Predicting the effect of environmental enrichment (music and light) in leg disorders on broiler chicken

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Abstract

The present study aimed to develop predicting algorithms to identify the effectiveness of environmental enrichment (music and light stimuli) in reducing leg disorders in broiler chickens. The trial was carried out in one flock of broiler chickens on a poultry farm using four broiler houses. A total of 1,600 broiler chickens were used in the trial. Twenty broiler chickens (ten males and ten females) were caught and weighed, and footpad dermatitis, hock burn, valgus-varus deformity, and crooked toes were observed. The gait score was assessed once a week for five weeks. Data mining was applied using the decision tree classification algorithm based on the Iterative Dichotomiser 3 algorithm (J48 in the Weka® environment) and the cross-validation operator. Broiler weight was the decisive factor in predicting leg disorders. Environmental enrichment was the most critical factor in footpad dermatitis (81% accuracy). The vital factor for predicting valgus/varus is age. The environmental enrichment was the most crucial factor determining crooked toes' incidence (70% accuracy). The critical aspects affecting gait score were broiler weight and sex (decision tree with 82% accuracy), and the incidence of hock burn was related to weight, environment enrichment, and sex (77% accuracy). The algorithms predicted the leg disorder and lameness in broilers subjected to the stimuli utilizing environmental enrichment.

Keywords: real-time recognition, cough analysis, spectral analysis, signal processing

Introduction

Poultry meat production is known to be intensive, with systematic innovation and massive productivity increases. Broiler chicken meat has a high market demand resulting in a bird growing very fast, achievable with genetic selection, improved nutrition, and efficient production systems (Fanatico et al., 2007). The structure of poultry meat production represents a challenge (Hepworth et al., 2010). In the last two decades, researchers have studied the most critical issues of growth rate and leg disorders related to inactivity in chickens (Aydin et al., 2010). Environmental enrichment (EE) is recommended for animals living in non-natural habitats, zoos, laboratories, and farms. This technique helps to increase animal welfare and improve biological functions by reducing aggression and competition and improving social interaction (Estevez et al., 1997). The study aimed to develop predicting algorithms to identify the effectiveness of environmental enrichment (music and light stimuli) in reducing leg disorders in broiler chickens.

Materials and methods

Experimental data

The field trial was carried out in one flock of broiler chickens on a poultry farm belonging to a cooperative company in Mogi Mirim County, Sao Paulo, Brazil. The poultry farm consisted of four broiler houses with mechanically ventilated systems, and the inside temperature was automatically controlled. A total of 1,600 broiler chicken Cobb 500 were used on trial. A rectangle area (5 m x10 m) was delimited in each broiler house to rear the broiler chicken for 45 days using a stocking density of 12 birds m^2. The floor was covered with new wood shavings and sawdust. Inside the area, a tripod was inserted to allocate the sound box, digital camera, and laser projector (Figure 1). For the environmental enrichment, each broiler house received a different stimulus (Table 1).

Figure 1: The limited area where the boilers were restricted and observed.

Table 1: Environmental enrichment type and house nomenclature.

Broiler House	Environmental Enrichment (EE)
A 1	Music and light
A 2	Music
A 3	Light
A 4	Without environmental enrichment

Assessment of leg disorders

Crooked toes methodology was classified as without deviation of the phalanges on the toes (score 0) and one or more deviations of the phalanges (score 1) (Kapell et al., 2012). Every broiler was caught, weighed, and observed foot pad dermatitis, hock burn, valgus or varus deformation, crooked toes, and gait score (Leterrier and Nys,1992; Dawkins et al., 2004; Welfare Quality, 2009).

Data analysis

The data were processed in the Weka® 3.5 computer program, using the Iterative Dichotomiser 3 algorithm (J48 in the Weka® environment) and the cross-validation operator, considering cross-validation with 10% samples (10-fold cross-validation). Figure 2 shows the schematic of the data recording, processing and analysis. The State University of Campinas Ethics Committee approved the research under protocol n. n.4809/2018.

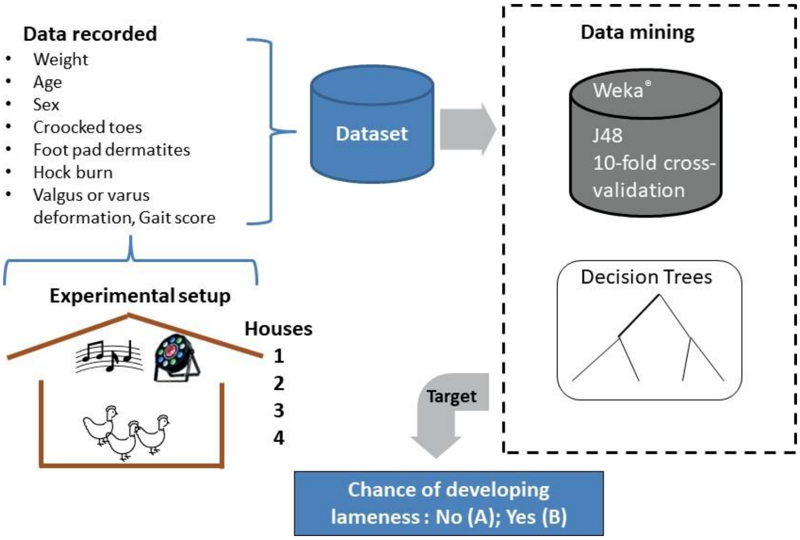

Figure 2: Schematic of the experimental setup, data processing and data analysis.

Results and discussion

The found gait score decision tree had 82% of accuracy. In the "tree-like" structure, the target is the last leaf of each branch in rectangles, and the branches are defined by the alternatives found in the path. The numbers inside the parenthesis indicate the proper assessment and the error, respectively. Body weight was the most critical factor determining the birds' lameness (Figure 3). The algorithm used three attributes (weight, gender, and broiler house) as crucial to developing lameness. According to the decision-tree algorithm, if a broiler chicken has less than 1.47 kg, there is no chance of developing lameness (A). If the broiler chicken has more than 1.47 kg and is male, it is possible to develop lameness (B), whereas if it is a female, it depends on the broiler chicken house. If the bird weighs more than 1.47 kg, it is female, and the broiler house has environmental enrichment with music and light, then it does not present lameness (A).

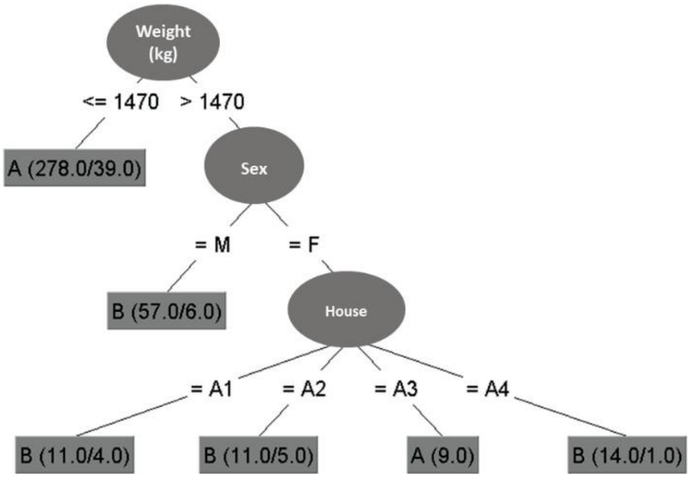

Figure 3: Decision tree generated by the machine learning algorithm J48 for classifying lameness in broiler houses with or without environmental enrichment.

Toward hock burn, we found a decision tree with an accuracy of 77%. The weight is the most critical factor determining what makes the birds present hock burn (Figure 4). The algorithm used four attributes (weight, broiler house, sex, and weight) as essential to developing hock burn. According to the decision-tree algorithm, if a broiler chicken has less than 800 g of body weight, there is no chance of developing hock burn (A). If the broiler chicken had more than 800 g of body weight and was reared in a broiler house with EE of the type music or light, there is a chance to develop hock burn (B).

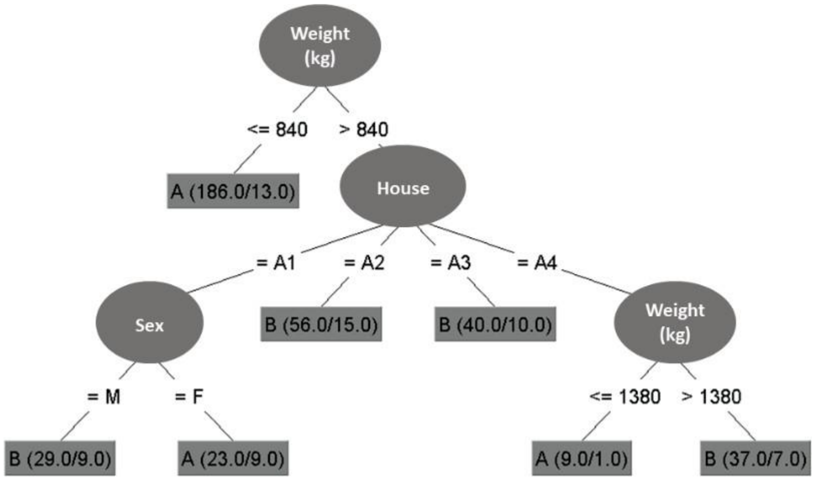

Figure 4: Decision tree generated by the machine learning algorithm J48 for classifying hock burn in a broiler house with or without environmental enrichment.

For footpad dermatitis, the decision tree found had 81% of accuracy. The broiler house type was the most critical factor in determining which birds have footpad dermatitis (Figure 5). The algorithm used four attributes (broiler house, age, gender, and weight) as crucial to developing foot pad dermatitis. Secondly, to the decision-tree algorithm, if a broiler chicken has been raised in a broiler house with or without EE music and light, there is no chance of developing foot pad dermatitis (A). Otherwise, age, weight, and sex need to be checked.

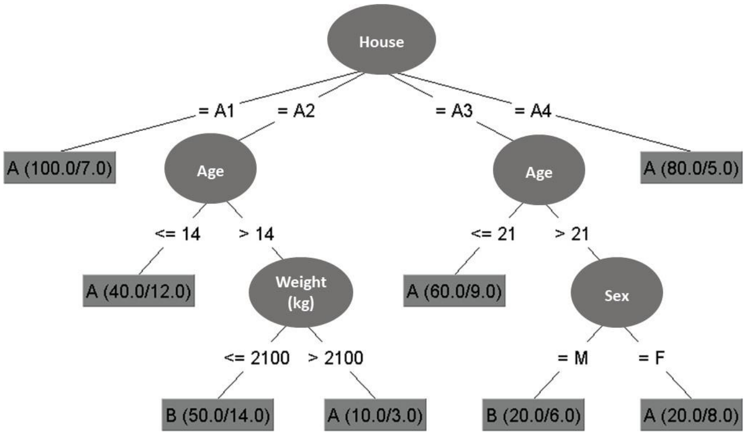

Figure 5: Decision tree generated by the machine learning algorithm J48 for classifying foot pad dermatitis in a broiler house with or without environmental enrichment.

The valgus/varus decision tree presented 76% of accuracy. Age was the most critical factor in determining which birds have valgus/varus (Figure 6). The algorithm used three attributes (age, broiler house, and weight) to develop the valgus/varus decision tree. According to the algorithm, if a broiler chicken has more than 21 days of age, there is a chance to develop valgus/varus (B). Suppose the broiler chicken is less than 21 days old and raised in a broiler house with or without EE music. In that case, there is a chance to develop valgus/varus (B), whereas if the broiler chicken is reared in a broiler house with EE with music or light will depend on the weight of the broiler chicken.

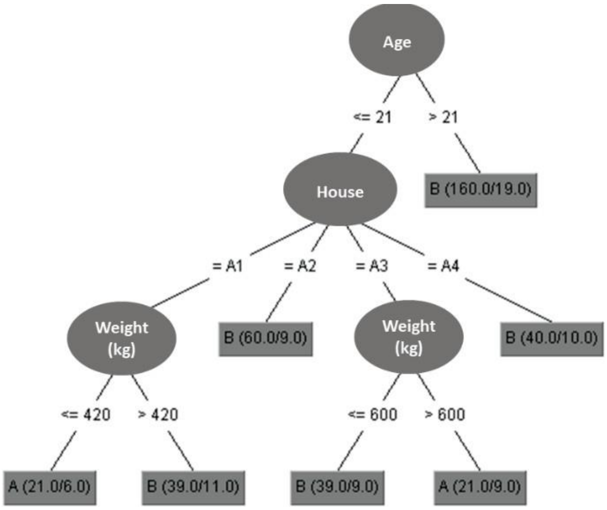

Figure 6: Decision tree generated by the machine learning algorithm J48 for classifying valgus/varus in a broiler house with or without EE.

We found a decision tree with 70% accuracy for predicting crooked toes. The broiler house type was the most critical factor determining the birds' crooked toes (Figure 7). The algorithm used two attributes (broiler house and age) as essential to developing crooked toes. According to the decision-tree algorithm, if a broiler chicken is raised in a broiler house with or without EE, the chance of developing foot pad dermatitis depends on the age. The change of presenting crooked toes (B) is in the house with music, and the broilers are 7-14 days old. Another incidence (B) is when broilers are reared with music and light and are 14-21 days old.

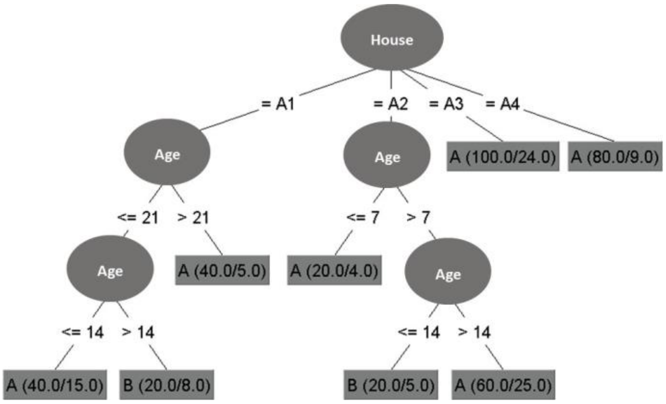

Figure 7: Decision tree generated by the machine learning algorithm J48 for classifying crooked toes in a broiler house with or without environmental enrichment.

Our results indicate that the studied leg issues are related to age, weight, sex, and the type of EE in different ways. However, in all found trees, the broiler weight appeared as an attribute that impacted the result (Figures 2, 3, 4, and 5). Except for the algorithm predicting the valgus/varus incidence (Figure 6), broiler sex also impacted the outcome. The effect of EE on broiler lameness was noticed in females (Figure 3) and had different overcome.

Several variables affect leg weakness disorders. According to Zuowei et al. (2011), leg weakness is associated with diet, sex, and stocking density. Vermette et al. (2016) observed that male turkeys had higher values for gait score than females, categorized as gait score 0. Although the male is heavier than the female, the tibia strength is equal (Reis et al., 2011; Alnahhas et al., 2017), and the muscle fiber degeneration occurs early in broilers after two weeks of growth until 28 d of age, but it was independent of sex and genotype (Radaelli et al., 2017).

We found that sex could influence the presence of foot pad dermatitis (Figure 5). Previous studies show that broiler chicken females are more susceptible to hock burn because male broiler chicken skin contains more collagen (Hepworth et al., 2010; Bassler et al., 2013). As for the incidence of crooked toes, we found that the chance of presenting the disorder increased in the 14-21 days old broilers when exposed to music and light (B). In the house with music, there was a chance of broilers presenting the disorder between 7 and 14 days old. Oviedo-Rondón et al. (2009) state that this issue is related to variables other than those studied in the present experiment, such as diet and incubation.

Conclusions

We propose decision tree algorithms to predict several leg issues in broiler chickens. The variables that most affect leg disorders are sex, weight, and age. The use of environmental enrichment (music and light stimuli) affected the presence of leg issues under different combinations of those variables. However, further analysis must be carried on in the subsequent studies.

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