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Performance and welfare of different genetic groups of laying hen

Jean Kaique Valentim[1*], Heder José D 'Ávila Lima[2], Tatiana Marques Bittencourt[2], Fernanda Keller Queiroz Barros[2], Jefferson Darlan da Costa Braga[2] and Hellen Cristina Ferreira Antunes[1]

[1]Universidade Federal dos Vales do Jequitinhonha e Mucuri, Campus JK, Rodovia MGT 367, Km 583, 5000, 39100-000, Diamantina, Minas Gerais, Brasil.
[2]Universidade Federal de Mato Grosso, Cuiabá, Mato Grosso, Brasil. Author for correspondence. *E-mail: Kaique.tim@hotmail.com

ABSTRACT. The objective was to evaluate the performance, egg quality, thermoregulation, body morphology and behavior of different categories of laying poultry. Two treatments with two genetic groups were used, 50 birds of the Hisex Brown strain and 50 birds of the Black Avifran chicken breed with 55 weeks, distributed in a completely randomized design with 10 replicates and 5 birds in each experimental unit. The variables egg weight, weight and percentage of albumen, yolk and shell, marketable eggs, specific gravity, color b *, egg / poultry production day^{-1} were not different ($p > 0.05$) between the two groups. Feed conversion by egg mass and dozen eggs, yolk color, L color, diameter, height, shell color presented a difference ($p < 0.05$), being higher values for the Black Avifran breed. The Black Chicken Avifran had higher body temperature; however, its performance and the quality of its eggs did not change. Black Chicken Avifran presented higher values in relation to body morphology, and better results in relation to the animal performance, therefore, it was more efficient, since it obtained a lower consumption and production equal to the lineage Hisex Brown, when created in the Cage – Free system.

Keywords: Black Hens; Hisex Brown; lineage; poultry breed.

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Introduction

Several factors can influence animal production, which can be beneficial or harmful to each species. In addition to the ambience, nutrition and sanity, the genetic characteristics of the breeds / lineages also cause changes in the adaptation and performance of the animals (Azevedo, Fosse Filho, Pereira, Andrade, & Júnior, 2016).

In the current market there are three genetic groups of poultry according to their ability to produce: heavy poultry, light laying hens and semi-heavy laying hens. In hot climates, where birds are constantly in a state of thermal stress, the use of air-conditioned sheds or means of reducing the influence of environmental heat guarantees good production, but often the small producer does not have such technologies.

According to Costa, Dourado and Merval (2012), animal and environmental interaction should be considered when seeking higher productivity. The different responses of the animals to the peculiarities of each region are determinant in poultry success. Research in the area of genetics and breeding is necessary for the purpose of knowing the phenotypes, lineages, races and patterns existents, willing to verify which categories are most efficient for each production system, since these variables are intrinsically related to their performance

The internal and external quality of the eggs is fundamental to be evaluated, especially when these birds are raised in alternative environments, such as cage-free. Analyzes of productive parameters and egg quality are measures adopted to determine the effects of the breeding environment on the performance and welfare of birds (Alves, Silva, & Piedade, 2007). Therefore, the objective of this work was to compare and evaluate the thermoregulatory, morphological, behavioral, performance and egg quality variables of two genetic groups of laying hens, Hisex Brown and Avifran black hens under the same conditions environmental and nutritional needs.

Material and methods

The experiment was conducted in the poultry sector of the Experimental Farm of the Federal University of Mato Grosso. The project was submitted, analyzed and approved by the committee on animal research and ethics (CEUA), registered under number 23108.092960 / 2015-80. Two treatments with two genetic groups of laying hens were used, 50 Hisex Brown strain and 50 Black Chicken Avifran breed with 55 weeks, distributed in a completely randomized design with 10 replicates and 5 birds in each experimental unit. The birds were raised in Cage Free system, on the floor, with nest, perch and bed of rice husk. Each box is 1.5m wide and 1.5m long, making a density of 0.45m² per bird. The birds received the same diet, following the recommendations of Rostagno et al. (2017) according to table 1.

Animal Performance

The experiment lasted 63 days, divided into three periods of 21 days each. The performance variables evaluated were: percentage of viable egg production, marketable eggs, feed intake (g bird day^{-1}), feed conversion per mass per dozen eggs and viability. To calculate the percentage of production, the total number of intact, broken, cracked, thin-shell, shelled and deformed eggs produced in the 3 experimental periods was used, after that, the percentage of posture was calculated.

Data on marketable eggs were obtained by the difference between the percentage of laying and the percentage of broken, cracked, thin-shelled, shelled and deformed eggs. To calculate feed intake (g bird day^{-1}) the leftovers was subtracted from the quantity offered in a week at the end of each week. The average daily intake was calculated according to the replicates and treatments. Feed conversion by mass was calculated by dividing the means of the performance variables feed intake in grams by the egg mass in grams. The feed conversion per dozen was obtained by dividing the feed consumption in kilograms in the total period by the dozen eggs produced in the total period. Finally, viability was calculated from the total number of dead birds subtracted from the total number of live birds, and the values converted to percentage at the end of the experimental period.

Egg Quality

At each end of the 21-day cycle, analyzes were performed on egg weight, egg diameter, egg height, bark color, Haugh unit (HU), specific gravity, height albumin, weight and percentages of yolk, bark and albumen. The mean weight of the eggs was estimated from the whole eggs. Therefore, at the end of the period, 3 eggs per lot were chosen randomly, excluding the dirty ones and with problems in the shell (thin bark, deformities, cracked). These were weighed individually and, with the aid of a digital pachymeter Starret 150 mm, the height and diameter of the eggs were measured (mm). For a color scale was carried out the color comparison of the shell.

Specific gravity was determined by immersing the eggs in saline solutions with a density ranging from 1,070 to 1,095 g cm^{-3}, with an interval of 0.005 g cm^{-3}, duly calibrated by means of a densimeter (OM-5565, Incoterm). Following the evaluations, the eggs were broken for analyzes of albumin height, weight and percentage of yolk, bark and albumen. Measurement of the albumin height was done using the Starret 150 mm digital caliper. With the data of egg weight and albumen height, UH was obtained by the formula:

$$UH = 100\log\{H - \frac{\sqrt{G(30W^{0,37} - 100)}}{100} + 1,9\}$$

where: H = height of the dense albumen (millimeters); G = gravitational constant of 32; W = weight of the egg (grams), according to Brant (1951).

Table 1. Ration used for both treatments and calculated composition.

Diet Composition			
Ingredients	%	Nutrients	
Ground corn	61,98	Metabolizable energy (Kcal kg^{-1})	2800,0
Soy bean meal	25,00	Crude protein (%)	19,46
Soybean oil	1,52	Digestible lysine (%)	1,080
Limestone	8,10	Digestible methionine + cysteine (%)	0,94
Common salt	0,50	Digestible tryptophan (%)	0,23
Dicalcium phosphate	1,10	Digestible Threonine (%)	0,68
1Nucleus of posture	1,80	Calcium (%)	3,07
Total (kg)	100	Available phosphorus	0,30
		Sodium (%)	0,16
		Crude Fiber (%)	2,76

[1]Nucleos composition: Calcium (min) 80 g kg^{-1}, Calcium (max) 100 g kg^{-1} Phosphorus (min) 37 g kg^{-1} Sodium (min) 20 g / Vitamin B1 (min) Vitamin A (min) 125000 IU kg^{-1}, Vitamin D3 (min) 25000 IU kg^{-1}, Vitamin E (min) 312 IU kg^{-1}, 20 mg kg^{-1}, Vitamin B2 (min) 62.5 mg kg^{-1}, Vitamin B6 (min) 37.5 mg kg^{-1}, Vitamin B 12 (min) 200 mcg kg^{-1}, kg, Pantothenic Acid (min) 125 mg kg^{-1}, Biotin (min) 1.25 mg kg^{-1}, Choline (min) 1700 mg kg^{-1}, Niacin Iron (min) 680 mg kg^{-1}, Iodine (min) 8.75 mg kg^{-1}, Manganese (min) 937 mg kg^{-1}, Selenium (min) 3.75 mg kg^{-1}, Zinc (max) 370 mg kg^{-1}.

The yolks were separated by hand and weighed individually. The shells, after washing in tap water to remove residues from the albumen, were left at room temperature for 72 hours for later weighing. The albumen weight was obtained by the difference between the weight of the whole egg and the weight of the yolk and the shell.

Two methods were used to determine the color of the yolk, one based on the comparison of the Yolk Color Fan - DSM ® color range scale (score from 1 to 15, ranging from light yellow to dark orange) and another through the digital colorimeter. For both analyzes of the color of the yolk were used two samples of each repetition, these placed on a flat surface, where its coloration was obtained immediately after breaking the egg. The same people, always in the same place and same luminosity, carried out these evaluations in order to avoid variations.

Color verification by the digital form was performed using the Konica Minolta colorimeter, model CR-410, previously calibrated on a white surface according to pre-established standards. The measurement was performed directly on the surface of the yolk, maintaining its integrity. Two color parameters were evaluated: L *, and b *. The value b * indicates coloring in the range of yellow (+ b *) to blue (-b *). The value L gives us the luminosity, varying from white (L = 100) to black (L = 0) (Harder, Canniatti-Brazaca, & Arthur, 2008).

Thermoregulation

During the 63-day period, maximum and minimum temperatures and relative humidity were recorded daily with the use of thermo hygrometers installed in the pits, obtaining average values of 33.1C° and 18.1°C and 80.6 and 36.1% respectively. In this period, the thermoregulation data of the birds were also collected.

The evaluation of the body temperature of the birds was performed once a week, in alternate days, from 1:00 p.m. to 2:00 p.m. - hours when environment temperature reaches highest values, using 100% of the birds in each plot. Data of the temperature of variables such the head, legs, chest, back and wings were collected using an infrared thermometer (Mira Laser Infrared Digital Thermometer). The thermometer had a laser sight at 15 cm from the animal skin, and the cloacal temperature (CT) using a digital thermometer with a rigid tip (iColor- THGTH150B - White - G-Tech), introduced into the cloaca of the birds, with an audible signal when temperature stabilization.

The collected physiological data were then used to calculate the average skin temperature (AST) and average body temperature (ABT) of birds. According to the equation proposed by Richards (1971), considering the surface temperatures and the birds cloaca temperature: AST = (0.70 BT + 0.12 WT + 0.09 HT + 0.09 LT), in °C where: BT = back temperature (°C); WT = wing temperature (° C); HT = head temperature (° C); LT = leg temperature (° C). ABT = 0.3 AST + 0.7 RT, in °C, where: CT = cloaca temperature (°C).

Birds Behavior

The birds went throughout an adaptation period of 5 days prior data collection, in which pre-visualizations were done to elaborate the behavioral ethogram. The behavioral observations of the birds were recorded during 12 hours in the natural light period, from 6:00 am to 6:00 p.m., on two consecutive days, totaling 24 hours of observation in 10 minute intervals, totaling 144 behavioral data, in instantaneous focal sampling.

The etogram (Table 2) was composed of the following behaviors: sitting, eating, drinking, foraging, exploring feathers, non-aggressive pecking, panting, scratching, inside the nests, comfort, and alert, according to Nazareno et al. (2016).

Table 2. Etograma of the behaviors of different categories of poultry reared in warm weather.

Behavior	Description
Sitting (Sit)	Animal sitting in the pen
Eating (Eat)	Animal feeding in the pen
Drinking (Dri)	Animal drinking water
Foraging (For)	Animal feeding in the piquet
Exploring Feathers (ExpF)	Animal preening its own feathers
Non-aggressive pecking (NAPec)	Animal interacting with others through non-aggressive pecking
Panting (Pan)	Animal demonstrating gasping through keeping its beak and wings wide open
Scratching (Scr)	Animal laying scratching inside or outside the pen
Inside the nest (InsN)	Animal laying inside the nest in the pen
Comfort (Com)	Animal still without any signs of discomfort
Alert (Alt)	Animal attentive to signs of predators

Body Morphology

Body's biometry was performed by indicating and recording morphometric characteristics of the 100 birds under experimentation. For this, the circular actions were taken, such as cable, weight, girth, wingspan, perimeter of the leg and the length of the leg. The animals were measured using a graduated measuring tape. Cable length was considered from the foot to the crest. Weight was measured using a digital scale. For the perimeter of the leg, measure of the leg angle and length of the leg it was used a curvilinear measure until the insertion of the spur. For a measure of wingspan, it was performed tip measurement from one wing to another of the bird and girth was the measurement around the chest and back of the bird.

Statistical Analysis

Statistical analysis of the variables related to performance, egg quality, thermoregulation and body morphology was performed in the Assistat statistical program (Silva & Azevedo, 2016) and the means were compared using the F test at the 5% probability level. For behavioral analysis, after analysis of the data, the results were evaluated through simple descriptive statistical analysis.

Results and discussion

Performance and egg quality

There was no difference ($p > 0.05$) for the variables egg mean weight, albumen weight, yolk weight, bark weight, albumen percentage, yolk percentage, shell percentage, marketable eggs, specific gravity, yolk coloring by parameter b* and egg production between the two groups analyzed (Table 3).

Variables of egg diameter and height were influenced ($p <0.05$) between the two groups. In relation to the variables of feed intake (g bird day^{-1}), feed conversion by egg mass and dozens of eggs, significant differences were observed ($p < 0.05$), and the Hisex Brown line presented a higher intake of 120.82 g bird^{-1}. These values are higher of what is recommended in the manual, 113 g bird^{-1}. Red - egg laying birds require a higher amount of feed compared to white (light) egg lines (Franco - Jimenez et al., 2007). Black chicken had better results in relation to feed conversion per dozen, feed intake (g bird day^{-1}) and feed conversion by mass and presented similar egg production, therefore, this category was more efficient, with lower feed consumption and production equal to the Hisex Brown lineage.

Also according to the manual of Hisex Brown lineage, these birds present production posture intensity amid 82 to 84% (between 50 and 55 weeks), and feed conversion of 2.18 in periods up to 90 weeks. In the present study Hisex and Black chickens presented 69.19 and 64.26%, respectively, values below the indicated, which can be explained by the age of the birds (55 weeks) and also by the periods of thermal stress that birds suffered during the experiment. At a higher temperature than indicated, birds present reduced consumption and, consequently, lower egg production.

Similar to this study, Franco-Jimenez et al. (2007), comparing the productive performance in egg production, feed intake and egg quality, of Hy - Line Brown laying hens, W36 and W38, concluded that both performance. Categories. Two genotypes showed 100% viability and were adapted to the region during test period.

For the color of the yolk, by the colorimetric fan and digital colorimeter (L and b) and the shell color, there was difference ($p < 0.05$) between the birds. The color of the egg yolk is the result of the deposition of xanthophyll (carotenoid pigments), which may be from different sources, natural or synthetic, being the most common corn (Garcia et al., 2002).

As for the shell color, it relates more to the genetics of these birds. Black hen eggs were darker in color than Hisex Brown eggs, according to the scale established in the experimental period. In the parameter L, which represents egg yolk brightness, Hisex Brown presented a higher luminosity than the Blacks, 77.87 and 74.68 respectively did. Genetically, light birdies lay lower weight eggs compared to semi-heavy strains; however, the age and weight of the laying hens are the major determinants of egg size.

Thermoregulation

The temperature variations of the two genetic groups of laying hens are shown in table 4. Only the body temperature and the climatic temperature did not present significant differences ($p < 0.05$).

This can be explained by the environmental conditions that the birds were subjected to, as reported by Costa et al., (2012) the environment of the breeding system has a direct influence on the comfort condition (associated with physiological characteristics that regulate the temperature of the animal) and animal welfare.

Table 3. Performance and egg quality of Hisex Brown and Black Hens

Variables	Hisex Brown	Black	VC%[1]
Medium egg weight (g)	59,63^{ns}	60,67^{ns}	6,24
Albumin weight (g)	39,38^{ns}	39,94^{ns}	7,65
Yolk weight (g)	15,16^{ns}	15,29^{ns}	4,62
Shell weight (g)	5,79^{ns}	5,43^{ns}	5,12
%Albumin	65,36^{ns}	65,74^{ns}	2,28
%Yolk	24,99^{ns}	25,27^{ns}	4,60
%Shell	9,64^{ns}	8,98^{ns}	4,26
Gravity (g cm^{-3})	1,083^{ns}	1,081^{ns}	9,42
Feed conversion per dozen	2,16*	1,49*	10,00
Ration consumption (g bird day^{-1})	120,82*	105*	5,63
Mass feed conversion	2,03*	1,73*	9,08
% Eggs production	69,19^{ns}	64,26^{ns}	4,05
% Marketable eggs	79,15^{ns}	81,81^{ns}	8,02
Diameter of the egg	42,42*	41,57*	1,12
Height of the egg	56,14*	55,57*	1,25
Yolk color	4,67*	7,63*	10,00
L color	77,87*	74,68*	2,72
b color	74,64^{ns}	75,82^{ns}	2,59
Viability	100**	100**	-----

*significant to the level of 5% of probability ($p < 0,05$); ns: non-significant ($p > 0,05$) by the F test; [1]Variation coefficient; ** descriptive analysis.

Table 4. External temperature variations (wing, barb, head, body, breast, skin and leg) and internal temperature (cloaca) of laying hens of the Hisex Brown and Black Avifran lineage.

Variables	Hisex Brown	Avifran Black	VC%[1]
WT (°C)	33,67*	35,8*	0,89
BT(°C)	32,19*	34,48*	0,46
HT(°C)	30.37*	36,32*	1,20
BoT(°C)	37,36^{ns}	37,44^{ns}	0,30
BrT(°C)	30,53*	34,43*	1,00
ST(°C)	30,21*	28,71*	0,78
LT(°C)	33,18*	22,94*	1,76
CT(°C)	40,43^{ns}	41,12^{ns}	0,20

WT - wing temperature; BT - barb temperature; HT - Head temperature; BoT - Body temperature; BrT- Breast temperature; ST - Skin temperature; LT - Leg temperature; CT - Cloaca temperature. *significant at the 5% probability level ($p < 0.05$); ns non-significant ($p > 0.05$); [1]CV% = variation coefficient.

Poultry of both strains maintained their different thermoregulatory characteristics in relation to the external temperature in the wing, barb, head, body, chest, skin and leg. This can be explained by the different genetic characteristics of each species, which makes one more resistant than another. The birds of the breed Avifran Black presented higher values in almost all evaluated parameters compared to Hisex Brown.

As observed, WT of the Black Hens was higher, possibly due to the skin color and its greater weight, the average weight of the birds of the Hisex lineage was of 1,610 kg. and Black Chicken 1,875 kg. As presented by Gonçalves (2017), animals of lower body mass have advantages in dissipating heat in relation to those of greater mass.

The BT variable of the Blacks was also higher, the barb being one of the mechanisms of heat exchange. In high temperature and humidity conditions, birds have difficulty in transferring this surplus heat to the environment, causing a rise in body temperature and, as a consequence, thermal discomfort and falling production (Souza, 2005).

HT and BT were also higher in Blacks. Black birds generally had higher temperatures. Only ST and LT were higher in Hisex.

The increase in surface temperature may serve as the physiological response of the bird to inadequate housing conditions, as well as warpage, which is an adaptive response to the environment and influences heat loss (Nascimento, Pereira, Näas, & Rodrigues, 2011). Thermal comfort in birds is a point of paramount importance, especially in areas with elevated temperature and humidity.

Behavior

As highlighted by Figure 1 the two genotypes showed similar behavior, both in the morning and in the afternoon.

Both lineages showed a higher proportion of poultry seating in the morning, more evident behavior when birds are in thermal discomfort. This behavior was observed mainly in Black hens because they are birds of a larger size and body weight. Gonçalves et al., (2017), observed an increase in movement of discomfort in lines with greater body weight (Carijó, Colorpak, Pesadão Vermelho, Tricolor) because they present greater sensitivity to the higher temperatures.

Neme et al. (2006) in the comparison between Hy-Line Brown and Hy-Line W36 strains, found that Hy-Line Brown in the morning spent more time eating, drinking, chasing, nesting, bathing sand and investigating feathers that line Hy-Line W36.

The eating behavior was observed with a higher number of animals in both periods. This may have occurred due to the feeding management, in which the birds received feed in the early morning and afternoon, having occurred in search of food in the feeder. In this study, Silva, Barbosa Filho, Silva, and Piedade (2006) reports that a factor of great influence in the expression of the behavior of the birds is the time, since all the animals follow a biorhythm, this biorhythm is mainly connected to the photoperiod, which in its experiment was 16 hours of light and 8 hours of dark.

The authors reported that the influence of the evaluation period (morning and afternoon) on the expression of behaviors should be considered, in the morning birds spent more time in the feeder due to the feeding time (Costa et al., 2012). In addition, all the categories obtained a similar frequency of consumption throughout the day, increasing in the afternoon, which shows the physiological need of these animals to maintain the internal temperature.

Equally the animals were more breathless in the afternoon, but this behavior were identified with greater intensity in Avifran Black hens. The maximum and minimum temperature and humidity of the shed in the evaluated period was 33.1 and 18°C and 80.6 and 36.1%, respectively. According to Santos, Baeta, Tinôco, Albino, and Cecon (2009), the birds showed a maximum productive performance when the ambient temperature is between 18 and 26°C. However, the animals acclimatized to the heat can perform well in an environment with 28°C, and the maximum temperature is well above the indicated for the animals, thus justifying the increase in panting behavior.

Lopes, Ribeiro, and Lima (2015) also found that bird panting is one of the most efficient means of dissipating heat under thermal stress conditions, although, if relative humidity is appropriate, most birds will be able to dissipate its metabolic heat through this mechanism.

Regarding the variable exploring feathers, it was observed an average occurrence in the morning, probably due to the thermal conditions being considered favorable to the physiology of the birds. As for aggressive and non-aggressive pecking behavior, few birds did so, showing that the animals were already adapted to the environment and the hierarchy of the population in each box.

Chasing behavior was more intense in the afternoon between both birds. The sand bath, inside the nest and the alert was more intense in the morning, because it is the time in which the posture is performed. For comfort behavior, Hisex stood out in the morning as well as in the afternoon compared with the Black ones, since these birds were mostly feeding.

Body morphology

Data collected for the morphological analyzes are expressed in table 5.

All morphological variables analyzed were statistically different ($p < 0.05$). The birds Black Avifran showed higher values in relation to body length, circumference, wingspan, perimeter and length of cinnamon compared to Hisex birds. These characteristics can be positive when it comes to the disposal of animals after the egg production cycle.

Laying birds, due to their low weight, do not have a good harvesting capacity. Nevertheless, the Black category, after the productive period, is more efficient in terms of weight and size, and may be a secondary profit alternative for the producer.

Identification of the phenotypic characteristics of birds is important and can help programs for the conservation of genetic resources and their recognition. Méndez, Pons, and Francesch (2011), using zoomometric comparisons in chickens of different races, found that Mallorquina chicken presented lower weight and lower values of the measurements in relation to the other races. Native chickens are essential for family farming, making it possible to obtain quality animal protein (Aldersm & Pym, 2010).

The analyzed poultry had few morphological and production distinctions because they do not have many genetic variations, because they are a lineage and an already defined race. The use of morphological descriptors results in important information for the study of phenotypic diversity in conservation programs of animal genetic resources (Awatef, Hédia, Sonia, & Mohamed, 2013).

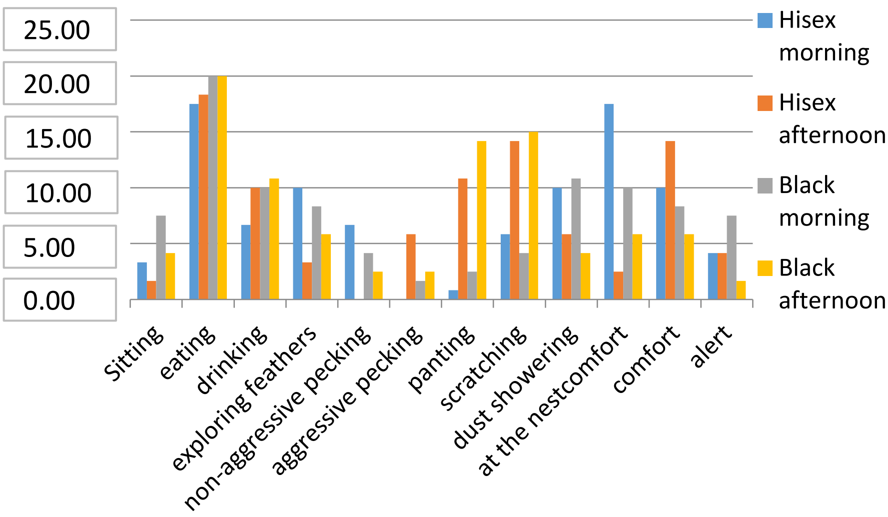

Figure 1. Behavioral analysis of two laying hens genotypes.

Table 5. Body length, circumference, wingspan, cinnamon perimeter and cinnamon length of the two laying bird genotypes.

Variables	Body length	Weight	Girth	Wingspan	Leg perimeter	Leg length
Hisex	43,87*	1,61*	31,75*	47*	4,53*	6,68*
Black	46,62*	2,19*	36,93*	52,37*	5,25*	9,18*
VC[1]	4,85	3,97	6,32	4,81	10,83	10,91

*significant at the 5% probability level ($p < 0.05$); ns non-significant ($p > 0.5$); [1]VC% = variation coefficient.

Conclusion

Avifran Black poultry presented higher values in relation to the body morphology, and better results regarding performance; therefore, it was more efficient than Hisex Brown lineage, when created in Cage-Free system.

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