Agronomy Research **17**(2), 371–377, 2019
https://doi.org/10.15159/AR.19.106

Effect of environmental temperature during the of brooding period on growing period of pullets viscera and tibia

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Abstract. Poultry production in subtropical and tropical regions faces many problems, one of which is the high air temperature causing thermal stress, particularly dangerous in high-producing birds. Thus, the negative effects caused by heat stress (HS) must be managed. The objective of this study was to evaluate the effects of four different levels of HS in viscera and tibia of pullets. A total of 648 chicks (Lohmann LSL Lite) were used in this study in two different phases. The pre-experimental phase (PEP) was from day 1 through 6 weeks of age. The birds were reared with three different environmental temperatures: thermal comfort, hot and cold. The experimental phase (EP) was conducted from the 7th to the 17th week. Pullets from each thermal environment of the PEP were submitted to: 20 °C, 25 °C, 30 °C, 35 °C. At the end of the 17th week of age 120 pullets were euthanatized and the organs, heart, liver, spleen and gizzard were weighed, as also their tibias. Effects of PEP, and its interaction with EP, were not significant ($P < 0.05$) for viscera and tibia weight. However, a significant increase ($P < 0.05$) in heart weight with the decrease of the environmental temperature was observed, being the pullets subject to 20ºC and 25 °C with the heaviest weights. For the liver, pullets subject to the 35 °C had the lowest weight and were different ($P < 0.05$) from the other three treatments. For gizzard, the difference ($P < 0.05$) was between the treatments 20ºC and 35 °C. These results indicate that brooding temperatures tested during the first 6 weeks of life did not affect the viscera and bone weight during the growing phase.

Key words: heat stress, poultry, pullet, thermoregulation, viscera.

INTRODUCTION

Tropical and subtropical, characterized by high average temperatures in most of the year, are responsible for high animal protein production requiring special care regarding thermal stress, to which birds are predominantly submitted in most of the year. In this sense, the production environment is essential to reach high levels of productivity, with maintenance of the thermal comfort of the birds. Thus, the climatic environment cannot

be a determining factor for reducing production, and the heat stress (HS) negative effects must be managed.

The HS is a well-known cause of decreased development, growth and productivity of poultry (Cassuce et al., 2013; Lara & Rostagno, 2013; Cândido et al., 2016; Freitas et al., 2017; Santos et al., 2017; Arcila et al., 2018). When birds are exposed to stressful environments, physiological changes may occur, such as increased plasma corticosterone, changes in thyroid hormone levels triiodothyronine (T_3) and thyroxine (T_4), immunosuppression, elevation of heart rate and respiratory rate (Donkoh, 1989; Moraes et al., 2002; Sahin et al., 2002; Mack et al., 2013). Other changes resulting from stress are the behavioral changes of the birds, which can be reflected in anomalous behaviors (Zimmerman et al., 2000; Moura et al., 2008; Xie et al., 2015).

Also, the proper development of organs and the skeleton is determinant for a long productive life and birds' welfare, especially during the first phases of life. However, viscera and bone development may be also affected by HS (Moraes et al., 2002; Regmi et al., 2015; Casey-Trott et al., 2017). The laying hens skeleton becomes fully developed during the growing period, when the bird is a pullet. An underdevelopment in this phase may cause laying problems during the productive phase (Whitehead, 2004; Casey-Trott et al., 2017).

A hen spends over 76 weeks of her life laying eggs. To avoid economic losses during this period, the thermoregulation system must be prepared for cope to high environment temperatures. However, it is inferred that, possibly adapting to the Brazilian climate, the physiological responses of the birds can be altered, so that the areas currently considered as comfort in temperate climates may be different from those occurring in hot climates or tropical. This difference can occur due to changes in genetic and nutritional standards, environmental and breeding management, especially acclimatization to the conditions of the tropical climate (Cassuce et al., 2013; Arcila et al., 2018).

In this sense, objective of this study was to evaluate the effects of four different levels of HS in pullets viscera and tibia, when they were previously acclimatized to three different temperatures during the brooding phase.

MATERIALS AND METHODS

Experimental Design

All animal care procedures were approved by Ethics Commission on the use of Farm Animals of the Federal University of Viçosa (CEUAP-UFV Protocol No. 37/2016).

The research was conducted in two phases, pre-experimental and experimental. The pre-experimental phase was from day one through the 6th week of age, and the experimental phase started at the 7th week through the 17th week.

A total of 648 commercial replacement chicks (Lohmann LSL Lite) were randomly allocated to one of four controlled-environment chambers, housed from day one to 17 weeks of age. Each chamber measured 3.20 m x 2.44 m x 2.38 m (LxWxH). Chicks were placed inside steel cages measuring 0.50 m x 0.50 m x 0.50 m (LxWxH). The placement density was 140 cm² chick^{-1} for the first four weeks (17 chicks cage^{-1}), and 357 cm² chick^{-1} (seven pullets) from the 5th week to the 17th week per industry guidelines (Lohmann, 2016). The cages were equipped with 0.5 m of linear feeder at the cage front,

and one nipple drinker placed on a side midway between the front and back. Birds were provided with feed and water ad libitum and fed with a starter feed till the 6th week, and a grower feed thereafter (Rostagno et al., 2011).

The light program used was that recommended by the industry guidelines (Lohmann., 2016). The Light:Dark (L:D) hourly schedule was 24L:0D and 16L:8D, for days 1–2, and 3–6 respectively. It was then reduced by 1 hour per day, until the 6th week, finishing with 10L:14D applied for the remainder of the experiment.

Chamber temperatures were individually controlled with a microcontroller (model MT-531R Plus, Full Gauge Controls, Canoas/RS, Brazil), connected to an air heater (Model AB Split 1, Britania Eletrodomesticos S.A. Pirabeiraba, SC, Brazil) and an air conditioner (Model ABS 12FC 2LX, Komeco, Manaus, AM, Brazil). Relative humidity was maintained in the range of 40–60% with an ultrasonic humidifier (Model HUL535W, Kaz USA, Inc., Marlborough, MA) and the air conditioner. Ventilation was provided by two 10 cm axial fans (model FD08025 S1M, Ambition Technology Company, Guangdong, China), providing approximately 1.08 m^3 min^{-1} (3.6 air changes hr^{-1}) Air quality was monitored daily for ammonia (Gas Alert Extreme NH3 Detector, BW Technologies®, Oxfordshire, UK) and carbon dioxide (AZ 77535, AZ Instrument Corp., Taichung City, Taiwan). Chamber temperature and relative humidity were recorded by a datalogger (Model HOBO U14-001, Onset, USA), each five minutes for the entire experiment.

Pre-Experimental Phase. The pre-experimental phase of this work had the purpose of acclimatizing groups of chicks to one of three different air temperatures prior to assignment to different HS levels during the experimental phase. During this pre-experimental phase, the chicks were divided randomly into groups of 216 and placed into one of three environmental chambers, each one with a different air temperature (mild cold stress, thermal comfort, mild heat stress) as shown in Table 1. The chicks were subjected to the Pre-Experimental Phase temperatures 24h per day. Evaluation of performance and physiological responses of these chicks at the end of the pre-experimental phase are reported separately in Andrade et al. (2017). As important note for this study, the body weight of pullets at the start of this experiment were similar, averaging 418 g $bird^{-1}$.

Table 1. Air temperatures during the pre-experimental phase

Thermal Environment	1st week	2nd week	3rd week	4th week	5th and 6th week
Mild cold stress	28	25	23	20	17
Thermal comfort[1]	31-35	28	26	23	19
Mild heat stress	38	31	29	26	22

[1]Per Lohmann (2016); Albino & Carvalho, 2014.

Experimental Phase. The period from the 7th to the 17th week of age involved a total of 420 pullets, 140 of which were obtained from each of the three pre-experimental phase temperatures and divided into four groups of 35 pullets (five cages) and placed separately into one of the four experimental phase temperature treatments, as depicted in Fig. 1. These temperature treatments were denoted as: Thermal Comfort (TC, 20 °C); presumed Mild Heat Stress (MiHs, 25 °C); presumed Moderate Heat Stress (MoHs,

30 °C); presumed Severe Heat Stress (SeHs, 35 °C). During the night the air temperature was set to 20 °C, from 7:00 p.m. to 7:00 a.m. for all chambers.

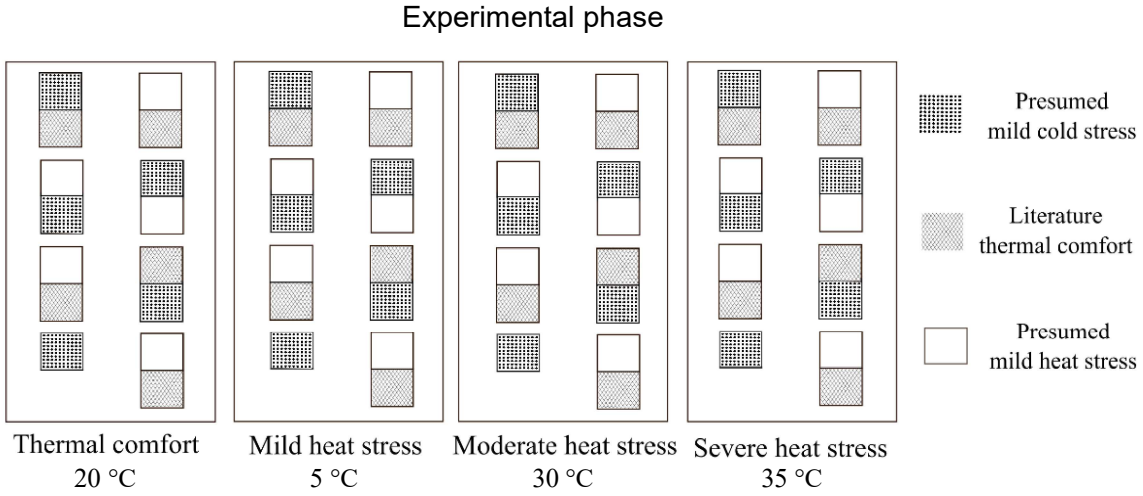

Figure 1. Experimental design of pullets' distribution in the environmentally controlled chambers during the Phase II, from the 7th through the 17th weeks of age.

Bone and Viscera Measurements

The bone and viscera measurements were assessed by weight measurements at the 17th week. For these measurements 2 pullets for cage (120 pullets) were obtained randomly and subjected to cervical dislocation. The viscera heart, liver, spleen and gizzard were removed and immediately weighed. The same procedure was done with the tibias.

Statistical Analyses

The experimental design was completely randomized in subdivided parcels (chambers), with four treatments (experimental phase temperatures - TC; MiHs; MoHs; SeHs), three sub-parcels (pre-experimental phase temperatures), their interactions, and five replicate cages per treatment x sub-parcel combination. The quantitative analysis of relative visceral weight (expressed as percentage of body weight) for heart, liver, spleen and gizzard, and the tibias weights was performed using analysis of variance (SAEG, 2007). Differences between group means were compared by Tukey's test, with a 5% confidence level ($P < 0.05$) for significance of treatment effects, interactions and differences between means.

RESULTS AND DISCUSSION

The target temperature levels were maintained each day of the 17-week experiment within 1.0ºC deviation. Effects of pre-experimental temperature treatment, experimental temperature and its interaction were not significant ($P > 0.05$) for tibia weight at 17th week of life, Table 2. In an experiment with chick broilers in the first week of life Moraes et al. (2002) found a difference in tibia weight between the ones at 20 °C compared with 25 °C and 35 °C. Also, Bruno et al. (2000) found difference between tibia weight for broilers raised in hot and thermoneutral environments. It is well-known that the fast

development of broilers may cause leg disorders and skeletal problems and, that hens have slower body development than broilers (Bruno et al., 2000; Whitehead, 2004). With this in mind, the contrast between the literature and the results of this work may be due the development velocity between the two types of birds.

Relative viscera weight from heart, liver, spleen and gizzard of pullets subjected to the 4 different experimental temperatures during the growing phase (TC, 20 °C; MiHs, 25 °C; MoHs, 30 °C; SeHs, 35 °C) are presented in Table 2. Effects of pre-experimental temperature treatment and its interaction with experimental temperatures were not significant ($P < 0.05$) for all evaluated viscera. Pullets subjected to 20 °C and 25 °C, had higher weight, for heart ($P < 0.01$) compared with pullets subjected to 30 °C, 35 °C. Pullets subjected to 35 °C had less weight, for heart ($P < 0.01$) and spleen ($P < 0.01$) compared with pullets subjected to 20 °C, 25 °C and 30 °C treatments. For the gizzard, only the treatments TC, 20 °C and SeHs, 35 °C were different from each other ($P < 0.01$).

Moraes et al. (2002), found higher absolute values for heart and liver weight in broilers subjected to cold stress, but this difference was not significant ($P > 0.05$). The difference between the viscera weight pattern in cold and hot environments can be due the fact of when birds are exposed to lower temperatures, especially in the first week of life if related to high metabolic rate, and increased oxygen demand to maintain the body temperature (Yang & Siegel, 1997).

Deaton et al. (1969) in an experiment with broilers reported lower liver weight for birds subject to heat stress when compared to the ones in thermoneutral and cold stress. These findings corroborate with this study. In stressed poultry is well-known the reduction in mass of lymphoid tissues, like thymus, spleen and bursa of Fabricius (Etches et al., 2000). In this experiment the spleen weight was reduced in pullets subject to severe heat stress.

Table 2. Relative visceral weight and tibia weight (expressed as percentage of body weight) of pullets subjected to 4 levels of experimental temperature, pre-experimental temperature, and interactions on the performance of pullets at 17 weeks of age

Thermal Environments	Performance Parameters				
	Heart (%)	Liver (%)	Spleen (%)	Gizzard (%)	Tibia (%)
TC, 20 °C	0.53[a]	1.57[ab]	0.17[a]	2.05 [a]	0.62
MiHs, 25 °C	0.50[a]	1.69[a]	0.17[a]	2.12[ab]	0.63
MoHs, 30 °C	0.49[b]	1.46[bc]	0.17[a]	2.05 [ab]	0.65
SeHs, 35 °C	0.43[c]	1.56[c]	0.16[b]	2.11[b]	0.70
SEM	0.49	1.39	0.26	2.29	0.46
P-value (Experimental phase)	< 0.001	< 0.001	< 0.001	< 0.01	ns
P-value (Pre - Experimental phase)[1]	ns	ns	ns	ns	ns
P-value (Interactions)	ns	ns	ns	ns	ns

[a–c] Means within a column with different superscripts differ significantly ($P < 0.05$); [1] Temperatures used in the Phase I are listed in Table 1; Treatments were: Thermal Comfort – 20/20 °C (TC); Mild Heat Stress – 25/20 °C (MiHs); Moderate Heat Stress – 30/20 °C (MoHs); and Severe Heat Stress – 35/20 °C (SeHs); ns = not significant; SEM: Root Mean Square Error.

CONCLUSIONS

The results of the study indicate that brooding temperatures tested during the first 6 weeks of life did not affect the viscera and bone weight during the growing phase.

The thermal environment affected pullets' viscera weight, as proved by the birds subjected to 35 °C, which resulted the most affected. The tibia relative weight was not affected either by the brooding temperatures tested nor by the temperatures during the growing phase.

ACKNOWLEDGEMENTS. AMBIAGRO research group, Department of Agricultural Engineering and Department of Animal Science of Federal University of Viçosa (UFV); Department ABE of University of Illinois at Urbana-Champaign and Department DAGRI of University of Florence. We also thank the Brazilian Government support through CAPES - Finance Code 001, CNPq and FAPEMIG. The authors would like to thank also Marcos Borges of Lohmann do Brasil for donating the birds.

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