which is the maximum threshold permitted under both industry guidelines and most third-party animal welfare certification programs. In some instances, ammonia levels reached 80 ppm, while in another case ammonia levels averaged 85 ppm with a peak of 100 ppm. Other studies found that ammonia levels tend to increase during colder ambient temperatures. The potential health impacts for hens exposed to high levels of ammonia include damage to the respiratory system, increased susceptibility to respiratory disease and illnesses, such as Newcastle disease, and increased rates of keratoconjunctivitis, which is inflammation of the cornea and conjunctiva of the eye.

Green, Angela R., et al. "Air quality and bird health status in three types of commercial egg layer houses." Journal of Applied Poultry Research 18.3 (2009): 605-621.

This article presents the results of a field observational study that monitored three different types of egg-laying hen housing for air temperature, relative humidity, and atmospheric ammonia levels during the winter and summer. The three hen housing systems monitored were high-rise and manure belt housing, both of which are cage systems, as well as cage-free floor-raised housing. The findings of the study showed that cage-free houses had significantly higher ammonia levels during the winter than the two cage housing systems, and far exceeded 25 ppm, which is the maximum threshold permitted under both industry guidelines and most third-party animal welfare certification programs. In the summer, monitored ammonia levels tended to remain within the recommended level, with the exception of multiple cage-free houses that reached 42 ppm and 29 ppm. It is important to note, the authors of this article were hesitant to definitively link particular results of the study to housing type; however, subsequent research reinforces this study's findings especially in regards to elevated ammonia levels in cage-free housing.

Quote: "In comparison, NH3 concentrations in the FR houses substantially exceeded the recommended level of 25 ppm, with a daily mean of 46 ppm, as compared with 14 ppm for the HR houses and 7 ppm for the MB houses. The maximum concentration in the FR houses reached 85 to 89 ppm."

Zhao, Yang, et al. "Environmental assessment of three egg production systems–Part I: Monitoring system and indoor air quality." Poultry science 94.3 (2015): 518-533.

As part of a multi-institute and multi-disciplinary project known as the Coalition for Sustainable Egg Supply, this study compared the indoor air quality of three different commercial egg-laying hen housing systems by quantifying the indoor gaseous and particulate matter concentrations in each system over a period of 27 months. The three housing systems were conventional cage housing, enriched colony cage housing, and aviary housing (commonly referred to as "cage-free"). Much of the focus of the study was on ammonia, carbon dioxide, nitrous oxide, methane, and particulate matter levels, all of which are viewed as concerning due to their potential impacts on hen health. The study found that daily ammonia concentration levels were highest in the aviary housing, especially during colder temperatures when ammonia levels were *significantly* higher and even exceeded 25 ppm, which is the maximum threshold permitted under industry guidelines and most third-party animal welfare certification programs. Daily carbon dioxide levels were again highest in aviary housing systems and the daily particular matter concentration in aviary housing was more than 6 times higher than that of conventional cage housing and about 9 times higher than enriched colony cage housing.

According to the study, particulate matter and indoor gaseous concentrations, excluding methane, are inversely related to ambient temperature and building ventilation rate, meaning concentrations increase when ambient temperatures and ventilation rates decrease. Also, according to the study, quality of and access to litter, bird movement, and manure storage practices are also contributing factors to concentration levels.

Quote: "Indoor air quality of the CC and EC houses were comparable, which was better than that of the AV house that had higher ammonia (occasionally exceeding 25 ppm) and PM concentrations, especially at ambient temperature <10°C." (It is important to note, this was the case even with a significantly higher stocking density in the conventional cage housing, which housed 200,000 hens as opposed to 50,000 hens in the aviary and colony cage systems.)

Quote: "Investigation of mitigation practices to improve indoor air quality of the litter-floor aviary housing system is warranted."

Zhao, Y., et al. "Environmental assessment of three egg production systems–Part III: Airborne bacteria concentrations and emissions." Poultry Science 95.7 (2016): 1473-1481.

As part of the Coalition for Sustainable Egg Supply project, this study monitored the concentrations of airborne microorganisms and bacteria throughout an eight-month period in three different commercial egg-laying hen housing systems, conventional cage housing, enriched colony cage housing, and aviary (also known as cage-free) housing. Indoor concentration of airborne microorganisms is considered a critical indicator of animal well-being, thus higher concentrations may reflect poor hen health

and welfare. The study found that aviary housing consistently had much higher airborne bacteria concentrations than both conventional cage and enriched colony cage housing. In fact, during cold climatic conditions, total bacteria in the aviary housing was 30 to 80 times higher than conventional cage and enriched colony cage housing.

Evidence Presented by Industry Publications

D. Heard, "Research to improve cage-free air quality and hen welfare," WATTPoultry, August 12, 2020.

In recognizing the need to improve air quality in cage-free facilities, especially as the industry-wide shift to this housing system continues to occur, the U.S. Poultry & Egg Association and the USPOULTRY Foundation has awarded a grant to researchers at North Carolina State University to evaluate potential technology to reduce dust levels. This article discusses how the researchers intend to develop and scale electrostatic precipitation technology that can be used in a commercial cage-free barn with the goal of being able to effectively remove particulate matter, ammonia, and microorganisms from the air. Potential benefits of the research include improved bird performance and welfare due to better indoor air quality and the potential for adapting this sort of technology to the broiler and turkey industries as well.

R. Kosch, "Reducing the dust load, protecting the health in layer houses," The Poultry Site, March 22, 2019.

In addition to recognizing how the transition from cage housing to cage-free systems has led to high dust concentrations that can have harmful effects on hen health, this article points to litter as the main source of high dust levels and discusses how the formation of dust occurs. According to the article, "since the hens are constantly active in the litter, its particles are ground finer and finer until they are so small that they are suspended in the air as suspended particulate matter. More dust forms the longer the litter stays in the house." Warm dry air that is the result of hens emitting very little water into the air and high air change rates are also contributing factors for high dust levels.

L. Chai, "Suppressing dust in cage-free henhouse with the sprinkling system," UGA Cooperative Extension, February 1, 2019.

This article focused on research conducted at Iowa State University as part of the Coalition for Sustainable Egg Supply project, the findings of which are highlighted above. To summarize, the article states, "one environmental challenge posted [sic] by cage-free housing is high dust or particulate matter (PM) levels, especially during cold weather when the house has limited ventilation." It also reiterates the point that the level of particulate matter in cage-free houses is significantly higher than that of conventional cage manure-belt and enriched colony houses, therefore, reducing dust

levels is crucial to protecting the health and well-being of the animals and farm workers in cage-free houses. Additionally, the article mentions dust suppression tests that have been carried out to improve air quality in cage-free housing. One strategy that appears promising was carried out in a commercial cage-free facility in Iowa in which a sprinkling system was installed to spray water just before birds accessed the litter floor. This resulted in a 37-51% dust reduction without increasing ammonia levels—an issue that has proven difficult to avoid when spraying liquid agents on the litter floor.

J. Dreyer, "Tackling cage-free layer housing air quality challenges," WATTPoultry, April 11, 2018.

While it is undoubtable that cage-free housing offers egg-laying hens additional welfare benefits from the ability to express natural behavior, air quality has proven to be a significant issue with scientific studies showing dust can be 6 to 9 times higher in cage-free housing. As Dr. Albert Winkel, a livestock and environment researcher states in the article, "we have learned that moving to cage-free production has solved an animal welfare problem, but has created another serious issue – environmental contamination." This article discusses how litter and manure management plays a key role in controlling dust and ammonia levels, and discusses ongoing research at Iowa State University and in the Netherlands that is looking into control measures, including spraying litter with electrolyzed water to control dust and separating the birds' "clean and dirty" activities into different areas.

A. Alonzo, "How to mitigate dust and ammonia in cage-free houses," WATTPoultry, May 4, 2017.

As the egg industry continues to transition from conventional cage and enriched colony cage housing to cage-free, researchers and industry leaders are looking into ways to address an increase in indoor air pollutants, such as dust and ammonia, which results from increased bird movement that stirs up litter and debris and makes managing bird waste difficult. This article discusses research presented by a lead agricultural engineer, Dr. Hongwei Xin, at an Egg Industry Center Issues Forum. This research has looked into reducing ammonia through feed management, such as reducing dietary protein, adding dietary fibers, and adding supplements, and controlling ammonia and dust through technology, including sprays that reduce dust levels in litter and electrostatic devices that attract dust particles, thereby improving air quality.