Revista Brasileira de Ciência Avícola
ISSN: 1516-635X
revista@facta.org.br
Fundação APINCO de Ciência e Tecnologia Avícolas
Brasil

Jacob, FG; Baracho, MS; Nääs, IA; Salgado, DA; Souza, R
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Revista Brasileira de Ciência Avícola, vol. 18, núm. 2, abril-junio, 2016, pp. 247-253
Fundação APINCO de Ciência e Tecnologia Avícolas
Campinas, Brasil

Brazilian Journal of Poultry Science
Revista Brasileira de Ciência Avícola

ISSN 1516-635X May - Jun 2016 / v.18 / n.2 / 247-254

http://dx.doi.org/10.1590/1806-9061-2015-0047

Incidence of Pododermatitis in Broiler Reared under Two Types of Environment

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Keywords

Footpad dermatitis; surface litter temperature; poultry litter.

Submitted: May/2015
Approved: July/2015

ABSTRACT

Housing environment is essential to achieve good broiler performance and to prevent diseases, including footpad dermatitis (FPD). The objective of this study was to determine the incidence of footpad dermatitis in broilers chickens according to housing type. The study was carried out with broilers reared for 5, 12, 19, 29 and 40 days. Four houses were used in this observational study. House 1 (A1) had positive pressure and reused litter; house 2 (A2) had positive pressure and new litter (sawdust); house 3 (A3) had positive pressure and new litter (rice husks); and house 4 (A4) had negative pressure and reused litter. During the entire experiment, air environmental and litter surface temperatures, and litter compaction were recorded. Pododermatitis was assessed by visual scoring of the footpads. Footpads were scored as function of the severity of the lesion. The comparison of means by the test of Bonferroni at 95% confidence interval showed higher incidence of footpad dermatitis in A3, probably due to the particle size of litter substrate. The lowest footpad dermatitis incidence was found in A1, with reused sawdust litter.

INTRODUCTION

The first cases of footpad dermatitis in broilers were recorded in the 1980s (Greene *et al*., 1985). The disease is called footpad dermatitis and/or contact dermatitis and refers to inflammation of the birds' feet resulting in necrotic lesions of the plantar surface. The lesions may be severe and cause pain, hindering birds to move freely around the house, negatively affecting their welfare (Schmidt & Luders, 1976; Greene *et al*., 1985; Ekstrand *et al*., 1998; Martrenchar *et al*., 2002; Dawkins *et al*., 2004; Bilgili *et al.*, 2009; Hoffmann *et al.*, 2013; Harn *et al*., 2014). In Brazil, footpad dermatitis is used as a welfare indicator in processing plants, and it is regulated by law (BRAZIL, 2010). In the USA and in the European Union, pododermatitis is also used as a criterion for animal welfare assessment (NCC, 2010).

Litter substrate (Ekstrand *et al*., 1997) and feed composition (Mc Ilroy *et al*., 1987) are some of the factors that influence the severity of footpad dermatitis. Flock density may negatively affect litter quality, as it increases the amount of excreta in the litter and litter humidity (Vieira, 2011). Other factors affecting the incidence of pododermatitis in a flock are rearing environment conditions (Payne, 1967), enteric infections (Neill *et al*., 1984), and drinking water hygiene (Elson, 1989). Broiler house ventilation is commonly used to maintain low litter moisture, reducing the incidence of FPD (Tucker & Walker, 1992; Haslam *et al*., 2007; Bilgili *et al*., 2010).

The use of infrared thermal images allows the identification of radiant temperature values in a known surface, and it is a valuable tool to understand physiological aspects of animals. This technique allows measuring surface temperature without disturbing the animals, especially of animal body areas that have low heat capacity (Denoix, 1994; Weschenfelder *et al*., 2013; Nääs *et al*., 2014).

The Principal Component Analysis (PCA) allows graphically identifying data patterns, and to express them in a manner that highlights their similarities and differences. Small vectors may be neglected. Vectors with the same magnitude and direction are strongly positively associated, while vectors with opposite directions and length are not related. Vectors that present an angle of 90º are not correlated.

This study aimed at determining the incidence of footpad dermatitis in broilers reared in houses with different ventilation systems and on reused or new litter.

MATERIALS AND METHODS

The study was carried out in four houses of a commercial broiler farm, in Artur Nogueira county, São Paulo, Brazil (latitude 22 34’23” South, longitude 47 ° 10’21” West, and an altitude of 650 m). The climate is characterized by highland tropical climate, with rainfall in summer and dry in winter, with average temperature during the hottest month above 22 °C.

Experimental procedures

The characteristics of the broiler houses (dimensions, roof material, curtain material and color) and of the birds (housing density, strain) are presented in Table 1.

Broilers were offered a starter feed (1-21 days), a grower feed (22-37 days), and a finisher feed (38-44 days) and water *ad libitum* in automatic feeders and nipple drinkers.

The broiler houses (Table 1) were divided into three quadrants. The first quadrant was in the air inlet area, the second was in the center of the house, and the third was in the air outlet area. Thermal environment data were registered in the geometric center of each quadrant every two hours during 40 days of the grow-out period, using a data logger (Hobo, MicroDaq Ltd., New Hampshire, USA). The recorded variables were dry bulb temperature (DBT, ºC), air relative humidity (RH, %), and air velocity (AV, m s^{-1}). Litter surface temperature (LST, ºC) was recorded in two randomly-selected locations in each quadrant at 1 m from litter, using high resolution (320 x 240 pixels) images made by an infrared thermal camera (Testo 882, Testo Instruments, Lenzkirch, Germany). Litter compaction degree (LC, kg cm^{-2}) was registered at the same points the litter surface temperature was recorded, using a portable penetrometer (FT 327, Wagner Instruments, Greenwich, UK). Litter moisture was determined according to the Litter Humidity Determination Degree Method (BRASIL, 1992), with samples collected from two randomly selected locations in each quadrant. Pododermatitis lesions were scored according to a 0-3 scale as: score 0, no lesion; score 1, lesion covered less than 50% of the footpad; score 2, lesion covered 50-100% of the footpad; and score 3, lesion covered 100% of the footpad (Hashimoto *et al*., 2011). During pododermatitis scoring, footpad surface temperature (FPST, ºC) of each individual bird was registered to assess inflammation. The infrared camera was positioned at 1 m distance from the target, and the adopted emissivity of skin adopted was 0.95, and 0.91 for the litter (Cangar *et al*., 2008; Nääs *et al*., 2010).Footpad surface temperature were recorded in five selected points around footpad using the TESTO software.

Statistical analysis

Variables related to footpad injury, such as footpad surface temperature (FPST, ºC) and footpad dermatitis scores (FPD) were compared among houses (A1, A2, A3 and A4). After that, the association among FPST,

Table 1 – Description of the broiler houses used in the experiment

House	Height (m)	Lenght (m)	Width (m)	Tile type	Curtain Type/color	Litter	Flock density (bird m^{-2})	Genetic strain	Ventilation type	Total of birds
A1	3	111	11	Fiber-cement	Polypropylene/yellow	Re-used/ sawdust	12	Ross+ Cobb	Positive pressure	15.000
A2	3	105	10	Ceramic	Polypropylene/yellow	New/saw dust	12	Ross	Positive pressure	15.000
A3	3	111	11	Fiber-cement	Polypropylene/yellow	New/rice husks	12	Cobb	Positive pressure	16.000
A4	3	150	15	Fiber-cement	Polypropylene/blue	Re-used Rice husks	13	Ross	Negative pressure	25.000

FPD, and internal house environment parameters were submitted to the Principal Component Analysis (PCA). PCA was applied to the recorded data for each variable in each house (A1, A2, A3, A4) to correlate or to associate them by graphically observing the obtained vectors.

In all analyses, the significance level of 5% was adopted. Analyses were performed using Minitab software v.1.5 (Minitab, Inc., State College, PA, USA).

RESULTS AND DISCUSSION

Air temperature was the highest in A2 (29.16 °C) and the lowest in A3 (26.6 °C), as seen in Table 2. The recorded air relative humidity values were within the 50-70% range recommended by Medeiros (2001) and Tinôco (2001). The lowest air relative humidity was recorded in the positive-pressure ventilation house with new rice husks litter (A3). Medeiros *et al.* (2005) suggested optimal environmental temperature of 26 °C, relative humidity of 55%, and air velocity of 1.5 m s^{-1} for broilers between 22-42 d of age. Air temperature values were higher in A1, A2, and A4 than in A3. According to Silva *et al*. (2009) and Moura *et al.* (2010), when the thermal environment is beyond the threshold value of 22°C broiler performance is compromised.

Table 2 – Mean and standard deviation of the internal environmental parameters recorded in the studied houses.

House	DBT (°C)	SD	RH (%)	SD	AV (m s^{-1})	SD
A1	29.02	1.35	70.20	10.34	0.86	0.43
A2	29.16	1.21	64.20	9.87	0.69	0.33
A3	26.60	1.53	58.01	7.22	0.41	0.60
A4	27.03	2.73	67.58	13.79	0.90	0.63

DBT= air dry bulb temperature; RH=air relative humidity; AV=air velocity; SD= standard deviation. n=245 (A1 and A2); n= 425(A3 and A4).

The recorded variables were dry bulb temperature (DBT, °C), air relative humidity (RH, %), and air velocity (AV, m s^{-1}), litter surface temperature (LST, °C), litter humidity (LH) and the degree of compaction (LC, kg cm^{-2}).

Mean litter surface temperature and litter humidity values found in A3 (25.83 °C and 22.91%) were lower than those recorded in the other studied houses (Table 3). Pododermatitis incidence was higher in A3 than in the other broiler houses (Figure 1), which may be attributed to the new rice husks, which sharp edges may injury the birds' feet, resulting in subsequent footpad lesions. Rice husks are widely used as litter substrate in Brazil because they are cheap and widely available in all regions (Lopes *et al*., 2013). Broilers housed both in A2 and A4 presented similar pododermatitis results, while those in A1 showed a low incidence of the lesion.

Table 3 – Mean and standard deviation of litter temperature, humidity, and compaction in the evaluated houses.

House	LST (°C)	SD	LH (%)	SD	LC (kg m^{-2})	SD
A1	29.53	1.37	21.66	3.22	21.30	4.75
A2	29.18	1.27	24.07	3.43	17.10	4.24
A3	25.83	1.34	22.91	7.66	12.08	7.27
A4	26.74	1.65	26.74	7.48	16.67	6.36

(LST= litter surface temperature; LH=litter humidity; LC=litter compaction; SD= standard deviation. n=245 (A1 and A2) and n=425 (A3 and A4).

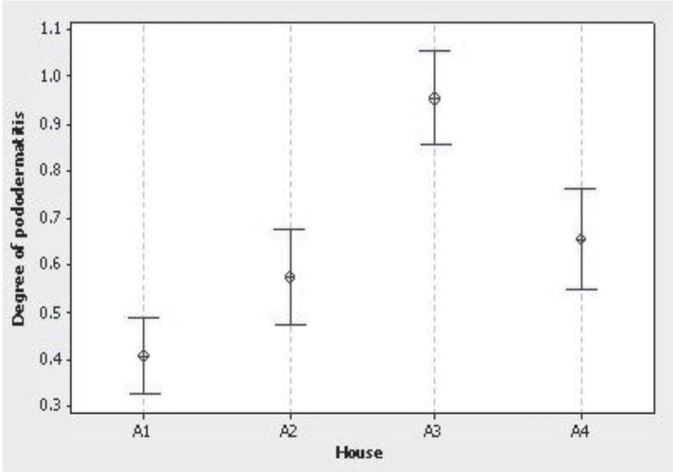

Figure 1 – The incidence of pododermatitis *per* studied house.

The main factor contributing for the development of pododermatitis is the litter quality. Substrates with sharp edges or chips may increase the prevalence and the severity of pododermatitis as a direct result of their abrasive action on the footpad. The function of the litter is to protect broilers' feet, minimizing the impact of the contact of the footpad with the floor (Bilgili *et al*., 2009). According to Refatti *et al.* (2009), wood-shavings litter caused a higher incidence of footpad lesions than sawdust. Ekstrand *et al*. (1997) found that the footpad lesions may develop in less than one week of rearing. Mayne *et al*. (2005) found a high incidence of pododermatitis in 2 to 4-d-old turkeys. The incidence of pododermatitis according to broiler age recorded in the present study is shown in Figure 2.

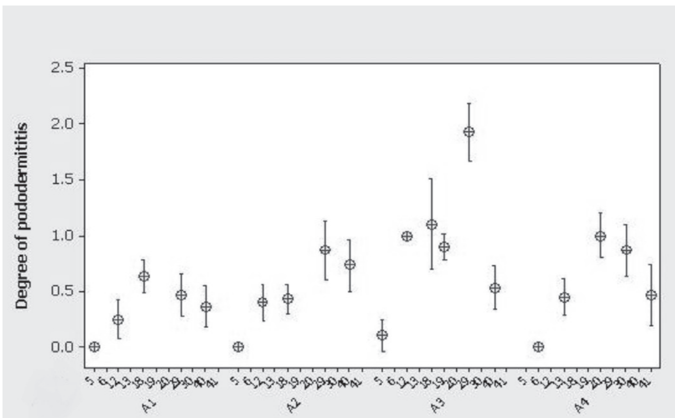

Figure 2 – Incidence of pododermatitis according to broiler age in each studied house.

In all evaluated broiler houses, the incidence of footpad dermatitis (FPD) increased when birds were between 19 and 29 days old. This is the stage of adaptation to the grower feed, and according to Bilgili *et al*. (2010), diet composition, nutrient density and feeding programs affect broiler performance and health of broilers, directly or indirectly influencing the development of pododermatitis. Mendes *et al.* (2012) observed that FPD incidence in broilers increased as a function of age. Harn *et al.* (2014) evaluated broilers reared on dry or wet litter, and did not observe any performance, feed intake, behavior, or FPD incidence differences before 28 days of age. However, after this period, FPD incidence increased independently of litter moisture, resulting in poorer performance as a consequence of significant reductions in feed and water intake.

Different litter surface temperature were recorded among the evaluated broiler houses. The house with positive-pressure ventilation and new rice-husks litter (A3) presented 26.0 °C average litter surface temperature, while the house with positive-pressure ventilation and reused rice-husks litter showed 29.5° C average litter surface temperature (Figure 3).

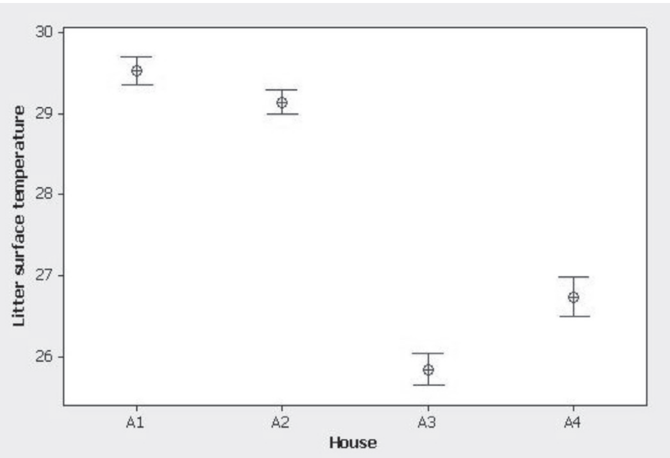

Figure 3 – Litter surface temperature distribution in the studied broiler houses.

There are several studies in current literature on broiler litter temperature. Miles *et al.* (2008) stated that litter temperature in houses with negative-pressure ventilation tend be similar to the environmental temperature. However, those authors recorded litter temperatures near 40 °C in the areas where birds were concentrated. Oliveira *et al*. (2000) observed that litter temperature in thermally-insulated houses was reduced ($p<0.01$) in the morning. When comparing litter temperature at flock densities of 10, 16, and 22 birds m^{-2}, the lowest litter temperature was recorded at the lowest flock density, probably due to less heat generation and lower excreta volume. Carvalho *et al.* (2011) analyzed litter temperature for 1-d-old chicks and verified that low litter temperature (25.3 – 23.7° C) impaired chick growth. According to Dowsland (2008), litter temperature should remain within the range of 28-30 °C during the first days of rearing in order to remove excessive moisture, as moist litter may "cake", deteriorating litter quality.

The results obtained in PCA (Figure 4) indicate an association between footpad surface temperature (maximum and minimum) and house air temperature. Several studies show similar results (Yahav *et al*., 2005, Dahlke *et al*., 2005; Welker *et al*., 2008). Mello *et al*. (2011) found that heat stress during rearing may increase the incidence of footpad dermatitis, increasing carcass downgrade rates due to footpad lesions.

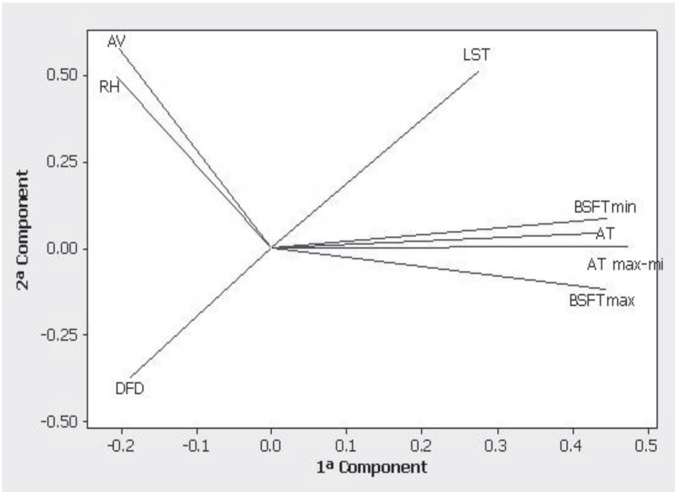

Figure 4 – Principal Components Analysis graph showing the association of environmental parameters, litter conditions, and pododermatitis.

The PCA showed an association between air velocity (AV) and air relative humidity (RH). High air moisture may result in wet litter and increase the incidence of pododermatitis. During the winter, when moist air is maintained in houses with low ventilation rates, the incidence of footpad dermatitis increased (Dawkins *et al.*, 2004; Shepherd & Fairchild, 2010).

Figure 4 shows that litter surface temperature (LST) was highly correlated with footpad dermatitis score. This result is in agreement with the findings of Birth (2011), who indicated a strong correlation between broiler surface temperature and litter surface temperature in houses with two ventilation systems (positive and negative).

Figure 5 shows an association of the score of pododermatitis with litter humidity, air temperature, litter temperature and with maximum and minimum footpad surface temperature in A1. Figure 6 shows the

PCA analysis of A2, indicating an association between litter humidity and pododermatitis score.

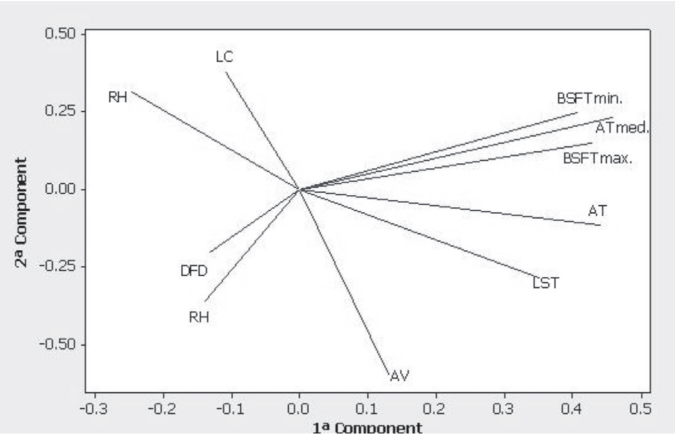

Figure 5 – Principal Components Analysis graph for house A1, showing the association of environmental parameters, litter conditions, and pododermatitis.

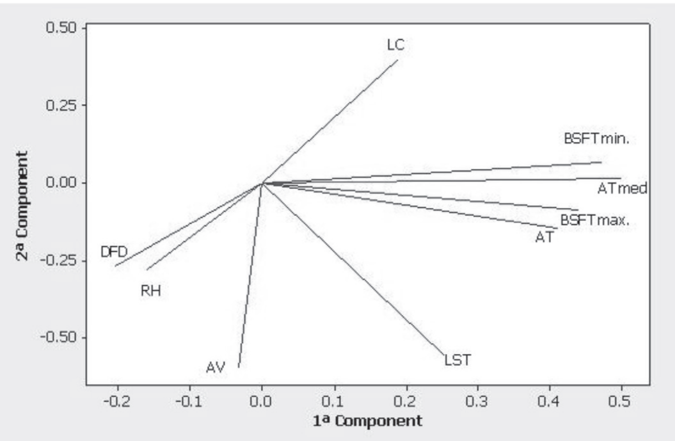

Figure 6 – Principal Components Analysis graph for house A2, showing the association of environmental parameters, litter conditions, and pododermatitis

According to Harn *et al*. (2014), high litter moisture promotes the development of footpad dermatitis in broilers. When excreta adhere to the broilers' feet, the contact with the corrosive litter is extended, increasing the severity of the lesions and of inflammation, resulting in necrosis (Tucker & Walker, 1992). Dawkins *et al*. (2004) found that the presence of ammonia and moist litter deteriorate broiler health. The capacity of moisture absorption is one of the important features when choosing a litter substrate (Bilgili *et al.,* 2009).

Litter compaction did not show any association with the incidence of pododermatitis. According to Ritz *et al*. (2014), compacted litter induces the volatilization of noxious gases and may increase the incidence of pododermatitis in broilers.

An association between minimum and maximum footpad surface temperature with the air temperature was found, but litter surface temperature was not associated with any other analyzed component in the present study. Nascimento (2011) found a similar relationship between house temperature and the surface temperature of the broilers legs.

Minimum and maximum footpad surface temperature was correlated with air temperature, as well as with air velocity and litter moisture (Figure 7). The graph results for A4 (Figure 8) show an association between minimum and maximum footpad surface temperature and air temperature and litter humidity.

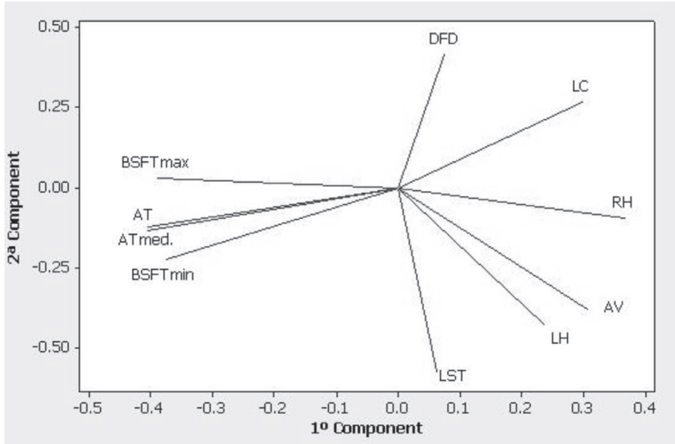

Figure 7 – Principal Components Analysis graph for house A3, showing the association of environmental parameters, litter conditions, and pododermatitis.

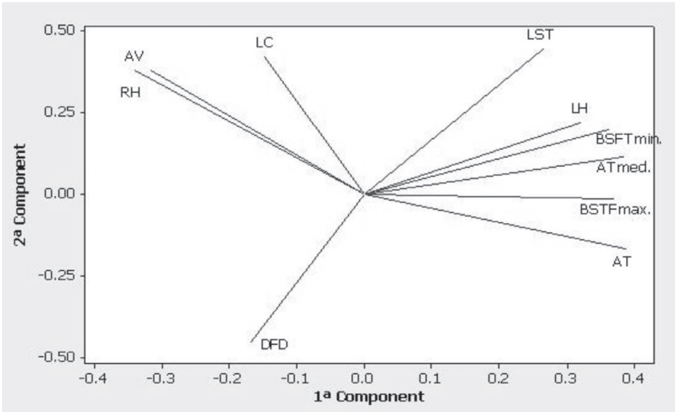

Figure 8 – Principal Components Analysis graph for house A4, showing the association of environmental parameters, litter conditions, and pododermatitis.

Several factors may influence litter humidity. High litter humidity causes "caking", increasing FPD incidence and severity, particularly in reused litter (Vieira *et al*., 2011). Broilers reared on dry litter present fewer feet lesions than those on humid litter (Traldi *et al*., 2007). The fast growth rate of some modern broiler strains has caused these birds to be more sensitive to heat stress (Skomorucha *et al*., 2010), as well as to be more susceptible to pododermatitis (Tucker and Walker 1992; Dawkins *et al*., 2004) than slow-growing broilers.

Air velocity was positively correlated with air humidity. Litter compaction was not correlated with either variables, and pododermatitis score was inversely proportional to litter surface temperature. Broiler leg abnormalities are often associated with their rearing environment, and such problems may be reduced by improving flock management practices (Dawkins *et al*., 2004; Cummings *et al*., 2005).

CONCLUSION

The Principal Components Analysis showed high incidence of pododermatitis in broilers housed in A3, probably due to the new rice husks used as litter substrate. The lowest pododermatitis incidence was recorded in house A1, with reused sawdust litter. Although house A4 presented the most appropriate environmental conditions, the results were not conclusive relative to the incidence of pododermatitis under that rearing environment, in particular.

ACKNOWLEDGEMENT

The authors thank the Coordination of Higher Education (CAPES) for the scholarship and the Research Support Foundation of São Paulo (FAPESP), for the research grant.

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