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Morphological Asymmetry and Broiler Welfare

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ABSTRACT

Health status, feed conversion ratio, and mortality are long known broiler chicken production indicators. However, further parameters are required by today's demanding meat markets, as these indicators are not sufficiently accurate to determine flock overall welfare. Morphological asymmetry has been pointed as an alternative welfare indicator as it reflects the ability of the bird to cope with the challenges that rearing conditions may impose. This study aimed at evaluating the possibility of using morphological asymmetry as a welfare indicator. Broilers from 28 to 42 days of age were used in the trial. Birds were randomly selected in a commercial poultry farm and transported to the laboratory. They walked over the force measurement platform in order to determined their feet force as a percentage of body weight. The following body parts of the live birds were measured by two different operators using a digital caliper: tarsometatarsus length, outertoe length, midtoe length, and backtoe length. In the corresponding carcasses, the following traits were measured: wattle width, eye length, and first secondary feather length. Data were submitted to statistical analyses and no correlation was found between specific feet trait measurements and walking ability. Considering the time budget involved in measuring morphological asymmetry, this procedure did not appear to be a practically feasible welfare indicator.

INTRODUCTION

The latest focus of animal welfare research is to provide evidence on how certain genetic and rearing components may affect animals' expressive response and biological functioning (Dawkins *et al*., 2004; Broom, 2006). Productive response can be measured by feed conversion ratio and mortality as a result of several factors, such as flock or herd health status (Kestin *et al*., 2001). However, animal "affective" reaction cannot often be directly predicted, and indicators of animal "affective" status need to be carefully observed in order to allow more precise welfare estimation (Hall, 2001; Sanotra *et al*., 2002). The correct deduction of animal "affective" status based on such indicators may improve with the number of observed factors (behaviors, reactions, environment, etc.), and must involve multiple elements that should be combined in order to provide an accurate welfare prediction (Tuyttens, 2003). Morphological asymmetry (MA) has been pointed as a potential animal welfare indicator as it reflects the ability of an individual to cope with the challenges that may affect its growth during a certain period of life (Tuyttens, 2003; Broom, 2006; Knierim, 2007). Asymmetry is defined as random direct deviations from perfect growth symmetry that is generally expected in certain body parts when there was a successful control of the morphological development, and it is a result of both genetic factors and environmental conditions.

Leg deformities are an important problem in the poultry industry, and it is suggested that it is related to breeding (Kestin *et al*., 1992; Boekker & Koene, 2003), rearing conditions (Gonzales & Macari, 2000; Dawkins *et al*., 2004), and stocking density (Sorensen *et al*., 2000; Hall, 2001). In commercial production, it has been reported that 26 - 31% of the broilers suffer leg abnormalities which severity compromises their behavioral pattern and welfare (Kestin *et al*., 1992; Sorensen *et al*., 2000; Reiter & Kutriz, 2001; Bokkers & Koene, 2003; Weary *et al*., 2006). A large proportion of leg disorders result in reduced ability to walk, causing unnatural biomechanical forces and gait changes (Kestin *et al*., 1999; Hall, 2001). Reduced walking or standing ability often leads to breast blisters and hock burns as the bird has to spend a long time crouching on poor quality litter. In addition, lameness causing behavioral restriction and pain has become a major welfare concern (Reiter & Kutriz, 2001; Weary *et al*., 2006).

The objective of this study was to evaluate morphological asymmetry associated to locomotor characteristics of broilers after the fourth week of rearing as a predictor of welfare status.

METHODOLOGY

The experiment was conducted at the Center for Technology of the State University of Campinas, Brazil, on February 2 to 4, 2008, and approved by the Animal Experimentation Ethics Committee of the School of Veterinary Medicine and Animal Science, UNESP State University, Botucatu, Brazil, Protocol n. 182/2007.

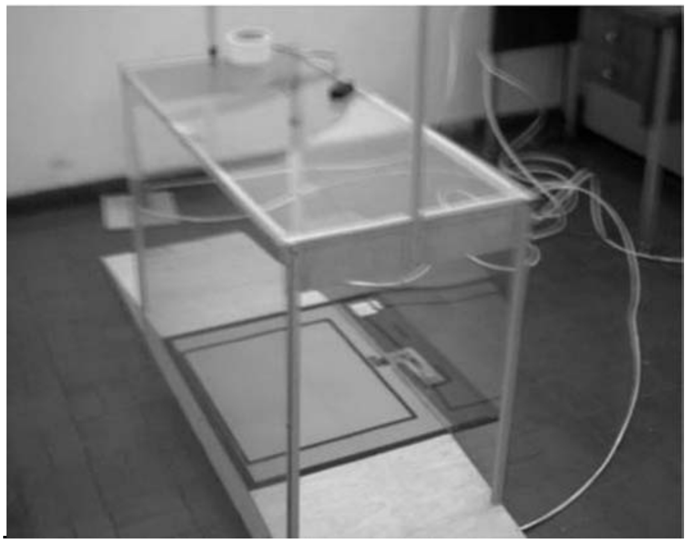
Bird management

Nine Cobb® 500 male broilers of 28, 35, and 42 days of age (three of each) were randomly selected in a commercial poultry farm, where they were reared at an average stocking density of 13 birds per m^2. Birds were transported in boxes for 35km to the laboratory early in the morning to prevent heat stress and unnecessary discomfort before the trial. Immediately after arrival at the experimental facility, birds rested for 30 min and were offered water. Each bird was identified by a number, and had its head marked with a different color to allow individual recognition. The birds were weighed, and then placed in boxes according to age.

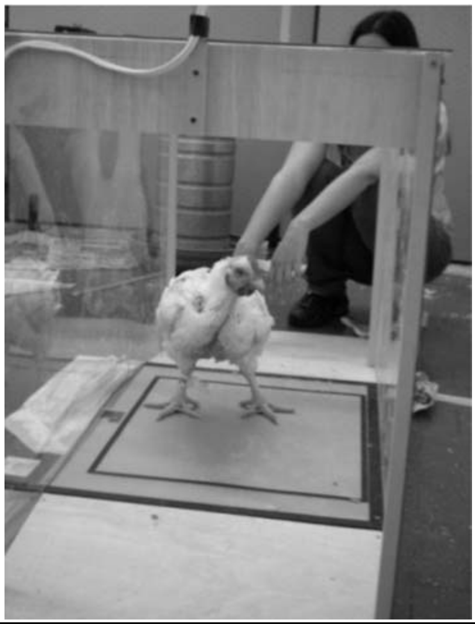
Gait assessment started with the youngest birds, as described below.

Walking effort measurement

In order to determine the force exerted by the bird's feet while walking, a chamber with a walking runway was built. The chamber was 0.48m wide, 0.70m high and 1m long with transparent acrylic walls, a 0.20m inlet ramp, a horizontal plateau of 0.60m in the middle, and a 0.20m outlet ramp. Both inlet and outlet ramps had an angle of five degree from the floor, as shown in Figure 1a. A 0.01m step was carved in the horizontal plateau of the walking area and a thin mat (0.01m) of piezoelectric crystal sensing elements (Tekscan®) was placed inside it to measure broiler's feet (right and left) walking force as the bird walked across the walkway (Figure 1b).



(a)



(b)

Figure 1 - View of the broiler feet force measurement system (a) and a broiler walking on the force platform system with the video cameras capturing the movement from the top and side angles.

The force-measurement platform system (FMPS) consisted of two parts: hardware (force mat including about two thousands sensels organized in columns and rows) that recorded the pressure data and transferred them to the software, which recorded feet force distribution, as well as processed and analyzed the recorded data. The output of each sensel was divided into 256 increments, and read by the software in values called raw sum, ranging from 0 to 255. The software was set up in a desktop computer, and data were saved for further analysis, as used in earlier studies (Carvalho *et al*., 2005; Oviedo-Rondón, 2007). The force mat was calibrated to the average weight of the birds in each box for each different age group.

Morphological measurements

All morphological measurements were carried out using a digital caliper (to the nearest 0.01mm), except for first secondary feather length, which was measured with a ruler (to the nearest 0.5mm). The left and right sides of the following four bilateral traits were measured twice in intact alive birds by two different persons (Van Nuffel *et al*., 2007; Van Poucke *et al*., 2007):

- **Tarsometatarsus length - TL** (distance between the joint of the tarsometatarsus with the tibiotarsus and the proximal skin fold on the midtoe, holding the tibiotarsus perpendicular to the tarsometatarsus and holding the midtoe in line with the latter);
- **Outertoe length - OL** (distance between the outer skin folds on the fourth phalanx when folding the outertoe);
- **Midtoe length - ML** (distance between the outer skin folds on the third phalanx when folding the midtoe), and
- **Backtoe length - BL** (distance between the tarsometatarsus and the nail, holding the backtoe perpendicular to the tarsometatarsus).

The following traits were measured in the corresponding carcasses:

- **Wattle width - WW** (distance between outer junctures);
- **Eye length - EL** (distance between eye corners);
- **First secondary feather length - FL** (total feather length after plucking).

Experimental procedure

The experiment consisted in recording information on bird walking ability on the FMPS. After stimulated to walking on the FMPS and arriving at the opposite side, broilers were gently picked up, and both left and right traits (TL, OL, ML and BL) were measured. Birds were then immediately slaughtered by cervical dislocation and WW, EL, and FL were measured, as suggested by Van Nuffel *et al*. (2008).

Statistical analysis

Logarithm scale was used in order to amplify the measured data. Recorded data were submitted to two-way ANOVA: the force applied as percentage of body weight (BW) was used to verify the variability between groups and within the group for each foot, and the measured morphological traits (left and right) were compared by Students paired t-test at a confidence interval of 95%. Data were analyzed using Minitab (2004).

RESULTS AND DISCUSSION

Table 1 shows the morphological traits measurements and the feet force as percentage of bird body weight. Average body weight was 1,391.67 ± 2.65g for 28-day-old broilers; 2,230.00± 5.05g for 32-day-old broilers, and 2,912.50± 6.37g for 42-day-old birds.

At 28 days of age there was no significant morphological differences between the left and right sides in five measured traits (WW, EL, FL, TL and ML). However, outertoe length (OL) and backtoe length (BL) values presented significant difference, as well as the force exerted on the FMPS by the left (7.31 %BW) or the right foot (6.73 %BW). This means that 28-day-old birds presented an uneven way of walking. No correlation was found between force and the measured traits.

The 35-day-old birds showed significantly different wattle width (WW) and the midtoe length (ML), and also presented different body balance while walking as proportion of body weight (left=4.02 %BW and right=3.42 %BW).

At 42 days of age there were morphological differences in wattle width (WW), first secondary feather length (FL), midtoe length (ML), and backtoe length (BL); however, there was no difference in the force exerted on the FMPS between the left and the right feet. No correlation was found between gait response and traits measurements.

The findings of the present study do not indicate that morphological asymmetry in broiler feet structures may cause poor walking ability, as indicated by Moller & Manning (2003). Distinct results were also reported

Table 1 - Morphological trait measurements and force exerted on force platform measurement system by both feet as percentage of body weight.

Morphological data	Age (days)					
	28		35		42	
	Left	Right	Left	Right	Left	Right
Wattle width (mm)	23.73e	23.30e	28.24c	25.43d	32.25a	31.60b
Eye length (mm)	12.85c	12.66c	13.02b	13.07b	14.50a	14.95a
First secondary feather length (mm)	11.67d	11.53d	12.65c	12.75c	14.75a	13.75b
Tarsometatarsus length (mm)	68.33c	66.28c	78.35b	77.97b	82.24a	82.65a
Outertoe length (mm)	17.67a	13.81c	15.35b	15.59b	15.47b	15.55b
Midtoe length (mm)	21.44d	21.53d	25.34a	24.36b	23.96c	25.78a
Backtoe length (mm)	17.91e	18.92d	20.07c	19.91c	24.13a	21.24b
Feet force (% BW)	7.31a	6.73b	4.02d	3.42e	6.85c	6.87c

Means followed by similar letter indicate no significant difference at a confidence interval of $P < 0.05$.

by Resch-Magras *et al*. (1993), cited by Oviedo-Rondón (2007), who found that some specific leg conditions can create asymmetry in walking forces, which result in asymmetrical bone development of each leg leading to lameness in turkeys. According to Bizeray *et al*. (2000), asymmetrical bone development is naturally compensated by asymmetric gait, which may cause future lameness, and has negative impact on the welfare as it makes it difficult for the bird to reach feeders and drinkers, and ultimately causes pain (Weeks *et al*., 2000; Kestin *et al*., 2001, Manning *et al*., 2007).

Broiler plantar pressure is not evenly distributed across the plantar surface of each foot during walking, but it is concentrated in the areas of the digital pads. In general, the metatarsal pad is subject to lower pressures, with the highest pressures seen on the back and medial toe (Corr *et al*., 1998). Those authors reported that when the broiler is walking, the back toe is submitted to high pressure as the foot initially contacts the ground, and the pressure decreases as the footstep progresses. Low pressures are recorded throughout the metatarsal pad and part of the middle toe; while higher pressures are initially found on the proximal part of the lateral toe. Pressures decreases in the middle of the footstep as the pressure rises on the proximal part of the medial toe. Therefore, the traits that may be correlated to walking ability are toe lengths (OL, ML, and BL).

The results of the present experiment showed that 28-day-old male broilers presented higher OL and BL asymmetry, and that feet plantar force (%BW) were proportional to OL, whereas the asymmetry found in 35-day-old broilers was correlated to ML. In general, no specific pattern correlating asymmetry with the measured traits was found. These results are consistent with those of Van Poucke *et al*. (2007), who found that MA may not be a sensitive indicator of welfare in broiler chickens. It is also known that MA constitutes a small signal (often >1% of the trait size) and that its applicability depends both on measurement accuracy and statistical power. Knierim et al. (2007) observed that larger sample sizes and more repeated measurements may increase correlation in morphological asymmetry studies. However, higher repeatability or the increase in the number of measurements also would increase the time budget during the measuring task, compromising the feasibility of using morphological asymmetry as an efficient indicator of welfare.

CONCLUSIONS

According to the results of the present study, specific morphological asymmetry associated to the force the bird exerts while walking as percentage of its body weight alone is not be a suitable indicator of broiler welfare.

REFERENCES

Bizeray D, Leterrier C, Constantin P, Picard M, Faure JM. Early locomotor behaviour in genetic stocks of chickens with different growth rates. Applied Animal Behaviour Science 2000; 68:231-242.

Bokkers EAM, Koene P. Behaviour of fast and slow growing broilers to 12 weeks of age and the physical consequences. Applied Animal Behaviour Science 2003; 81:59-72.

Broom DM. Behaviour and welfare in relation to pathology. Applied Animal Behaviour Science 2006; 97:73-83.

Carvalho VRR, Bucklin RA, Shearer JK, Shearer L. Effects of trimming on dairy cattle hoof weight bearing and pressure distributions during the stance phase. Transactions of the ASAE 2005; 48(4): 1653-1659.

Corr SA, McCorquodale CC, Gentle MJ. Gait analysis of poultry. Research in Veterinary Science 1998; 65:233-238.

Dawkins MS, Donnelly CA, Jones TA. Chicken welfare is influenced more by housing conditions than by stocking density. Nature 2004; 427:342-344.

Gonzales E, Macari M. Enfermidades metabólicas em frangos de corte. In: Berchieri Júnior A, Macari M. Doenças das aves. Campinas: FACTA; 2000. p. 449-464.

Hall AL. The effect of stocking density on the welfare and behaviour of broiler chickens reared commercially. Animal Welfare 2001; 10: 23-40.

Kestin SC, Knowles TG, Tinch AE, Gregory NG. Prevalence of leg weakness in broiler chickens and its relationship with genotype. The Veterinary Record 1992; 131:190-194.

Kestin SC, Su G, Sorensen P. Different commercial broiler crosses have different susceptibilities to leg weakness. Poultry Science 1999; 78(8):1085-1090.

Kestin SC, Gordon S, Su G, Sorensen P. Relationships in broiler chickens between lameness, liveweight, growth rate and age. Veterinary Record 2001; 148(7):195-197.

Knierim U, Van Dongen S, Forkman B, Tuyttens FAM, Spinka M, Campo JL, Weissengruber GE. Fluctuating asymmetry as an animal welfare indicator - A review of methodology and validity. Physiology & Behavior 2007; 92:398-421.

Manning L, Chadd SA, Baines RN. Key health and welfare indicators for broiler production. World's Poultry Science Journal 2007; 63: 46-62.

Minitab® Statistical Software for Windows, 2004 [cited 2008 fev 10]. Available from: http://www.minitab.com/products/minitab/.

Moller PA. Manning J. Growth and developmental instability. The Veterinary Journal 2003; 166:19-27.

Oviedo-Rondón EO. Predisposing factors that affect walking ability in turkeys and broilers [cited 2008 may 12]. Available from: http://www.ces.ncsu.edu/depts/poulsci/conference_proceedings/nutrition_conference/2007/oviedo_2007.pdf.

Reiter K, Kutriz B. Behavior and leg weakness in different broiler breeds. Archiv fur Geflügelkunde 2001; 65:137-141.

Sanotra GS, Anotra J, Damkjer Lund J, Vestergaard KS. Influence of light-dark schedules and stocking density on behaviour, risk of leg problems and occurrence of chronic fear in broilers. British Poultry Science 2002; 43:344-354.

Sorensen P, Su G, Kestin SG. Effects of age and stocking density on leg weakness in broiler chickens. Poultry Science 2000; 79(6):864-870.

Tuyttens FAM. Measures of developmental instability as integrated, a-posteriori indicators of farm animal welfare: a review. Animal Welfare 2003; 12:535-40.

Van Nuffel A, Tuyttens FAM, Van Dongen S, Talloen W, E. Van Poucke E, Sonck B, Lens L. Fluctuating asymmetry in broiler chickens: A decision protocol for trait selection in seven measuring methods. Poultry Science 2007; 86:2555-2568.

Van Nuffel A, Van Poucke E, Van Dongen S, Lens L, Tuyttens FAM. Measuring fluctuating asymmetry in broilers [cited 2008 jun]. Available from: http://www.ilvo.vlaanderen.be/documents/fluctasbroilers.pdf.

Van Poucke E, Van Nuffel A, Van Dongen S, Sonck B, Lens L, Tuyttens FAM. Experimental stress does not increase fluctuating asymmetry of broiler chickens at slaughter age. Poultry Science 2007; 86:2110-2116.

Weary DM, Niel L, Flower CF, Fraser D. Identifying and preventing pain in animals. Applied Animal Behaviour Science 2006; 100:64-76.

Weeks CA, Danbury TD, Davies HC, Hunt P, Kestin SC. The behaviour of broiler chickens and its modification by lameness. Applied Animal Behaviour Science 2000; 67:111-125.