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Footpad Dermatitis in Broilers: Differences between Strains and Gender

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ABSTRACT

Pododermatitis, also known as "bumblefoot", is an inflammatory lesion of the footpad. The objective of this study was to evaluate the influence of genetic strain and sex on the incidence of footpad lesions in broilers. The experiment was carried out at São Paulo State University, using 480 broilers distributed in a completely randomized experimental design in a 2X2 factorial arrangement (2 strains X2 sexes), with four replicates of 30 broilers each, totaling 16 experimental units. Feed intake, weight gain, feed conversion ratio, and livability were evaluated at 21, 35 and 42 days of age; production efficiency factor was determined at the end of the rearing period. On day 42, the footpads of 100 broilers were grossly examined and assigned a lesion score in a 1-3 scale (Almeida Paz & Martins, 2014). Three samples per score within treatment were collected for microscopic evaluation. Analysis of variance was applied and performance parameter means were compared by Tukey's test. Footpad lesion incidence was analyzed by the $\chi 2$ test using SAS (version8.2). Ross® broilers presented higher feed intake during all evaluated periods, and higher weight gain only in the period 1 to 21 days compared with Cobb® broilers. On the other hand, Cobb® presented better feed conversion ratio in the periods of 1 to 35 and 1 to 42 days. The incidence of foot pad lesions was statistically different ($p<0.05$) between strains and sexes, but there were no interactions between these factors. The lesion scores assigned were compatible with the histopathological results, showing that the higher the score, the more severe were the dermal and epidermal lesions.

INTRODUCTION

Footpad dermatitis is known by multiple names, such as pododermatitis and contact dermatitis, all of which refer to a condition characterized by superficial to deep inflammatory and necrotic lesions of the plantar surface of the footpads and toes (Shepherd & Fairchild, 2010).

Studies have shown that litter quality and substrate, genetics, nutrition, and broiler body weight and sex affect the incidence of pododermatitis (Hess *et al.*, 2011). Others studies reported that footpad dermatitis in broilers may increase partial carcass condemnation rates in processing plants, and is an indication of bird welfare (Dullius *et al.*, 2011).

Broiler sex, strain and size have been investigated as possible factors that affect the onset of footpad dermatitis. Male broilers tend to have higher incidence and more severe footpad dermatitis than females (Harms & Simpson, 1975; Shepherd & Fairchild, 2010). The continued selection for increased body weight, not including resistance

to footpad dermatitis in the breeding goals is likely to result in increased cases of footpad dermatitis in broilers in the future. Genetic variation between and within 10 commercial broiler lines was determined for both footpad dermatitis and hock burns (Ask, 2010). Jacob *et al.* (2015) recently evaluated the influence of sex and genetic strain on the incidence of footpad dermatitis.

Because microbial contamination is commonly associated with that injury, the Brazilian Ministry of Agriculture does not allow domestic trade and exports of broiler feet with severe injuries for human consumption. This causes economic losses for the poultry industry, because of the significant exports of this product to the Asian market, especially Hong Kong and China (Bean *et al.*, 2007).

The aim of this study was to determine the histological characteristics of footpad lesions of male and female broilers of two genetic strains.

MATERIAL AND METHODS

The experiment was carried out in the experimental poultry house of School of Veterinary Medicine and Animal Science, São Paulo State University, Botucatu (FMVZ – UNESP), state of São Paulo, Brazil. In total, 480 broilers were distributed in a completely randomized experimental design in a 2X2 factorial arrangement, with two fast-growing broiler strains (Ross®308 and Cobb®500) and two sexes, with four replicates of 30 birds each (16 experimental units). Broilers were housed in 2.5 m^2pens at a density of 12 birds/m^2. New wood shavings were used as litter substrate. The litter was 10-cm deep and was turned weekly. The experiment was conducted during the summer, and maximum and minimum temperature and humidity were daily recorded using a minimum-maximum thermohygrometer. Average maximum and minimum temperatures of 30.9° C and 21.3° C and relative humidity of 65.60% and 43.86%, respectively, were recorded during the experimental period.

One-day-old broiler chicks from the two different strains were obtained from the same commercial hatchery. Broilers were reared according to the conventional management practices applied on commercial broiler farms. The experimental poultry house was equipped with bell drinkers and tube feeders. Ventilation fans were uniformly distributed in the broiler house. Brooding was provided by one 250W infrared lamp per pen until the end of week 2.

A three-phase feeding program was applied and included a starter feed (1-22 days), grower feed (22-35 days), and finisher feed (36-42 days). The diets were formulated to supply the nutritional requirement of broiler according to rearing phase as recommended by Rostagno *et al.* (2011). Salinomycin was added as coccidiostat in all diets. Feed and water were supplied *ad libitum* during the entire rearing period.

Feed intake (FI), weight gain (WG), feed conversion ratio (FCR) and livability (L) were determined for the periods of 1 to 21 days, 22 to 35 days and 36 to 42 days. Birds, feed offer and feed residues were weighed the beginning and end of each period. Mortality was daily recorded, and used for daily feed intake correction. Weight gain was calculated as the difference between body weight at the end and beginning of each period. Feed intake was calculated as the weight difference between feed supply and feed residues in the feeder at the end of each period. The feed conversion ratio was determined as the ratio between the average feed intake and average weight gain per period, corrected by the weight of dead broilers during each period. Livability per period was calculated as a percentage of live birds in each period. Production efficiency index (PEI) were also calculated as: daily weight gain (g) x livability (%) / feed conversion ratio X 100.

On day 42, 100 broilers (25 Ross® males, 25 Cobb® males, 25 Ross® females and 25 Cobb® females) were submitted to gross examination for the incidence of footpad lesions in both feed. Lesions were scored according to the following scale: 1= no lesion, 2= initial lesion, 3= clear swelling and evident necrotic areas, with foot pad enlargement (Almeida Paz & Martins, 2014).

For the microscopic evaluation scores, three samples of the food pad per gross score per treatment were collected and submitted to routine histological processing.

The obtained data were subjected to analysis of variance (ANOVA) using the General Linear Models (GLM) of SAS statistical software (SAS, version 8.2). When significant, means were compared by Tukey's test at 5% probability level. The frequency of foot pad lesion scores were submitted to ANOVA and compared by the $\chi 2$ test ($p<0.05$),using SAS (version 8.2) (SAS, 2004).

RESULTS AND DISCUSSION

Table 1 shows the obtained performance results.

Table 1 – Feed intake (FI), weight gain (WG), feed conversion ratio (FCR), livability (L), and production efficiency index (PEI) of the evaluated genetics strains in the periods of 1-21, 1-35, and 1-42 days.

	FI(g)	WG(g)	FCR(g/g)	L (%)	PEI
			1-21 days		
Ross®	1242.81[a]	861.65[a]	1.44	98.33	-
Cobb®	1141.22[b]	801.23[b]	1.43	97.92	-
Average	1192.01	831.44	1.44	98.12	-
CV, %	5.73	6.01	2.03	2.95	-
			1-35 days		
Ross®	3275.5[a]	1970.00	1.67[a]	98.33	-
Cobb®	3021.1[b]	1872.80	1.62[b]	97.92	-
Average	3148.29	1921.40	1.64	98.12	-
CV, %	6.43	7.09	1.14	2.95	-
			1-42 days		
Ross®	4303.8 [a]	2412.95	1.79 [b]	98.33	316.02
Cobb®	3981.6 [b]	2324.14	1.72 [a]	97.92	314.80
Average	4142.69	2368.54	1.75	98.13	315.41
CV, %	7.12	7.87	0.94	2.98	7.36

Means followed by different letters in the same column differ by Tukey's test ($p<0.05$). CV (%): coefficient of variation.

During the starter phase (1 to 21 days), weight gain and feed intake were statistically different ($p<0.05$) between strains, with the highest values obtained in Ross® broilers. These results are different from those of Kim & Corzo (2012), who reported differences between strains (strain A was a Ross® × Ross® 308 hybrid, and strain B was a broiler strain that was still undergoing performance evaluations and not commercially available) only for weight gain at 21 days of age when the broilers were fed semi-purified diets containing an animal by-product blend as the sole source of protein.

Although feed conversion ratio was not influenced by genetic strain in the present experiment, Moreira *et al.* 2004 reported strain (Ross® 308, Cobb® 500 e Hybro® PG) differences ($p<0.05$) broilers were reared at a density of 16 birds/m^2. In addition, in females, the FCR of Ross® 308 broilers was similar to that of Hybro® PG birds, and higher than Cobb® 500 birds; however, it was not different between Cobb® 500 and Hybro® PG. FCR differences between sexes were only observed in Cobb® 500, with females presenting better feed conversion that males. Ebling *et al.* (2013) did not observe any effect of genetic strain (Cobb® 500 and Ross® 308) on weight gain, feed intake and feed conversion ratio. Iqbal *et al.* (2012), studying the performance of broilers of different strains (Hubbard®, Arbor Acres®, Ross® 308, and Hybro® PN), found that Hubbard®, Arbor Acres®, and Ross® 308 presented no weight gain differences, but were significantly heavier than Hybro® PN broilers, but not FCR differences among strains. Vieira *et al.* (2007), comparing the performance of Cobb® and Ross® broilers fed diets with three different ideal protein profiles, found that Cobb® birds were heavier at 21 days of age and presented better feed conversion ratio until the end of the experiment (37 days), whereas Ross® presented higher feed intake during the entire experimental period.

During the period of 1-35 days of the present study, Cobb® broilers presented significantly lower feed intake and better feed conversion ratio than Ross® broilers. Moreira *et al.* (2003), comparing the performance, carcass yield, and breast meat quality of broilers of a high-yield strain with those of a conventional strain, reported that on day 35, birds of both strains with the highest weight gains presented higher feed intake. Differently from the present this study, Moreira *et al.* (2004) evaluated the effect of stocking density on the performance of the Ross® 308 and Cobb® 500 strains, and reported differences only for weight gain during the grower phase. For the total rearing period (1 to 42 days), although the production efficiency index was similar between strains, lower feed intake and better feed conversion ratio were obtained in Cobb® broilers compared with Ross® birds ($p<0.05$). On the other hand, Ebling *et al.* (2013) observed that Ross® broilers were heavier on the first day and during the entire rearing period, but presented higher feed intake and worse feed conversion ratio when compared with Cobb® broilers. Mustafa *et al.* (2014), studying the effect of the addition of acetic acid at 1% and 2% to the drinking water, reported significant increases in body weight and body weight gain, and better feed conversion ratio on day 42 days in the both Ross® and Cobb® broilers when compared with control.

Pododermatitis results are shown in Tables 2, 3 and 4. No significant interaction between strain and sex was found for footpad lesions. A higher number ($p<0.05$) of Cobb® broilers presented lesion score 1 (no lesions) both in the right and left feet compared with Ross® broilers. On the other hand, more ($p<0.05$) Ross® broilers presented score 3 (severe lesions). This may be explained by the higher feed intake, and therefore, higher excreta volume of Ross® broilers, which possibly resulted in increased litter moisture.

A higher number of Cobb® females presented no lesions (score 1) in the right foot compared with Ross® females, whereas no differences were observed for the most severe lesions (score 2 and 3). However, in the left foot, statistical differences were detected only for lesion score 3, with Ross® females presenting more severe footpad dermatitis than Cobb® females.

In males, no statistical lesion score differences were found between the evaluated strains or between the right and left feet. Although there is no consensus in literature relative to the influence of sex on pododermatitis, Jacob *et al.* (2015), observed a higher incidence in Cobb® broilers compared with Ross® broilers and in females relative to males.

Table 2 – Incidence of footpad lesions scores of Ross® and Cobb® broilers at 42 days of age.

Treatment	Right foot			Left foot		
	Scores					
	1	2	3	1	2	3
Ross®	0 [a]	22	28 [b]	0 [a]	24	26 [b]
Cobb®	6 [b]	29	15 [a]	4 [b]	34	12 [a]
p*	0.014	0.327	0.047	0.045	0.189	0.014

*Chi-square test - χ^2(p<0.05).

Table 3 – Incidence of footpad lesions scores of female Ross® and Cobb® broilers at 42 days of age.

Treatment	Right foot			Left foot		
	Scores					
	1	2	3	1	2	3
FemaleRoss®	0 [a]	12	13	0	13	12 [b]
Female Cobb®	4 [b]	16	5	3	19	3 [a]
p*	0.046	0.450	0.060	0.083	0.289	0.020

*Chi-square test - χ^2(p<0.05).

Table 4 – Incidence of footpad lesions scores of male Ross® and Cobb® broilers at 42 days of age.

Treatment	Right paw			Left paw		
	Scores					
	1	2	3	1	2	3
Male Ross®	0	10	15	0	11	14
Male Cobb®	2	13	10	1	15	9
p*	0.183			0.260		

*Chi-square test - χ^2(p<0.05).

Santos *et al.* (2002), in a study of pododermatitis in broilers, mentioned there is an initial inflammatory process associated with secondary proliferative response, which progresses to ulceration in the friction areas, with overlapping secondary bacterial infection.

According to Junqueira & Carneiro, (2013), the skin covers the surface of the body and consists of an ectodermal epithelial portion (epidermis) and a mesodermal connective portion (dermis). The epidermis is composed of five layers or strata: stratum basale, stratum spinosum, stratum granulosum, stratum lucidum, and stratum corneum, all of which were present and intact in the feet of the broilers with pododermatitis score 1 (Figure 1). The dermis has a papillary and a reticular layer, with the presence of blood vessels and dermal papillae (Figure 2). Rossi *et al.* (2007) observed that broiler skin quality and firmness improved with the addition of organic zinc to the diet, without affecting the performance of the birds.

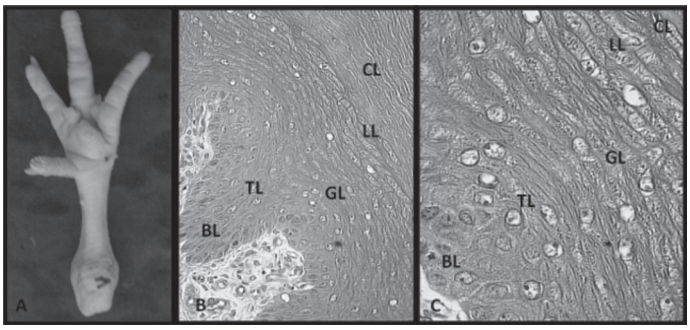

Figure 1 – Macroscopic and microscopic classification of callus paw lesion Score 1 of broilers at 42 days of age. A) Photograph of foot callus with Score 1. B) and C) Photomicrograph os score1; Basal Layer (BL); Thorny Layer (TL); Grainy Layer (GL); Lucid Layer (LL) and Cornea Layer (CL). HE, 20 and 40X.

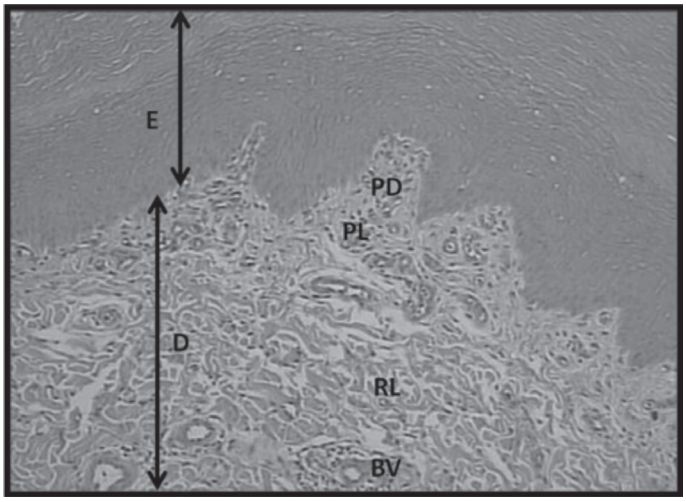

Figure 2 – Photomicrograph of Score 1 broiler callus paw lesion at 42 days of age. Epidermis (E), dermis (D), Dermal papilla (DP), Papillary layer (PL), Reticular Layer (RL) and Blood Vessel (BV). HE, 20X.

In feet with lesion score 2, all epidermal layers were affected. There was hyperplasia of the stratum spinosum, which cells invaded the basal layer and presented centralized and small oval nuclei (Figure 3). The dermal papillae were disrupted, the papillary layer was greatly reduced and there was confluence of both papillary and reticular layers, with the presence of lymph nodes, which are related with the inflammatory response (Figure 4 and 5). Teixeira (2008) scored pododermatitis lesions in broilers' feet according an A to C scale, and also described the presence perivascular lymph nodes of various sizes and numbers in feet scored A, with a moderate inflammatory response in most cases. Santos *et al.* (2002) studied footpad changes according to broiler age group, and reported discrete macroscopic changes characterized by

hydropic degeneration of the basal layer and stratum spinosum in 13-d-old broilers, whereas in 20-d-old birds, there were macroscopic cracks on the surface of the stratum corneum and epidermal hyperplasia associated with hydropic degeneration of the basal and stratum spinosum.

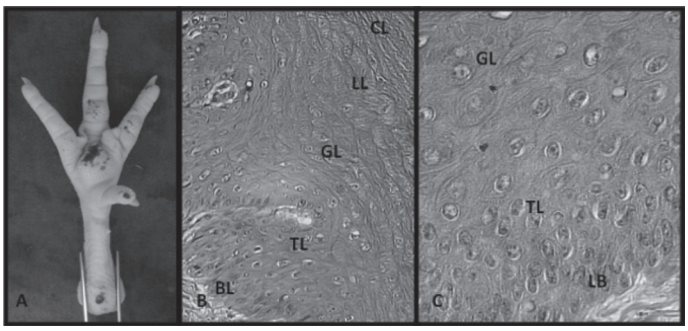

Figure 3 – Macroscopic and microscopic classification of Score 2 broiler callus paw lesion at 42 days of age. A) Photograph of foot callus with Score 2. B) Photomicrograph of Score 2; Basal Layer (BL); Thorny Layer (TL); Grainy Layer (GL); Lucid Layer (LL) and Cornea Layer (CL). C) Basal Layer (BL); Thorny Layer (TL) and Grainy Layer (GL). HE, 20 and 40X.

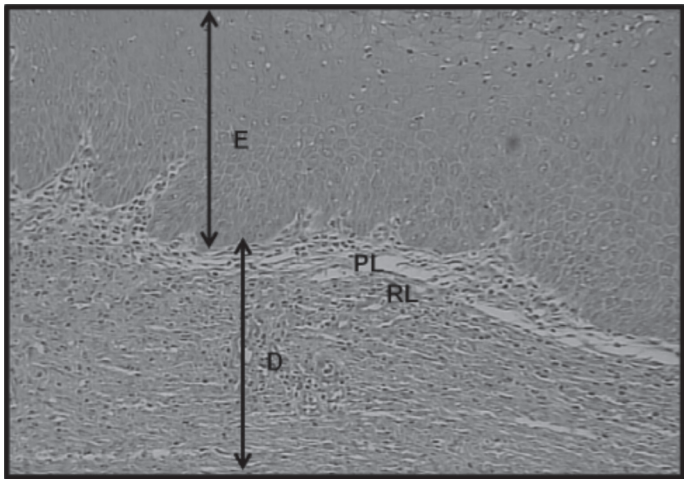

Figure 4 – Photomicrograph of Score 2 broiler callus paw lesion at 42 days of age. Epidermis (E), Dermis (D); Confluence of Papillary Layer (PL) with Reticular Layer (RL). HE, 20X.

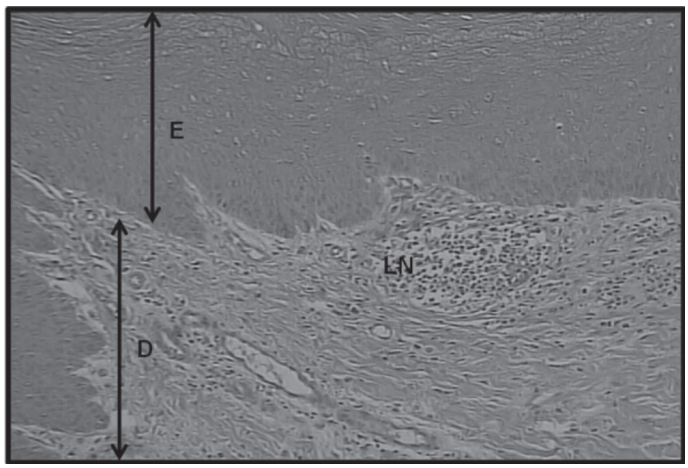

Figure 5 – Photomicrograph of Score 2 broiler callus paw lesion at 42 days of age. Epidermis (E), Dermis (D), Lymph Node (LN). HE, 20X.

In footpads with lesion score 3, overall epidermal strata structure and cell morphology were abnormal, and in some regions, it was no longer possible to identify the epidermal layers. In addition, typical dermal cells were present in the epidermis (Figure 6). Perivascular lymph nodes of different sizes and numbers, including coalescent lymph nodes were observed in the dermis (Figure 7). In the study of Santos *et al.* (2002), the severest footpad lesions were observed when broilers were 45 days of age, and with similar gross appearance as in 20-d-old birds. Histologically, large areas of ulceration, superficial diffuse heterophil infiltration and the deposition of large amounts of exudate containing bacterial lumps and remnants of plant material on the surface of the ulcers were described. Similarly, in the most severe footpad lesion score cases, Teixeira (2008) describes areas of necrosis and infrequent lymph nodes, and in some cases, intense inflammatory reaction in the necrosis area. A recent study with the addition of organic zinc to broiler diets (Oliveira *et al.*, 2010) observed skin keratinization improvement and reduction of pododermatitis lesions.

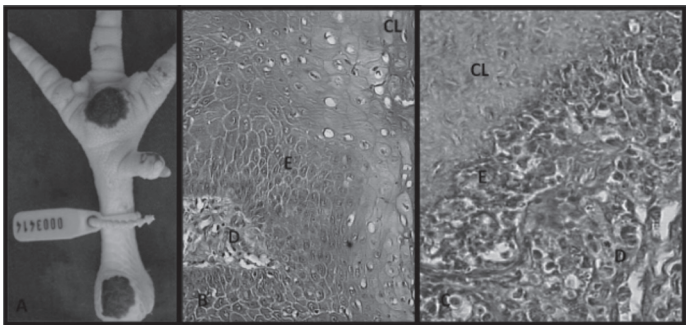

Figure 6 – Macroscopic and microscopic classification of Score 3 of broiler callus paw lesion at 42 days of age. A) Photograph of foot callus with Score 3. B) and C) Photomicrograph of Score 3, Dermis (D), Epidermis (E); Cornea Layer (CL). HE, 20 and 40X.

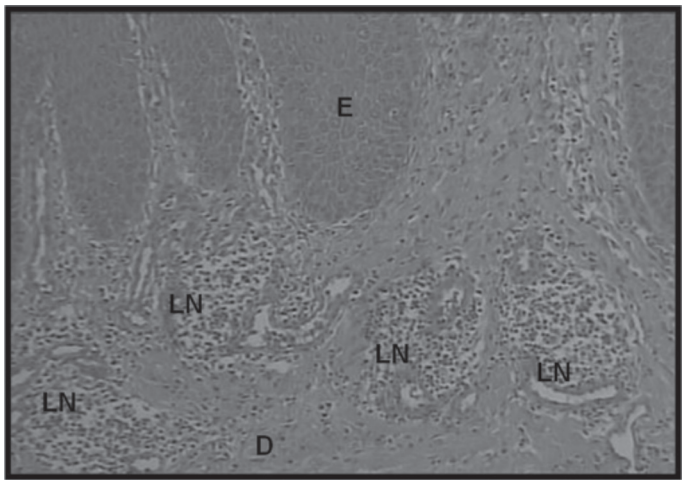

Figure 7 – Photomicrograph of lesion Score 3 of broiler callus paw at 42 days of age. Epidermis (E), Dermis (D), Lymph Node (LN). HE, 20X.

CONCLUSIONS

Under the conditions of the present experiment, the feed intake was different between the evaluated strains during all rearing phases. Weight gain differences between strains were observed only between 1 to 21 days of age. At 42 days of age, the incidence of footpad lesions was different between strains and higher in females with scores 1 and 3. The severity of the changes in the dermal and epidermal layers of the footpad increased with lesion score.

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