JOURNAL OF ANIMAL BEHAVIOUR AND BIOMETEOROLOGY

RESEARCH ARTICLE
Published Online: June 21, 2024
https://doi.org/10.31893/jabb.2024018

Environmental enrichment in birds: Physical integrity, keel problems and locomotor responses

Aérica Cirqueira Nazareno[a] | **Robson Mateus Freitas Silveira**[a] | **Sérgio Luís de Castro Júnior**[b] | **Iran José de Oliveira Silva**[a]

[a]Environment Livestock Research Group (NUPEA), Department of Biosystems Engineering, ''Luiz de Queiroz'' College of Agriculture, University of São Paulo, Piracicaba, São Paulo, Brazil.

Abstract The objective of this research was to evaluate the effect of environmental enrichment on physical integrity, keel damage and locomotor problems in broiler chickens reared in a controlled environment at different ages. Ninety-six Cobb broiler chicks were used, reared in a controlled environment, with 48 birds for each treatment (T1 = presence and T2 = absence of environmental enrichment) at different ages (1, 2, 3, 4, 5 and 6 weeks old) during the two production cycles. The use of environmental enrichment influenced the decrease in the percentage of birds with a score of 1, contrary to treatment with no environmental enrichment. Hock burns in broilers showed no difference (P = 0.069) between the presence and absence of environmental enrichment for score 1, so the treatments did not influence the appearance of hock burn score 1 in birds. Dermatitis on the feet of broiler chickens showed no difference (P = 0.0800) between scores 0 and 1 for the presence and absence of environmental enrichment. Dermatitis on the feet of the birds differed (P < 0.0001) between weeks 5 and 6 for scores of 0 and 1; however, in the other weeks, the treatments did not influence this variable. The highest percentage of birds with a score of 1 was observed at week 6, with 38.24% having dermatitis on the feet. The use of environmental enrichment favored a reduction in the score of 1 for plumage cleanliness and lameness in broilers. Hock burn, foot dermatitis and keel damage were not affected by the use of environmental enrichment. Week 6 had the highest percentage of birds, with a score of 1 for all physical integrity variables.

Keywords: leg health, ladder with perch, poultry, poultry welfare

1. Introduction

The poultry industry provides a breeding environment with little stimulus for the birds to move; on average, they spend most of their time lying down (76 to 80%). Several studies have shown that any adaptation that increases the mobility of broilers, such as exercise equipment (hay bales, perch, ramps, etc.), lower flock density and increased walking distance (use of barriers between feeding and water), results in increased movement in birds (Kaukonen et al 2017). A lack of activity (little movement) in broilers is one of the factors that leads to abnormal bone development and locomotor problems due to injuries and fractures (Baxter et al 2018). Therefore, the absence of environmental enrichment decreases the welfare of these productive animals (Pichova et al 2016).

The use of environmental enrichment improves the biological functioning of confined animals (Pichova et al 2016; Tahamtani et al 2018). In addition, it can improve the physical integrity (pododermatitis, hock burn, plumage cleanliness and lameness) and well-being of broilers (Gebhardt-Henrich et al 2018; Kiani & Borstel 2019). Lameness, pododermatitis and locomotor problems (tibial dyschondroplasia and spondylolisthesis) negatively affect economic returns in the poultry industry due to increased culling and bird mortality (Bailie & O' Connell 2015; Gebhardt-Henrich et al 2018).

Birds can suffer bone injuries in the keel in different ways (fractures, deformations or cuts along the edge of the ventral bone), which are caused by the type of rearing system (Clark et al 2008). Hens reared on aerial perches showed better leg health (Shipov et al 2010), but they presented damage to the keel due to the use of perches, which is due to birds falling off their perches (Stratmann et al 2015). On the other hand, Donaldson et al (2012) reported that the use of aerial perches by laying hens did not harm the keel bone or improve the health of the birds' legs.

In the face of this problem, several questions have been raised: Does the use of a ladder with perches affect physical integrity, cause damage to the keel and cause locomotor problems in broiler chickens? The objective of this research was to evaluate the effect of environmental enrichment on physical integrity, keel damage and locomotor problems in broiler chickens reared in a controlled environment at different ages.

2. Materials and methods

This study was part of a larger project (Nazareno et al 2022, 2024) that euthanized 8 animals/treatment weekly

 Received: March 28, 2024 | Accepted: May 5, 2024

during the two production cycles, which used 112 broiler chicks from the Cobb lineage, with a density of 12 birds/m2, in which 56 birds were used in treatments and 128 birds were used for replacement; these birds were reared during two production cycles (42 days of life). Notably, the replacement animals were subjected to the same conditions (treatment, density and diet) of rearing in relation to the controlled environment. Therefore, the use of replacement animals for replication was based on the methodology of Frutosa et al. (2018), who evaluated replacement animals as replicates throughout the experimental period. The study was approved by the Animal Ethics Committee (CEUA) of the same university under protocol no. 2016/10.

For the evaluations of physical integrity, tibial dyschondroblastia, spondylolisthesis and keel damage, 96 Cobb broiler chicks were used; the chicks were reared in a controlled environment, with 48 birds for each treatment (T1 = presence and T2 = absence of environmental enrichment) under different conditions. ages (1, 2, 3, 4, 5 and 6 weeks old) during the two production cycles.

The microclimatic variables (air temperature and relative humidity) were controlled through a climatic chamber and monitored with two Hobo® dataloggers. These variables were adapted to the thermoneutral needs of birds according to age according to the Cobb Lineage Management Manual.

The design of the environmental enrichment used was chosen based on other previous studies based on cost and ease of acquisition by the producer, with the aim of verifying its influence on the movement and exercise of broiler chickens. The type of environmental enrichment used was a ladder with a perch at the top, in the form of a stick with rounded edges, made of pine wood, a material that is light and has a high thermal capacity (the ratio between the amount of heat supplied to the wood and the temperature variation observed therein). This characteristic may be favorable to thermal comfort for birds, which are maintained at a height of 5 cm from the ground from 1 to 21 days of age and increased to a height of 10 cm from 22 to 42 days of age, maintaining a space of 15 cm/bird and a thickness of 4 cm. The dimensions of the enrichment (perch-type ladder) were 90 cm long, 35 cm wide and 30 cm high.

The strategy of placing the environmental enrichment (ladder with perch) between the feeder and drinker was based on the authors of Bizeray et al (2002a, 200b), who used barriers to increase the distance between these locations, with the aim of motivating and increasing the movement of broiler chickens.

The physical integrity (plumage cleanliness, lameness, burns on the hocks and dermatitis on the feet) of the birds was assessed weekly by an observer for all the study birds (48 birds/treatment) during two 42-day breeding cycles.

The assessment of plumage cleanliness was performed through observations of the chest, neck, vent, back, wings and tail of the birds, which were summed to produce a plumage cleanliness index, as performed by the authors Gebhardt-Henrich et al. (2018) and Kiani & Borstel (2019).

Hock burns were assessed based on the type of injury according to the following categories: no evidence of hock burns (score 0), minimal evidence of hock burns (scores 1 and 2) and evidence of hock burns (scores 3 and 4). This type of analysis was employed by Gebhardt-Henrich et al (2018), Karaarslan & Nazligül (2018) and Kiani & Borstel (2019).

Dermatitis on the feet of the birds was recorded using the following scores: no evidence of dermatitis on the feet (score 0), minimal evidence of dermatitis on the feet (scores 1 and 2) and evidence of dermatitis on the feet (scores 3 and 4). The authors Baxter et al (2018), Karaarslan & Nazligül (2018) and Gebhardt-Henrich et al (2018) used the same analysis procedure.

The lameness of broilers was verified through the type of gait (gait score) classified according to the following criteria: 0 – the birds walk normally with skill and agility; 1 – slight abnormality, but difficult to define; 2 – defined and identifiable abnormality; 3 – obvious abnormality, affected ability to move; 4 – severe abnormality, performs few steps; and 5 – inability to walk. Karaarslan & Nazligül (2018) and Kiani & Borstel (2019) employed the same methodology.

A total of 112 Cobb broiler chicks reared in a controlled environment were used, with 56 birds for each treatment (T1 = presence and T2 = absence of environmental enrichment). For the evaluation of locomotor problems (tibial dyschondroplasia and spondylolisthesis) and damage to the keel during growth, 8 birds/treatment at different ages (1, 7, 14, 21, 28, 35 and 42 days) during the two production cycles were euthanized weekly. The animals were euthanized via cervical dislocation in compliance with animal welfare standards.

Then, the legs (right and left) were removed through a veterinary incision made with a clinical scalpel. After this procedure, the bones of the tibias (right and left) were removed, and the bones were sawed using an electric saw (Invicta brand) (Figure 1). Next, tibial dyschondroplasia was verified using an electronic magnifying glass from the Bel brand.

The analysis of tibial dyschondroplasia was performed according to the criteria used by Edwards & Veltmann (1983) and adapted by Bizeray et al (2002b) and Karaarslan & Nazligül (2018) by collecting the right and left tibia of the birds and classifying them according to the presence of injuries. Scores ranged from 0 (normal) to 3 (severe) and were based on cartilage proliferation as follows: 0 = no lesions present (cartilage considered normal, narrow, with small irregularities); 1 = lesions smaller than 4.5 mm (thick cartilage with considerable irregularities); 2 = lesions larger than 4.5 mm and smaller than 10 mm (thickened cartilage, there is evidence of persistent prehypertrophic cartilage that is not calcified and has not been invaded by metaphyseal vessels, and deep irregularities of such cartilage are apparent); and 3 = lesions

greater than 10 mm (large amount of cartilage at the proximal end of the tibia).

Keel damage assessment was performed after removal of the breast through a veterinary incision made with a clinical scalpel. Therefore, 56 bones were removed from each treatment (T1 and T2) at different rearing ages. The evaluation was performed using a score ranging from 0 to 4, following the methodology of Donaldson et al. (2012) and Tarlton et al. (2013) (Figure 2).

Figure 1 Image of the procedure for verifying the presence of tibial dyschondroplasia.

Figure 2 Image of keel damage in broilers.

The evaluation of spondylolisthesis of the back was only considered when the broilers had problems in locomotion, as in this research, no case was diagnosed; therefore, there was no analysis of the disease. This disease does not always occur, and the factors that influence it are genetics, nutrition and inadequate management.

The experimental design was completely randomized in a split plot, and in the plots, the ages of the birds were allocated to the treatments and subplots, with 48 repetitions.

The assumptions were validated using residual plots and Shapiro–Wilk normality tests. The variables were nonparametric; therefore, all the response variables were investigated using the chi-square test to determine whether the observed frequency differed significantly from the expected frequency and to verify the associations between categorical variables. When checking the global association between variables at 5% significance, it was possible to observe whether there was a local association between categories by calculating the standardized residuals.

3. Results

There was a difference ($P < 0.0001$) between the presence and absence of environmental enrichment for scores of 0 and 1 for cleaning the plumage of broilers; that is, the use of environmental enrichment influenced the decrease in the percentage of birds with a score of 1, contrary to treatment with no environmental enrichment (Figure 3). The highest value of birds with a score of 1 was noted in the absence of environmental enrichment, with 69.6% plumage cleanliness.

Hock burns in broilers showed no difference (P = 0.069) between the presence and absence of environmental enrichment for score 1, so the treatments did not influence the appearance of hock burn score 1 in birds.

The cleanliness of the birds' plumage differed (P < 0.0001; Figure 4) among the weeks for scores of 0 and 1; therefore, the treatments did not influence this variable only in week 4. The highest percentage of birds with a score of 1 was observed at week 6, with 48% plumage cleaning.

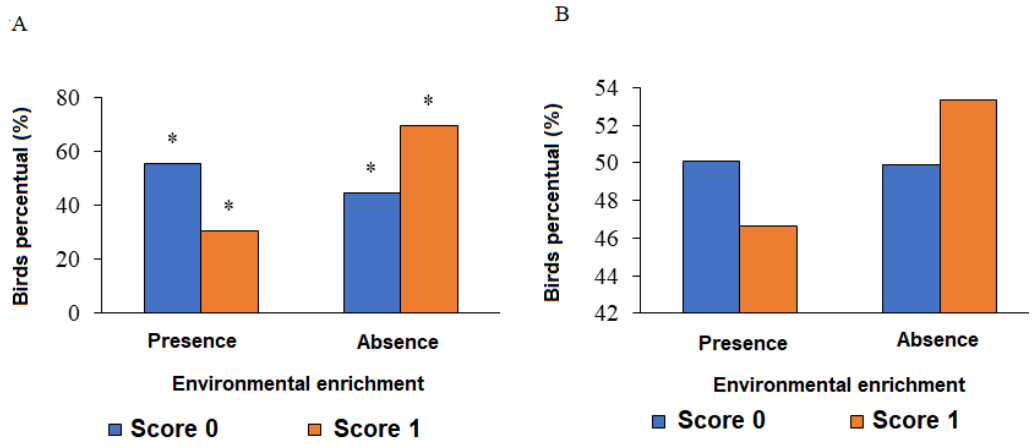

Figure 3 Percentages of broiler chickens reared with and without environmental enrichment that had plumage cleanliness scores of 0 and 1 (A) (P < 0.0001 and X2 = 24.49) and hock burn (B) (P = 0.069 and X2 = 0.79). * Significant values based on residual analysis.

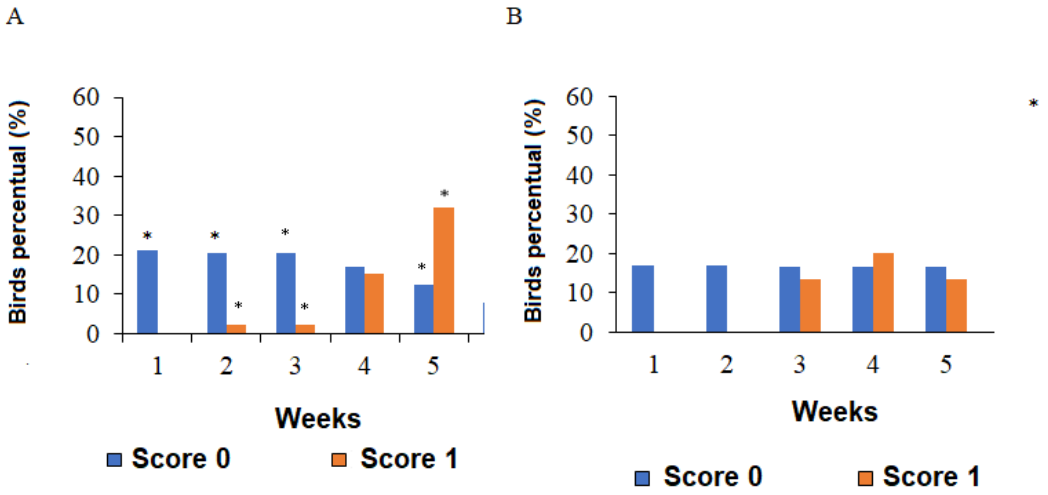

Figure 4 Percentages of broilers reared for different weeks that scored 0 or 1 for plumage cleanliness (A) (P < 0.0001 and X2 = 182.37) and hock burn (B) (P = 0. 0031 and X2 = 17.87). * Significant values based on residual analysis.

Broiler hock burns differed (P = 0.0031) only at week 6 for scores of 0 and 1, so the treatments influenced only the last week of rearing. However, the other weeks did not differ between the scores of 0 and 1. The highest percentage of birds with a score of 1 was observed in week 6, with 53.33% of the birds experiencing hock burn injury.

Dermatitis on the feet of broiler chickens showed no difference (P = 0.0800) between scores 0 and 1 for the presence and absence of environmental enrichment; that is, the treatments did not influence the appearance of a score of 1 for dermatitis on the feet of the birds (Figure 5).

The lameness of broilers showed a difference (P = 0.0063) between the presence and absence of environmental enrichment for scores of 0 and 1; therefore, the use of environmental enrichment (ladder with perch) influenced the decrease in the percentage of birds with a score of 1, contrary to treatment with no environmental enrichment. The highest percentage of birds with a score of 1 was verified in the absence of environmental enrichment, with 80% lameness.

Dermatitis on the feet of the birds differed (P < 0.0001) between weeks 5 and 6 for scores of 0 and 1; however, in the other weeks, the treatments did not influence this variable (Figure 6). The highest percentage of birds with a score of 1 was observed at week 6, with 38.24% having dermatitis on the feet.

Lameness in broilers showed a difference (P = 0.0090) at weeks 6, 3 and 1 for scores of 0 and 1; however,

in the other weeks, the treatments did not influence this variable. The highest percentage of score 1 birds was observed at weeks 3 and 6, with 35% lameness.

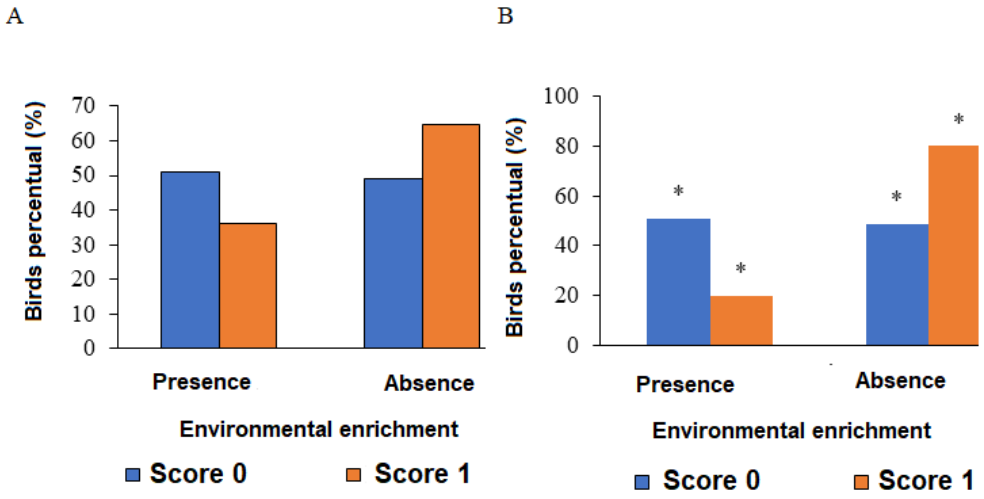

Figure 5 Percentages of broiler chickens raised with and without environmental enrichment that had scores of 0 and 1 for foot dermatitis (A) (P = 0.0800 and X2 = 3.13) and lameness (B) (P = 0.0063 and X2 = 7.46). * Significant values based on residual analysis.

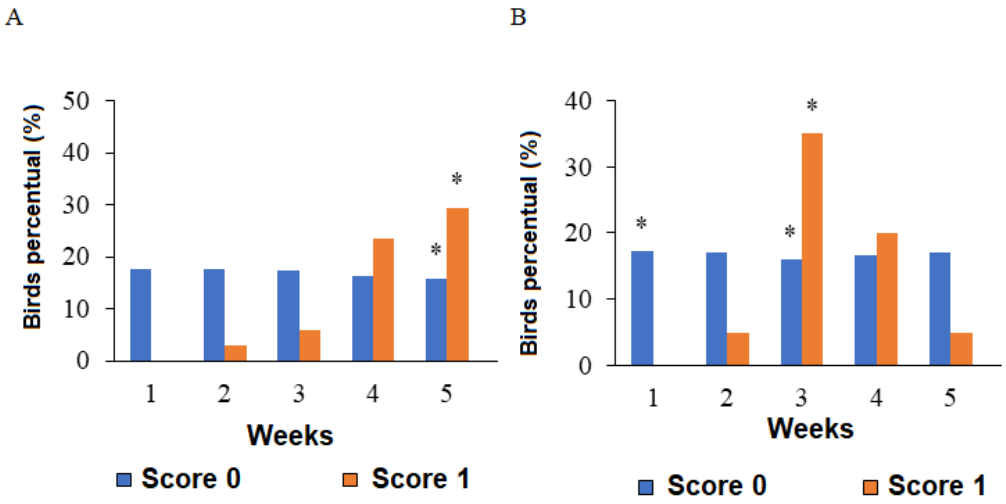

Figure 6 Percentages of broilers reared for 0 or 1 week for foot dermatitis (A) (P < 0.0001 and X2 = 27.26) and lameness (B) (P = 0.0090 and X2 = 15.33). * Significant values based on residual analysis.

4. Discussion

According to the results of the physical integrity analyses (plumage cleaning and lameness), the use of environmental enrichment (ladder with perch) decreased the score of 1 of these variables in broiler chickens. This may be related to the greater activity (movement) of the birds that used environmental enrichment, as this is commonly related to a high growth rate, high body weight and low activity level. Other authors have commented that the occurrence of lameness is due to an environment that does not stimulate the birds to move, as is the case with the conventional rearing system for broilers (Karaarslan & Nazligül 2018; Kiani & Borstel 2019). However, Su et al (2000) and Bailie & O'Connell (2015) commented that the provision of perch did not affect lameness scores, contrary to the results of this study. However, it was observed that birds subjected to environmental enrichment (ladder with perch) had better plumage cleanliness, in agreement with the findings of Zhao et al (2013), who reported that broiler chickens reared with perches had the cleanest plumage.

Hock burns and dermatitis on the feet of birds were not influenced by the use of environmental enrichment. Contrary to what was found in this study, Zhao et al (2013) and Karaarslan & Nazligül (2018) reported a reduction in the number of broilers with hock burn and foot dermatitis due to the use of perches, but Ventura et al (2010) only reported a trend toward a reduction in foot dermatitis. However, Bailie et al (2013) reported a decrease in the incidence of lameness and foot dermatitis in broilers attributed to increased physical activity through the use of perches and straw bales. Other studies have shown that these

enrichments improve the welfare conditions of birds (Bailie & O'Connell, 2014; Baxter et al., 2018).

Week 6 was the week with the highest percentage of birds with a score of 1 for all physical integrity variables (plumage cleanliness, lameness, burns on the hock and dermatitis on the feet). According to Kaukonen et al (2017), older birds tend to have the highest scores for dermatitis on the feet, hock burn and plumage cleanliness. Kiani & Borstel (2019) also commented that the age of the birds influences the occurrence of lameness; therefore, older animals had a greater occurrence of this problem. However, Bailie & O'Connell (2015) did not observe an effect of age on the percentage of broilers with lameness.

Regarding tibial dyschondroplasia in broilers, birds with this disease were not found in the treatments (presence and absence of environmental enrichment). Additionally, for keel damage, only one broiler chicken with this problem was diagnosed, which occurred in week 6 with no environmental enrichment. Therefore, the use of environmental enrichment (ladder with perch) by broilers does not contribute to the occurrence of tibial dyschondroplasia or keel damage.

In agreement with the results of this research, several authors reported that the use of perch had no influence on the occurrence of tibial dyschondroplasia in broilers. Kaukonen et al (2017) evaluated the effects of the use of perches and platforms on the health of the legs of broilers and reported that only the use of platforms decreases the incidence of tibial dyschondroplasia; there are no reports that perch influences this disease. Karaarslan & Nazligül (2018) commented that the use of perch prevents tibial dyschondroplasia. This finding was also verified by Bizeray et al (2002b), who evaluated the use of environmental enrichment (barriers between food and water) for broiler chickens and did not find a number of birds with tibial dyschondroplasia. However, Kiani & Borstel (2019) reported that an increase in the poultry group increased the incidence of tibial dyschondroplasia in broilers.

Keel damage due to perch use was observed in slow-growing birds, and the fact that this research was carried out with fast-growing birds may have contributed to the absence of this problem. The results of this study, which revealed that the use of perch in laying hens does not contribute to the appearance of bone lesions in the keel, were also verified by Donaldson et al (2012). However, Stratmann et al (2015) attributed the damage to the keel of laying hens to the use of perches.

Based on the results of this study, it can be said that the use of environmental enrichment (ladder with perch) decreases the physical integrity (plumage cleanliness and lameness) of broilers to a score of 1 due to greater activity (bird mobility). However, the ladder with perch did not influence the incidence of hock burn, paw dermatitis or keel damage. Tibial dyschondroplasia and spondylolisthesis were not diagnosed in this study.

5. Conclusions

The use of environmental enrichment favored a reduction in the score of 1 for plumage cleanliness and lameness in broilers. Hock burn, foot dermatitis and keel damage were not affected by the use of environmental enrichment. Week 6 was the period with the highest percentage of birds, with a score of 1 for all physical integrity variables.

Ethical considerations

The study was approved by the Ethics Committee on Animal Use (CEUA) of University of São Paulo – Luiz de Queiroz Agriculture School (USP/ESALQ), Piracicaba City, São Paulo State, Brazil, under protocol n. 2016/10.

Conflict of interest

The authors declare no conflicts of interest.

Funding

The authors thank the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for granting a scholarship and research funding (protocol n. 2016/10769–8).

References

Bailie CL, O'Connell (2015) The influence of providing perches and string on activity levels, fearfulness and leg health in commercial broiler chickens. Animal 9: 660–668. doi: 10.1017/S1751731114002821

Baxter MCL, Bailie NE, O'Connell (2018) Evaluation of a dustbathing substrate and straw bales as environmental enrichments in commercial broiler housing. Applied Animal Behaviour Science 200: 78–85. doi: 10.1016/j.applanim.2017.11.010

Bizeray D, Estevez I, Leterrier C, Faure JM (2002a) Effects of increasing environmental complexity on the physical activity of broiler chickens. Applied Animal Behaviour Science 79: 27-41.

Bizeray D, Estevez I, Leterrier C, Faure JM (2002b) Influence of increased environmental complexity on leg condition, performance, and level of fearfulness in broilers. Poultry Science 81: 767-773.

Clark WD, Cox WR, Silversides FG (2008) Bone fracture incidence in end-of-lay high-producing, noncommercial laying hens identified using radiographs. Poultry Science 87:1964–1970.

Donaldson CJ, MEE, Ball NE (2012) Aerial perches and free-range laying hens: The effect of access to aerial perches and of individual bird parameters on keel bone injuries in commercial free-range laying hens. Poultry Science 91: 304–315. doi: 10.3382/ps.2011-01774

Edwards HM Jr., Veltmann JRJr (1983) The role of calcium and phosphorus in the etiology of tibial dyschondroplasia in young chicks. Journal of Nutrition 113: 1568-1575.

Frutosa J, Andrés SE, Trevisi J, Benavidesa N, Santos A, Santos FJ (2018) Moderated milk replacer restriction of ewe lambs alters gut immunity parameters during the pre-weaning period and impairs liver function and animal performance during the replacement phase. Animal Feed Science and Technology 243: 80–89.

Gebhardt-Henrich SG, Toscano HW (2018) Use of aerial perches and perches on aviary tiers by broiler breeders. Applied Animal Behaviour Science 203: 24–33. doi: 10.1016/j.applanim.2018.02.013

Kaukonen EM, Norring A (2017) Perches and elevated platforms in commercial broiler farms: use and effect on walking ability, incidence of tibial dyschondroplasia and bone mineral content. Animal 11(5): 864–871. doi:10.1017/S1751731116002160

Karaarslan S, Nazlıgül A (2018) Effects of lighting, stocking density, and access to perches on leg health variables as welfare indicators in broiler chickens. Livestock Science 218: 31–36. doi: 10.1016/j.livsci.2018.10.008

Kiani A, Borstel UKV (2019) Impact of different group sizes on plumage cleanliness and leg disorders in broilers. Livestock Science 221: 52–56.

Shipov A, Sharir A, Zelzer E, Milgram J, Monsonego-Orna E, Shahar R (2010) The influence of severe prolonged exercise restriction on the mechanical and structural properties of bone in an avian model. Veterinary Journal 183:153–160.

Tahamtani FM, Pedersen C., Toinon AB (2018) Effects of environmental complexity on fearfulness and learning ability in fast growing broiler chickens. Applied Animal Behaviour Science 207: 49–56. doi: 10.1016/j.applanim.2018.04.005

Tarlton JF, Wilkins MJ, Toscano NC, Avery L (2013) Reduced bone breakage and increased bone strength in free range layinghensfedomega-3 polyun saturated fatty acid supplemented diets. Bone 52: 578–586.

Ventura BA, Siewerdt I (2010) Effects of barrier perches and density on broiler leg health, fear, and performance. Poultry Science 89: 1574-1583. doi: 10.3382/ps.2009-00576

Zhao JP, Jiao YB, Jiang ZG, Song XJ, Wang H (2013) Cool perches improve the growth performance and welfare status of broiler chickens reared at different stocking densities and high temperatures. Poultry Science 92: 1962–1971. doi 10.3382/ps.2012-02933