REVISTA BRASILEIRA
DE ZOOTECNIA

BRAZILIAN JOURNAL OF ANIMAL SCIENCE

Presence of roosters in an alternative egg-production system aiming at animal welfare

Dayana Cristina de Oliveira Pereira[1], Késia Oliveira da Silva Miranda[1], Luiz Carlos Demattê Filho[2], Gustavo do Valle Pereira[2], Sonia Maria de Stefano Piedade[3], Patrícia Berno[4]

[1] *Departamento de Engenharia de Biossistemas, Escola Superior de Agricultura Luiz de Queiroz da Universidade de São Paulo, Piracicaba, SP, Brasil.*
[2] *Centro de Pesquisa Mokiti Okada, Ipeúna, SP, Brasil.*
[3] *Departamento de Ciência Exatas, Escola Superior de Agricultura Luiz de Queiroz da Universidade de São Paulo, Piracicaba, SP, Brasil.*
[4] *Departamento de Zootecnia, Universidade Federal de Mato Grosso do Sul, Campo Grande, MS, Brasil.*

ABSTRACT - The objective of this study was to evaluate the effect of the presence of roosters on welfare and egg production of layers reared in an alternative system. Two breeding systems were established: Shed 1 - layers reared without roosters (4,500 birds); and Shed 2 - layers reared with roosters (4,500 layers and 250 roosters). Microclimate of the facilities, egg production, mortality, and behavior of the birds were evaluated. The analysis of the microclimate in the facilities showed, except for the morning period, that birds were under constant periods of heat stress. Even in this context, egg production and mortality were compatible with the indices recommended by the manual of the strain in the shed without roosters; in the shed with roosters, indices were even better, characterized by higher egg production and lower mortality rates. In addition to productive benefits, the introduction of roosters broadened the repertoire of activities performed by the birds, when reproductive behaviors were introduced. Coupled with this, there was a significant decrease in the tolerance-reflex behavior, which, according to the discussions of this study, are correlated with the impossibility of expressing reproductive behaviors. This fact proves that roosters are an important tool to poultry welfare. The present study launches new possibilities for evaluating, under other conditions, the presence of roosters in egg production systems.

Key Words: ambience, antibiotic-free, behavior, enthalpy, layer

1. **Introduction**

Along with issues concerning the environmental preservation and food safety, animal welfare is a topic of great repercussion in the media and productive environments. This scenario has been further impacted by the awareness of the population about the productive process as well as by the demand for foods with differentiated quality attributes (Pereira et al., 2015).

With regard to poultry farming, there has been much criticism on the practices involved in the production of commercial eggs. Images of beaked birds, reared in cages with extremely small paces, are truly moving.

In an attempt to make animal welfare a less empirical topic, making its adoption and inspection possible in a productive system, the Farm Animal Welfare Council (FAWC, 1993) listed five concepts of freedom to which animal must have access, as follows: nutritional, sanitary, psychological, environmental, and behavioral. The last one determines that animals must be reared under conditions in which they can express the natural behaviors of their species, such as scratching the floor, flapping wings, perching, among others. In this scenario, the presence of roosters in the production system is an important study factor, since reproductive behaviors are natural to this species, though egg production systems do not utilize roosters, except in rare cases.

In view of the lack of research, the present study aimed to evaluate the effect of the presence of roosters on the welfare and productivity of layers reared in an alternative egg production system.

1. Material and Methods

Two adjacent commercial sheds of the Korin Agropecuária company, located in Ipeúna - SP, Brazil (124° SE and 310° NW), were used in the experiment.

Layers and roosters of the Isa Brown strain were evaluated in the period between the start (15 weeks of age) and peak of egg-laying (31 weeks of age). The egg production system, here referred to as alternative, is characterized by the birds being reared on the ground, complying with the norm established by Humane Farm Animal Care (HFAC, 2014), and the diets utilized were free of antibiotics, chemoterapeutic agents, and animal products.

The effect of the presence of roosters was thus evaluated: Shed 1 - Housing for 4,500 layers; Shed 2 - Housing for 4,500 layers plus 250 roosters.

Proportions of feeders, drinkers, and perch area were adjusted according to the number of birds housed, so as to comply with the current norms established by HFAC (2014).

Data referring to dry bulb temperature (DBT) and relative humidity (RH) were collected inside the sheds using data loggers brand HOBO® model H08-00X-02, installed at 1.50 m above the floor. Readings were obtained in one-hour intervals. To obtain the black globe temperature, one globe-thermometer was installed in each shed. This variable was recorded once weekly, at 09.00 h, 13.00 h, and 17.00 h. Globe temperature-humidity index (GTHI) and enthalpy were calculated according to Buffington et al. (1981) and Villa Nova (1999) and cited by Furlan (2001), respectively.

Egg production and mortality rates were evaluated daily. Behavioral patterns (Table 1) were assessed once weekly, by the scanning method, in three periods of the day: morning (08.00 h to 09.00 h), noon (12.00 h to 13.00 h), and afternoon (16.00 h to 17.00 h). Images of the behaviors were captured simultaneously by cameras installed in the center of the sheds opposite one another. The observation period lasted 1 min, held in regular 10 min intervals, totaling twelve observations per hour, considering that each shed had two cameras.

Table 1 - Behavioral patterns evaluated

Behavioral group	Behavior	Description of behavior
Physiological	Drinking	Ingestion of water at the drinker
	Feeding	Ingestion of feed at the feeder
	Permanence at nest	Permanence of the bird at nest for laying eggs
Reproductive	Mating rituals	Rooster moving in half-circles around the layer
	Mating	The act of mounting
	Tolerance reflex	Layer lowering itself in human presence similarly to the behavior performed before mating
Anomalous and agonistic	Agitation	Birds agitated and moving rapidly
	Fighting	Two or more birds confronting each other, bristling the feathers on the neck and hitting each other with beak and nails
	Cannibalism	Bird pecking another bird in an already injured region
Indicative of welfare	Sand bathing	Bird throwing litter material over itself
	Flapping wing	Stretching and moving wings up and down
	Stretching legs and wings	Stretching leg and wings to axes opposite to the body
	Social interaction	Birds developing non-agonistic activities together, with coordinated movements
	Shaking and fluttering feathers	Movement in which bird shakes its body and bristles its feathers
	Investigating feathers	Activity in which bird cleans and straightens its own feathers with the beak

The methodology of evaluation of the tolerance-reflex behavior (Figure 1) consisted of counting the number of birds that manifested it along thirty linear meters from the entry of the shed. This evaluation was performed at the end of the image-recording period for the analysis of the other behaviors.


Figure 1 - Manifestation of the tolerance-reflex behavior.

The experimental design adopted was a randomized block in split plot arrangement. Data referring to egg production, mortality, meteorological variables, and behavioral variables were subjected to analysis of variance using the SAS statistical package (2001). Means were compared by Tukey's test at 0.05 significance level. Behavioral variables were subjected to the $Yt = \text{arcsen}\sqrt{(Y/100)}$ transformation.

2. Results and Discussion

Tukey's test applied to the temperature, humidity, GTHI, and enthalpy data did not indicate evidence to reject the hypothesis of equality between the thermal environments of the sheds (Table 2); therefore, the differences found can be attributed to the studied parameters.

The lowest temperature and the highest relative humidity index were recorded in the morning period, as compared with the other times (Table 2). The average and maximum daily temperatures remained most part of the time above the thermal neutral zone, which, according to the management guide of the strain (2012-2013), is in the narrow range of 21 ºC to 24 ºC, characterizing a situation of heat stress. The highest temperature recorded throughout the experimental period was 35.6 ºC and 35.7 ºC in sheds 1 and 2, respectively. As expected, the relative air humidity values were significantly higher in the morning period (Table 2).

Table 2 - Mean values for temperature (ºC), relative humidity of the air (RH, %), globe temperature humidity index (GTHI), and enthalpy (Kj/kg dry air) values recorded in the sheds during the three periods of the day (8.00 h-9.00 h, 12.00 h-13.00 h, and 16.00 h-17.00 h) and in the whole day.

Sheds	Temperature			RH			GTHI			Enthalpy		
	9h	13h	17h	9h	13h	17h	9h	13h	17h	9h	13h	17h
With roosters	24.0^{Ba}	29.9^{Aa}	30.1^{Aa}	78.8^{Aa}	52.0^{Ba}	52.2^{Ba}	73.7^{Ba}	78.2^{Aa}	78.4^{Aa}	67.4^{Ba}	72.9^{Aa}	73.5^{Aa}
Without roosters	23.9^{Ba}	30.0^{Aa}	30.3^{Aa}	78.8^{Aa}	51.5^{Ba}	50.7^{Ba}	73.3^{Ba}	78.3^{Aa}	77.3^{Aa}	67.3^{Ba}	72.8^{Aa}	73.4^{Aa}
CV_p (%)		1.33			5.38			3.08			0.85	
CV_s (%)		1.38			3.28			2.22			2.02	

CV_p - coefficient of variation of plot (rooster); CV_s - coefficient of variation of subplot (times).
Means followed by the same uppercase letter in the row and lowercase letter in the column do not differ by Tukey's test at 0.05 probability.

According to Ferreira (2005), adult birds have better production when reared in environments with relative humidity in the range of 40% to 70%. In the present study, except for the morning period, a misting system was necessary so that relative humidity would not reach critical levels; i.e., values below 40%.

The GTHI was significantly lower in the morning period. Adopting the values cited by Tinoco (1998), in which the GTHI of up to 75 is considered as thermal comfort for layers, we identify that the values shown in the period of midday and afternoon —between 77 and 78 — were above the recommended, which characterizes a situation of danger according to Baêta and Souza (1997).

The analysis of thermal conditions from the perspective of enthalpy confirms the condition of heat stress characterized by the values above 70. According to Barbosa Filho et al. (2007) and Silva et al. (2006), the comfort zone has upper and lower values of 70 and 64, respectively.

3.1 Productivity and mortality of birds

The egg production of the birds reared with roosters was statistically superior to that of the birds reared without them, and to the value recommended by the management guide of the strain (2009-2010) (Table 3). The birds housed with roosters, also displayed a lower mortality rate.

Table 3 - Mean values for egg production and mortality of Isa Brown layers reared with and without roosters and according to the management guide of the strain (manual of the strain).

Sheds	Egg production (%)	**Mortality (%)
With roosters	84.40^{A}	0.25^{B}
Without roosters	76.21^{B}	0.51^{A}
Manual of the strain	75.33^{B}	0.52^{A}
CV (%)	9.56	33.3

Means followed by the same letter in the column do not differ statistically by Tukey's test (P<0.05). CV - coefficient of variation. ** Highly significant.

At the 18th week of the age, according to the manual of the strain, birds were supposed to reach an egg-laying rate of 2%. Layers housed without roosters reached rates of 10.94%, and those housed with roosters had an egg-laying rate of 18.87%. It is inferred that the presence of roosters was the factor determining these results, which corroborates Leonard et al. (1993), who reported an improvement in the productivity of birds stemming from the exposure to the opposite sex.

According to Newberry (1995), the rooster plays a role of environmental enrichment, which can provide improvements in the biological functioning of birds in captivity and consequent improvements in their health. This fact can explain the lower mortality rate recorded in the shed in which roosters were used.

In absolute terms, at the end of the experimental period, in the shed with roosters, the mortality rate recorded was 0.49%, whereas in the shed without roosters the rate was 0.96%. It should be stressed that although mortality was more prevalent in the shed without roosters, that value was not higher than the 1.11% described by the manual of the strain at the end of the 31st week of age of the birds.

3.2 Behavior of birds

As regards the study of behavior, the obtained data were grouped as follows: physiological behaviors, reproductive behaviors, anomalous and agonistic behaviors, and behaviors indicative of welfare.

3.2.1 Physiological behaviors

Physiological behaviors are described in Table 4.

Table 4 - Expression of physiological behaviors, in percentage values, recorded in the sheds where layers with and without roosters were housed, in three periods of the day (8.00 h-9.00 h, 12.00 h-13.00 h, and 16.00 h-17.00 h) and in the whole day.

Sheds	Behavior								
	Drinking			Feeding			Permanence at nest		
	9h	13h	17h	9h	13h	17h	9h	13h	17h
With roosters	31.3^{Ab}	36.8^{Aab}	45.1^{Aa}	80.5^{Aa}	77.1^{Aa}	81.9^{Aa}	91.0^{Aa}	16.6^{Ab}	11.80^{Ab}
Without roosters	29.2^{Aa}	35.8^{Aa}	37.8^{Aa}	84.7^{Aa}	77.1^{Aa}	84.7^{Aa}	83.3^{Aa}	15.9^{Ab}	11.80^{Ab}
	Whole day								
With roosters	37.72^{A}			79.87^{A}			39.80^{A}		
Without roosters	34.26^{A}			82.18^{A}			34.25^{A}		

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ by Tukey's test at 0.05 probability.

The frequency of the "drinking" behavior was significantly changed only by the time of observation in the shed 1. There was no statistical difference due to the introduction of roosters; frequency in the whole-day period remained the same (Table 4).

The increased water consumption at the hottest time of the day is directly related to the increased demand for water to be used in the process of heat loss through evaporative processes. Many studies have suggested that endogenous heat production is associated with the lean tissue accrual shown by the individual (Brown-Brandl et al., 2004; Ballet al., 2008). This fact can explain the increase in drinking behavior only seen in the shed where roosters were housed, since they are heavier than the layers, which probably causes greater sensitivity to heat stress and make them more dependent on the latent forms of heat dissipation.

The "feeding" behavior was not influenced by the presence of roosters or by the observation time (Table 4). This was found to be a behavior of high priority, and its manifestation thus occurred at the high frequency of 77.1% to 84.7%.

In the evaluated production system, it was apparent that the greatest stimulus to consumption was the sound produced by the activation of the automated drinker. Upon hearing it, birds went straight to the feeder, and, for a few minutes, this was the prevailing behavior in the sheds. Utilizing the scanning method, Pereira et al. (2015) also did not observe a significant difference in the frequency

of the feeding behavior. However, other authors such as Barbosa Filho et al. (2007) and Silva et al. (2006), utilizing the method of individual bird tagging, reported a decrease in its frequency as the temperature increased.

The permanence at the nest was statistically similar regardless of the presence of roosters, but statistically superior at 09.00 h in both sheds, which is consistent with data available in the literature reporting a lower egg-laying rate in the morning period. At that time, frequencies of 90.97% and 83.33% were observed in the sheds with and without roosters, respectively. At the other times, frequency was lower than 17%, characterizing the high influence of the time in its expression.

According to Riber (2010), the use of nests is an important part of the behavioral repertoire of layers, and, thus, in commercial conditions, they must be granted this right so as to minimize their stress and improve their welfare. In this context, it is worth mentioning that the egg-laying incidence at the litter was low, which is in agreement with the reports of Barbosa Filho (2004), according to whom, after a period of acclimation, birds "learn" to utilize the nests.

3.2.2 Reproductive behaviors

With regard to the reproductive behaviors (Table 5), statistical analyses were not applied to compare the means between sheds for the mating rituals and mating behaviors, as the birds housed without roosters could not perform them.

Table 5 - Expression of reproductive behaviors, in percentage values, recorded in the sheds where layers with and without roosters were housed, in three periods of the day (8.00 h-9.00 h, 12.00 h-13.00 h, and 16.00 h-17.00 h) and in the whole day.

Sheds	Behavior								
	Mating rituals			Mating			Tolerance reflex		
	9h	13h	17h	9h	13h	17h	9h	13h	17h
With roosters	4.85^{b}	12.49^{a}	13.19^{a}	8.32^{b}	13.19^{ab}	19.43^{a}	0.36^{Ba}	0.43^{Ba}	0.43^{Ba}
Without roosters	-	-	-	-	-	-	22.50^{Ac}	36.64^{Ab}	55.07^{Aa}
	Whole day								
With roosters	-	-	-	-	-	-		0.40^{B}	
Without roosters	-	-	-	-	-	-		38.07^{A}	

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ by Tukey's test at 0.05 probability.
(-) absent behavior.

Both the mating rituals and the mating act itself had their expression significantly changed according to the observation time. Mating rituals were less frequent in the morning period, expressed at a frequency lower than 5%.

The mating frequency was statistically higher in the later afternoon when compared with the morning period. In these intervals, the frequency increased from 8.32% to 19.43% (Table 5). At 13.00 h, the recorded frequency was similar to that of the other times (Table 5).

Studying the behavior of birds, Campos (2000) suggested that the highest frequency of mounts being in the afternoon period is correlated with the lower egg production in this period, which, according to him, can be a strategy to facilitate the ascent of spermatozoa through the reproductive tract, thereby allowing fertilization. The results of the present study thus corroborate those found by that author.

The tolerance-reflex behavior was more frequent in birds reared without the presence of roosters at all observation times (Table 5). The time significantly affected its expression only where there were no roosters, with the highest frequency observed in the afternoon periods (55.07%) and the lowest in the morning period (22.50%). The analysis of the whole-day period showed this behavior is significantly altered by the presence of roosters.

Particularly, the mating behavior reinforces the idea that the tolerance-reflex mechanism is indeed related to the lack of an opportunity to execute the reproductive behaviors, since it is more frequently expressed in the absence of roosters and in the afternoon period, when the occurrence of mounts is also higher (Table 5). This fact confirms that roosters are an important tool to behavioral freedom.

3.2.3 Anomalous and agonistic behaviors

The following represented the anomalous and agonistic behaviors, i.e., indicators of stress: agitation, fighting, and cannibalism (Table 6).

Table 6 - Expression of anomalous and agonistic behaviors, in percentage values, recorded in the sheds with and without roosters, in three periods of the day (8.00 h-9.00 h, 12.00 h-13.00 h, and 16.00 h-17.00 h) and in the whole day.

Sheds	Behavior								
	Agitation			Fighting			Cannibalism		
	9h	13h	17h	9h	13h	17h	9h	13h	17h
With roosters	-	2.77^{Aa}	2.77^{Aa}	2.07^{Ab}	1.38^{Ab}	6.23^{Aa}	-	-	-
Without roosters	2.07^{a}	4.16^{Aa}	4.16^{Aa}	1.38^{Aa}	0.69^{Aa}	0.69^{Ba}	-	-	-
	Whole day								
With roosters	1.84^{A}			3.23^{A}			-		
Without roosters	3.46^{A}			0.92^{B}			-		

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ by Tukey's test at 0.05 probability.

The frequency of agitation in birds was low — lower than 5% — in both sheds, not differing statistically as a function of the presence of roosters and observation time.

It is possible that the roosters contributed to this low incidence, given that even the birds housed without their presence had visual and auditory stimuli due to the proximity to the experimental sheds, which might have transmitted a greater sensation of safety also to these birds. Odén et al. (2015) identified that layers reared with roosters demonstrated shorter periods of tonic immobility and a lower frequency of vigilance time, which are typical behaviors of animals with fear, and concluded that the presence of roosters reduces the fear sensation of layers.

The incidence of fights was significantly altered due to the presence of roosters and also observation time. The shed that included the presence of rooster showed a higher frequency of fights in the later afternoon (6.23%), differing statistically from the frequency recorded by the birds housed without the rooster (0.69%) (Table 6). Interestingly, at this time, the fights occurred almost totally among roosters. The higher frequency of mounts recorded in the late afternoon (Table 5) is likely to have intensified the disputes for females, causing increased conflicts among roosters. However, it

should be noted that this was an occasional behavior, occurring in a proportion lower than 10%, which corroborates the reports of Rodenburg et al. (2003), who observed a lower frequency of aggressive behavior in birds reared in big groups.

There was no cannibalism (Table 6), which can be attributed mainly to the low idleness of the birds, due to the possibility of expression of numerous other behaviors. In this same line of thought, Rocha et al. (2008) stresses the environmental enrichment as a tool to minimize cannibalism. Janczak and Riber (2015) also emphasized that, as a result of a continuous genetic selection, it is possible that the current genotypes utilized in egg production are less susceptible to feather-plucking and cannibalism, emphasizing the need for new studies investigating the actual practical need for debeaking.

3.2.4 Behaviors indicative of welfare

In this research, it was identified that the production system carried out on the ground allows the expression of a wide array of behaviors indicative of welfare, among which, in this study, the frequency of the following behaviors was quantified: sand bathing, flapping wings, stretching legs and wings, social interaction, shaking and fluttering feathers, and investigating feathers (Table 7).

The expression of the behavior named “sand bathing” was influenced only by the time of observation. This variable was less frequent ($p<0.05$) in the morning period for both sheds. The analysis of the whole-day period demonstrated that this behavior is expressed at a similar frequency between the sheds.

According to Santos et al. (2010), sand bathing consists of a mechanism of heat exchange with the environment; thus, it is coherent that this behavior was more frequent at the hottest times of the day, i.e., at 13.00 and 17.00 h, whereas in the morning period its frequency was lower than 3%.

Table 7 - Expression of behaviors indicative of welfare, in percentage values, recorded in the sheds with and without roosters, in three periods of the day (8.00 h-9.00 h, 12.00 h-13.00 h, and 16.00 h-17.00 h) and in the whole day.

Sheds	Behavior								
	Sand bathing			Flapping wings			Stretching legs and wings		
	9h	13h	17h	9h	13h	17h	9h	13h	17h
With roosters	2.77^{Ab}	36.80^{Aa}	45.12^{Aa}	70.83^{Aa}	72.20^{Aa}	68.76^{Aa}	4.15^{Aa}	4.15^{Aa}	3.45^{Aa}
Without roosters	2.08^{Ac}	30.55^{Ab}	53.45^{Aa}	62.50^{Aa}	45.81^{Ba}	51.37^{Ba}	6.23^{Aa}	4.15^{Aa}	2.77^{Aa}
	Whole day								
With roosters	28.69^{A}			70.59^{A}			3.92^{A}		
Without roosters	28.23^{A}			53.23^{B}			4.38^{A}		
Sheds	Behavior								
	Social interaction			Shaking and fluttering feathers			Investing feathers		
	9h	13h	17h	9h	13h	17h	9h	13h	17h
With roosters	13.86^{Aa}	24.31^{Aa}	24.30^{Aa}	31.92^{Aa}	34.70^{Aa}	32.62^{Ba}	86.12^{Aa}	65.28^{Ab}	55.56^{Ab}
Without roosters	13.09^{Aa}	22.92^{Aa}	17.35^{Aa}	36.79^{Aa}	36.10^{Aa}	47.22^{Aa}	86.11^{Aa}	70.13^{Aa}	61.78^{Ab}
	Whole day								
With roosters	19.90^{A}			33.08^{B}			72.67^{A}		
Without roosters	18.04^{A}			40.04^{A}			68.99^{A}		

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ by Tukey's test at 0.05 probability.

It was noted that, when given the chance to choose, birds prefer to sand-bathe at places with direct incidence of sun rays. It is though that the three main factors influencing this preference are: 1 - at these sites, the litter is usually drier and thus softer, facilitating the dispersion of the material over their legs; 2 - the exposure to sun rays benefits the control of ectoparasites; and 3 - when moving the bedding material, the incidence of sun rays causes some particles to reflect the light, which can whet their curiosity. Petherick et al. (1995) reported that the litter exerts an important visual stimulus to birds, representing one of the main factors that trigger the processes of sand-bathing behavior.

There was a statistical difference in the frequency of the “flapping wing” behavior as a function the presence of roosters in the period of 13.00 h and 17.00 h. At these times, their presence significantly increased the expression of this behavior, which reached indices of 72.2% and 68.76%,

respectively, whereas in the shed without roosters, the frequency was 45.81% and 51.37%. There was no difference ($p<0.05$) between the observation times. The evaluation of the whole-day period indicated that such behavior occurs at different frequencies between the sheds.

The observations made in the current study allowed us to identify that this behavior was executed proportionally more by the roosters, which agrees with reports of Wood-Gush (1956), according to whom this is a typical behavior of roosters during aggressive contacts and when courting females. Leonard and Zanette (1998) studied the behavior of roosters and also identified an increase in the frequency of this behavior when layers were around, and defined it as a mechanism of body display that influences the choice of roosters for hens.

"Stretching legs and wings" was expressed in similar proportions ($p<0.05$) in both sheds, not differing statistically as a function of the observation time (Table 7). Pereira et al. (2013), evaluating the behavior of layers, also observed a low frequency of expression of this behavior as was found in the present study, in which its frequency ranged from 2.77% to 6.23%. Of the behaviors indicative of welfare, this one had the lowest frequency.

The frequency of "social interactions" was not altered by the studied variables (roosters and time), with its occurrence in the whole-day period having no significant differences. In this study, the occurrence of this behavior varied between 13.09% and 24.31%; i.e., it was a very frequent behavior.

A trend was observed in layers towards greater interaction with roosters, cleaning their legs and giving them delicate and numerous little pecks, usually on the face. These forms of interaction, specifically, were less frequent where roosters were not present. In this condition, without the males, the predominant forms of interaction were collective sand baths and the act of scratching the ground together searching for insects and/or other objects in the litter.

The presence of roosters caused a significant decrease in the frequency of the "shaking and fluttering feathers" behavior in the afternoon period. In this period, this behavior was expressed at a frequency of 32.62%, whereas in the shed without roosters its frequency was 47.22%. Considering that the allocation of time and resources to different physical or behavioral activities is controlled by motivational mechanisms, it is hypothesized that this reduction is associated with a higher frequency of other behaviors performed in this day period; e.g., the reproductive behaviors.

The same behavior was expressed in a similar proportion in the different periods of the day; in other words, the observation time did not modulate its frequency, probably because it was more closely related to the act of straightening the feathers than the attempts to dissipate heat. Studying the frequency of this behavior, Pereira et al. (2005) also did not identify the influence of time on its frequency.

Also described as a behavior inherent to the species and representative of a state of welfare, "investigating feathers" had its frequency changed according to the observation period, not showing significant differences as a function of the roosters. The shed with roosters showed a higher frequency in the morning period — 86.12% — whereas the shed without roosters showed higher frequencies in the periods of morning and midday: 86.11% and 70.13%, respectively (Table 7).

It was found that, of the behaviors indicative of welfare, this was the most frequently performed by the birds in the morning period. Furthermore, it was possible to identify that this activity was systematically more expressed by the perched birds, whereas the birds on the floor were more dedicated to other activities such as feeding, drinking, and interactions with the litter.

3. Conclusions

This alternative rearing system appears to be a production model in line with animal welfare for providing and stimulating the manifestation of behaviors considered important for birds. Even subjected to constant periods of heat stress, the birds with and without the presence of roosters show egg production and mortality rates equal to or better than those recommended by the manual of the strain. In this production system, the presence of roosters allows the expression of reproductive behaviors, thereby widening the repertoire of natural behaviors of birds. Moreover, their presence significantly reduces the tolerance-reflex behavior, which, according to the discussions presented in this study, is correlated with the lack of an opportunity to exert the reproductive behaviors, characterizing the presence of roosters as an important tool to animal welfare.

4. Ethical statement

The experiment was carried out according to the ethical principles and was approved by the Ethics Committee of Escola Superior de Agricultura Luiz de Queiroz - ESALQ.

5. Acknowledgments

The authors thank Centro de Pesquisa Mokiti Okada and the Korin Agropecuária company for funding this research.

6. References

Baêta, F. C. and Souza, C. F. 1997. Ambiência em edificações rurais: conforto térmico animal.2th ed. Universidade Federal Viçosa, Viçosa.

Ball, R. O.; Samuel, R. S. and Moehn, S. 2008. Nutrient requirements of prolific sows. Advances in Pork Production Journal 19:223-236.

Barbosa Filho, J. A. D. 2002. Avaliação do bem estar de aves poedeiras em diferentes sistemas de produção e condições ambientais, utilizando análise de imagem. Dissertação (M.Sc.). Escola Superior de Agricultura Luiz de Queiroz, Piracicaba.

Barbosafilho, J. A. D.; Silva, I. J. O.; Silva, N. A. and Silva, C. J. M. 2007. Avaliação dos comportamentos de aves poedeiras utilizando sequência de imagens. Revista Engenharia Agrícola 27:93-99.

Brown-Brandl, T. M.; Nienaber, J. A., Xin, H.; and Gates, R. S. 2004. A literature review of swine heat production. Transactions of the ASAE 47:259-270.

Buffington, D. E.; Collazo-Arocho, A.; Canton, G. H.; Pitt, D.; Hatcher, W. W. and Collier, R. J. 1982. Black globe-humidity index (BGHI) as comfort equation for dairy cows. Transactions American Society Agricultural Engineer 24: 711-714.

Campos, E. J. O. 2000. Comportamento das aves. Revista Brasileira de Ciência Avícola 2:93-113.

FAWC - Farm Animal Welfare Council. 1993. Farm Animal Welfare Council: Report on priorities for animal welfare research and development, London, 27p.

Ferreira, R. A. 2005. Maior produção com melhor ambiente para aves, suínos e bovinos. 1th ed. Aprenda Fácil, Viçosa.

Furlan, R. A. 2001. Avaliação da nebulização e abertura de cortinas na redução da temperatura do ar em ambiente protegido. Tese (D.Sc.). Escola Superior de Agricultura Luiz de Queiroz, Piracicaba, SP, Brasil.

Hendrix Genetics. 2009-2010. Guia de Manejo da Isa Brow. Available at: <http://www.mercoaves.com.br/pdf/20150317164824.pdf>. Accessed on: Oct., 21, 2015.

Hendrix Genetics. (2012-2013). Guia de Manejo da Isa Brow.Available at: <http://www.joiceandhill.co.uk/~/media/Files/Joice%20and%20Hill/technical%20guides/isa%20brown/ISA%20Brown%20Management%20Guide.pdf>. Accessed on: Sep., 14, 2014.

Janczak, A. M. and Riber, A. B. 2015. Review of rearing-related factors affecting the welfare of laying hens. Poultry Science 94:1454-1469.

Leonard, M. L. and Zanette L. 1998. Female mate choice and male behaviour in domestic fowl. Animal Behaviour 56:1099-1105.

Leonard, M. L.; Zanette, L. and Fairfull, R. W. 1993. The effect of early exposure to the opposite sex on mate choice in white leghorn chickens. Applied Animal Behaviour Science 36:29-38.

Newberry, R. C. 1995. Environmental enrichment: increasing the biological relevance of captive environments. Applied Animal Behaviour Science 44:229-243.

Odén, K.; Gunnarsson, S.; Berg, C. and Algers, B. 2015. Effects of sex composition on fear measured as tonic immobility and vigilance behavior in large flocks of laying hens. Applied Animal Behaviour Science 95:89-102.

Pereira, D. F.; Nääs, I. A.; Romanini, C. E. B.; Salgado, D. D.; and Pereira, G. O. T. 2005. Indicadores de bem-estar baseados em reações comportamentais de matrizes pesadas. Revista Engenharia Agrícola 25:308-314.

Pereira, D. F.; Nääs, I. A.; Salgado, D. D.; Gaspar, C. R.; Bighi, C. A. and Penha, N. L. J. 2007. Correlations among behavior, performance and environment in broiler breeders using multivariate analysis. Brazilian Journal of Poultry Science 9:207-213.

Pereira, D. F.; Batista, E. S.; Sanches, F. T.; Gabriel Filho, L. R. A. and Bueno, L. G. F. 2015. Diferenças comportamentais de poedeiras em diferentes ambientes térmicos. Energia na Agricultura 30:33-40.

Pereira, D. C. O.; Miranda, K. O. S. and Demattê Filho, L. C. 2015. De olho no bem-estar animal sem perder o foco na produtividade. Avicultura Industrial 106:46-48.

Petherick, J. C.; Seawright, E.; Waddington, D. and Duncan, I. A. J. and Murphy, L. B. 1995. The role of perception in the causation of dustbathing behaviour in domestic fowl. Animal Behaviour49:1521-1530.

Riber, A. B. 2010. Development with age of next box use and gregarious nesting in laying hens. Applied Animal Behaviour Science123:24–31.

Rocha, J. S. R.; Lara, L. C. and Baião, N. C. 2008. Produção e bem-estar animal: Aspectos éticos e técnicos da produção intensiva de aves. Ciência veterinária nos trópicos 11:49-55.

Rodenburg, T. B.; Buitenhuis, A. J.; Ask B.; Uitdehaag, K. A.; Koene, P.; Van Der Poel, J. J. and Bovenhuis, H. 2003. Heritability of feather pecking and open-field response of laying hens at two different ages. Poultry Science 82:861-867.

Santos, M. J. B.; Pandorfi, H.; Almeida, G. L. P.; Morril, W. B.; Pedrosa, E. M. R. and Guiselini, C. 2010. Comportamento bioclimático de frangos de corte caipira em piquetes enriquecidos. Revista Brasileira de Engenharia Agrícola e Ambiental 14:554-560.

SAS Institute, 2001. User's Guide, Version 8.2. SAS Institute, Inc., Carry, NC, USA, 707 pp.

Silva, I. J. O.; Barbosa Filho, J. A. D.; Silva, M. A. N. and Piedade, S. M. S. 2006. Influência do sistema de criação nos parâmetros comportamentais de duas linhagens de poedeiras submetidas a duas condições ambientais. Revista Brasileira de Zootecnia 35:1439-1446.

Tinôco, I. F. F. 1998. Ambiência e instalações para a avicultura industrial. p.86. In: Anais do Congresso Brasileiro de Engenharia Agrícola, Sociedade Brasileira de Engenharia Agrícola, Minas Gerais.

Wood-Gush, D. G. M. The agonistic and courtship behaviour of the brown leghorn cock. 1956. British Journal of Animal Behaviour 4:133-142.