International Journal of Applied Poultry Research

ISSN: 2222-1263
www.ijscience.com

Resistance of Local Chicken and Commercial Broiler Breeds to Chronic Heat Stress in Tropical Environment: 2- Effects on Blood and Physiological Parameters

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ABSTRACT

The global warming and climatic changes is particularly deleterious to tropical agriculture in general and to the animal genetic resources in particular, impairing initiatives for their sustainable management. In order to contribute to the mitigation of the effects of climate changes on agriculture, this study was carried out to determine the effect of hyperthermia on the haematology and physiological parameters of the local chicken and a commercial broiler breed in tropical environment. For this purpose, pens of local and exotic chicks after the starter phase were conducted separately at 25 and 35°C. In the two genetic types, the effect of heat stress caused an increase of 525.43% of leukocytes in exotic chickens and of 1778.43% in local chickens. The same was observed for the monocytes in local chickens (227.22%). The mean globular volume, mean cellular haemoglobin and mean cellular concentration in haemoglobin were reduced in the local chicken, by -10.23, -22.87 and -14.07% respectively, but the values of these parameters were increased in exotic chickens by 179.54, 214.09 and 12.36%. The results of heat tolerance indexes suggested that with age the local chicken easily overcome heat stress, while the exotic chicken become increasingly vulnerable. These results have been confirmed by the high mortality rate observed in the commercial stock under heat stress, while there was no mortality among the local chickens.

Key words: Adaptability; blood; chicken; hyperthermia; physiology
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How to cite this article: Keambou T C, HakoTouko B A, Mboumba S, Mezui Mezui T, Toukala JP, Boukila B and Manjeli Y, 2014. Resistance of local chicken and commercial broiler breeds to chronic heat stress in tropical environment: 2- Effects on blood and physiological parameters. Int. J. Appl Poult. Res. 3(2): 28-32

INTRODUCTION

The ambient heat of the tropical zones constitutes a major constraint to the development of poultry production in these areas, because it induces considerable economic losses in their breeding by leading to fall in productivity and increase in mortality (Gous, 2007; El-Gendy, 2009). To limit the harmful effects of heat, several technical solutions including nutritional or environmentally oriented actions are possible (Tesseraud and Temim, 1999; Yahav, 2000). To date, none of these techniques could restore the zootechnical performances close to those obtained in temperate climate, reason for which the genetic approach for solutions should be envisaged.

The local animal genetic resources are theoretically better adapted to their environment. Knowing that the response of chickens to thermal waves is based on their genetic constitution (Yalcin *et al.*, 1997; El-Gendy *et al.*, 2007), the use of the crossings between hypothetical thermo tolerant local chicken and the highly productive exotic standard breeds are sometimes recommended for the improvement of the breeds, strains or lines for better yielding poultry production in tropical environment. However, such an initiative requires a good control of preliminary parameters comprising adaptability to the heat stress of the existing breeds and strain involved in the crossbreeding programmes.

The objective of this study was to evaluate the effects of heat stress on the hematological and physiological parameters of local and exotic chickens in Cameroon.

MATERIALS AND METHODS

The animals

The parental chicken: The parental animals consisted of a normal feathering type of local chicken, whereas the commercial breed was a Hubbard terminal line from a neighbouring hatchery operator in western Cameroon.

After 15 days of adaptation in station during which all the animals were vaccinated against current diseases and subjected to internal and external anti-parasitic treatment, the pens of reproduction was formed, with a sex ratio of 1:8. Birds of all pens received feed ration containing 18.5% crude protein and 2730 Kcal/kg of metabolisable energy. The crossings were done by natural mounting. The eggs were collected and stored for a maximum 7 days. These eggs were treated and kept in a conventional way before being artificially incubated.

Experimental chicks: Among the chicks resulting from incubations, only the viable ones presenting normal feathering were retained for the experiment. The chicks of each genetic type were separated into two batches, of which one was reared under a continuous average temperature of 35°C and a relative humidity ranging from 68 to 90% until the 8th week. Each of the other batches was started at 35°C, the temperature was gradually reduced by approximately 3-4°C every week until the average ambient temperature of 25°C at the end of the 4th week. The chicks were placed on wood chip litter, receiving the broilers' conventional prophylaxis, and having free access to fresh water and to a ration made of 22.19% CP and 3046.8 Kcal ME/Kg. From the 1st-8th week, the animals were subjected to a continuous lighting.

Data collection: The rectal temperatures of the animals were taken twice a day, at 9am and 3pm, and 3 days per week. This made it possible to estimate the index of heat tolerance according to the following formula:

HTI = 100 – 10X (FG_{15}-TF_9)

Where:
HTI= heat tolerance index
TF_{15} = rectal temperature (in Fahrenheit degrees taken at 3pm)
TF_9 = rectal temperature (in Farad degrees taken with 9am)

At the end of the 8th week, a sample of six (06) chickens were randomly selected in each batch and starved for 24h, with access only to the drinking water, chicken slaughter by decapitation. The blood of each animal was immediately collected in two labeled test tubes with or without anticoagulant (EDTA).

The hematocrit was determined by the method of Benson et *al.* (1992). The counting of the erythrocytes (RBC) and leucocytes (WBC) was carried out by the hemocytometric method according to Theml (2000). The leucocyte count was done by the blood smear method and colored using the May-Grünwald-Giemsa. The concentration in cellular haemoglobin was carried out with a spectrophotometer and read at the wavelength of 540 nm according to the protocol provides by the CHRONOLAB SYS S.L. kit.

Serum creatinine was evaluated by the spectrophotometer using the kinetic quantitative method without deproteinisation at 492 nm according to the protocol of the kit provided by CHRONOLAB SYS S.L. laboratory.

The quantification of serum cholesterol was made by the Chod-Pod enzymatic colorimetric method with the spectrophotometer at the wavelength of 505 nm according to the protocol of the kit provided by CHRONOLAB SYS S.L. laboratory.

The erythrocytic constants such as mean globular volume (VGM), mean cellular haemoglobin (HCM) and the mean cellular concentration in haemoglobin (CCMH) was calculated according to formulae mentioned below (Akp *et al.,* 2009; Ayuk and Essien, 2009).

VGM = HT (%) x10/RBC (millions/µl)
HCM = Hb (g/dl) x10/RBC(x106 µl)
CCMH = Hb (g/dl) x100/HT (%).
Where:
HT = Hematocrit
RBC = Red blood cell
Hb = Haemoglobin
VGM = Mean globular volume
HCM = Mean Cellular haemoglobin
CCMH = Mean cellular concentration in haemoglobin

Statistical Analysis: The collected data were subjected to the generalized linear model of the analysis of the variance according to the following statistical equation:

Yijk = $\mu + g_i + t_i + (gxt)_{ij} + e_{ijk}$ Where:
Y_{ijk} = measured Value of the parameter of the individual k, of genetics type i, and under treatment j
μ = average general of the value of the parameter
g_i = effect fixes genetic type i(i= 1 - 2)
t_i = effect fixes temperature j (j= 1 - 2)
e_{ijk} = residual error
The analysis was performed using Excel 2003 and SPSS 12.0softwares.

RESULTS

Blood parameters: The blood parameters of local and exotic chicken according to the breeding temperature are presented in Table 1. The analysis of variance revealed that the majority of the blood parameters are significantly affected by the genetic type of chicken and breeding temperature; however, the interaction between these two factors significantly affects only the number of white blood cells and red blood cells.

The analysis of Table 1 revealed that the almost all of the blood parameters were significantly affected ($P<0.05$) by a rise in the breeding temperature. However, the rates of creatinine, haemoglobin and eosinophil were not significantly affected ($P \geq 0.05$) by an increase in the breeding temperature. Moreover, in local chicken, hematocrit, haemoglobin, and heterophil were not significantly affected ($P \geq 0.05$) by the rise in the breeding temperature from 25 to 35°C. The same were observed in exotic chicken for the lymphocytes and monocytes.

The variations in blood parameters between local and exotic chickens subjected to a raised breeding temperature compared to their counterparts under thermoneutrality are illustrated in figure 1.

The variations in the WBC were highest, i.e., an increase of 525.43% in exotic chicken and 1778.43% in local chicken. Moreover monocytes experienced an increase by 227.22% in local chicken exposed to heat stress.

With regards to the hematological constants, the heterophil/lymphocyte ratio increased with the heat stress by 25.78 and 23.67% in local and exotic chicken respectively. In addition, the mean globular volume, mean globular concentration in hemoglobin and mean corpuscular hemoglobin were all reduced in local chicken by -10.23, -2.87 and -14.07% respectively, but the values of these parameters increased in the exotic chicken type by 179.54, 214.09 and +12.36% respectively.

Table 1: Blood parameters of local and exotic chicken according to the breeding temperature

Parameters	Blood parameters				Signification		
	Local chicken		Exoticchicken				
	25°C	35°C	25°C	35°C	G	T	GXT
RBC($x10^6/mm^3$)	0.84 ± 0.27^{ab}	0.97 ±0.29^{b}	2.37 ± 0.72 ^{c}	0.70 ±0.24^{a}	**	**	*
WBC ($x10^3/mm^3$)	8.30 ± 2.69^{a}	155.91 ±44.69^{d}	13.13± 0.06^{b}	82.12 ±12.51^{c}	**	**	*
Hematocrite (%)	16.95 ±8.32^{a}	17.57 ±7.10^{a}	27.64 ±0.84^{c}	22.82 ± 4.47^{b}	*	*	NS
Cholesterol (mg/dl)	244.05 ±27.57^{a}	189.43±34.01^{b}	213.89 ±22.38^{b}	125.01±40.86^{a}	*	*	NS
Haemoglobin (g/dl)	24.88±9.37 ^{a}	22.16 ±10.38 ^{a}	39.27±11.03 ^{b}	36.43±5.83 ^{b}	*	NS	NS
Creatinine (g/dl)	2.00 ±0.00^{a}	1.89±0.09^{a}	2.00 ±0.00^{a}	2.17±3.00^{a}	NS	NS	NS
VGM	201.78	181.13	116.62	326.00			
HCM	296.19	228.45	165.69	520.43			
CCMH (g/dl)	146.78	126.12	142.08	159.64			
Lymphocyte	78.11 ± 7.02^{b}	69.87±4.49^{b}	59.00 ± 4.67^{a}	58.45±3.65^{a}	*	NS	NS
Monocyte	2.02 ± 0.01^{a}	7.62±3.38^{b}	7.00 ± 2.30 ^{b}	6.35±0.66^{b}	*	*	NS
Eosinophil	2.33 ± 0.02^{a}	3.12±1.96^{a}	6.33 ± 1.20^{b}	8.02±2.88^{b}	*	NS	NS
Heterophil	12.33 ± 3.10^{a}	16.87±3.91^{a}	21.00 ± 4.01^{b}	34.64±1.56^{c}	*	*	NS
Basophil	6.10± 0.22^{b}	2.50±1.41^{a}	7.01± 2.10^{b}	4.65±1.37^{ab}	NS	*	NS
H/L (%)	15.78	24.14	35.59	59.26			

a, b c on the same line, values with the same superscripts are not significantly different; ** = P<0.01; *= P<0.05; G= genetic type, T= temperature, GXT= genetic type x temperature interaction

Respiratory frequency: The evolution of the respiratory frequency in chickens reared at 25 and 35°C is illustrated in figure 2.

Independently of the genetic types and breeding temperature, the curves showing the evolution of the respiratory frequency displayed a general decreasing trend as the age of the chicken increases. Within the same genetic type of chicken and breeding temperature, the various curves present an evolution in saw teeth shape.

The instantaneous respiratory frequency deviation expressed in term of percentage between the various breeding temperatures of each genetic type and according to time is illustrated in figure 3.

When exposed to the heat stress, the local chicken initially increased its respiratory frequency by about 9.10 to 33.97% in the first three weeks of stress. This situation was reversed thereafter as from the following weeks. On the other hand, the exotic chicken exposed to the thermal stress immediately reduced its respiratory frequency by 17.27 to 12.43% respectively during the first and second week of stress, the variations of the respiratory frequencies in this later chicken thereafter oscillated the following weeks between the fairly positive and negative values, i.e. respectively +17.3, -33.50 and +34.62% between 6th, 7thand 8th week.

Heat tolerance index: The weekly evolution of the heat tolerance index of the various genetic types of chicken according to the breeding temperature is illustrated in figure 4.

It is clear from figure 4 that the curves of the heat tolerance index of the genetic types of chicken according to the breeding temperature display almost the same pattern during all the trial period. The variation in saw teeth shape of the HTI might be due to the fact that animals with increasing age permanently seek a thermal balance by the regulation of their physiological mechanisms.

Figure 5 illustrates the variation of the HTI in local and exotic chickens exposed to a rise in breeding temperature from 25 to 35°C.

As shown in figure 5, there exist only weak variations in body temperature of the animals under the conditions of this test.

In the first three weeks following the induction of the heat stress, the HTI drops gradually in local chicken by about -6.34 to -15.10%. Thereafter, this chicken manages to readjust its temperature and to increase its thermal tolerance from 8.61 to 5.85% respectively during 7th and the 8th week of breeding. On the other hand, with the initiation of heat stress, the exotic chicken seemed to better support the stress, but the difference between the tolerance of the birds raised under hyperthermia and their counterparts in situation of thermal neutrality, although positive remainder, is reduced gradually between the 5th and the 7th week before presenting a negative value (-2.10%) at the 8th week. These results led to believe that with age, the local chickens are better able to tolerate the heat stress, whereas the exotic chickens become increasingly susceptible.

DISCUSSION

This study showed that high breeding temperature affects the local as well as exotic chicken stock. This is demonstrated by blood parameters which are affected in such situation, impairing the normal physiological processes of growth. These results are in conformity with the observations of Ozbey *et al.* (2006). Hematology can be used to diagnose morphological, physiological and quantitative traits deteriorations associated the heat stress. The results obtained in this study agree with those of Kubena *et al.* (1972) according to which the exposure of chickens in general to a high temperature reduced the values of hematocrit and haemoglobin. The hematocrit which tends to grow in local chicken with the rise in the breeding temperature would be a sign of the adaptability of this animal to high ambient temperatures.

In general, the results of this study on the adaptability to heat stress are in line with those of Washburn *et al.* (1980), Arad and Marder (1982 a, b), Zérate *et al.* (1988), Leenstra and Cahaner (1992), Eberhart and Washburn (1993) and N'dri (2006). According to these authors, breeds with slow growth rate and local breeds of the countries with hot climate demonstrate better resistance to the heat stress than those selected for a high growth rate. The heat resistance being a character moderately to highly

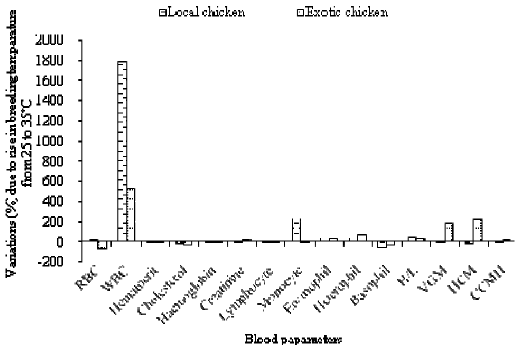

Fig. 1: Variation in the blood parameters in local and exotic chickens subjected to a rise in the breeding temperature from 25 to 35°C.

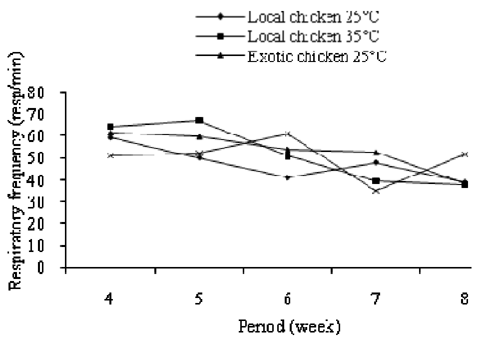

Fig. 2: Evolution of the respiratory frequency in local and exotic chickens reared at 25°C and 35°C

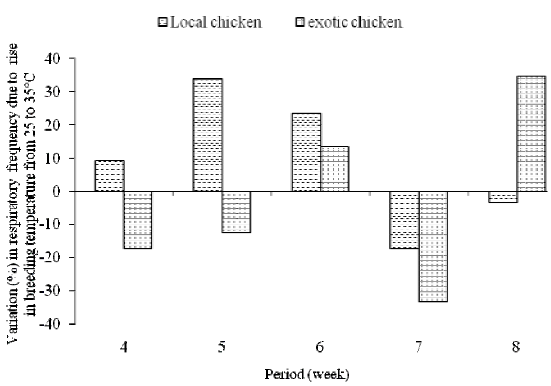

Fig. 3: Variation of the respiratory frequency in local and exotic chickens exposed to a rise in breeding temperature of 25 and 35°C.

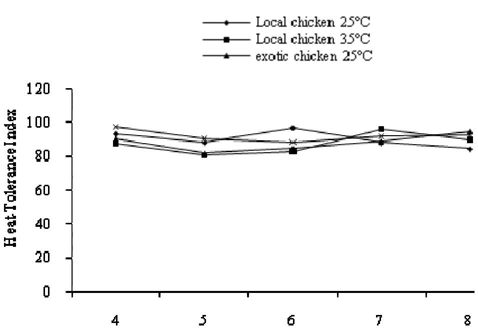

Fig. 4: Evolution of the heat tolerance index in local and exotic chickens according to the breeding temperature.

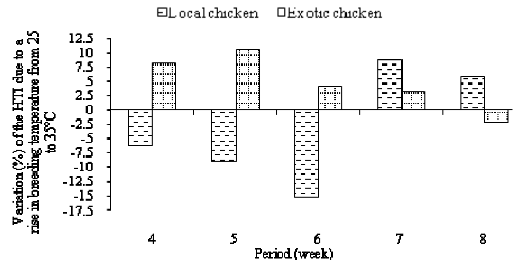

Fig. 5: Variation of the HTI in local and exotic chickens exposed to a rise in the breeding temperature from 25 to 35°C.

in heritable (N'dri, 2006), the local chicken can therefore effectively be used in genetic improvement programmes, by controlled crossbreeding and selection with highly productive strains for the creation of the stocks adapted to the production systems of the hot tropical countries.

Conclusion

In general, the local chicken tolerates the thermal stress better that its counterpart of commercial stock. Within sight of the genetic distance which would exist between these two genetic types and of the general and/or specific aptitudes of each one, a program of controlled crossing would make it possible to produce genetic types combining at the same time the good adaptive characteristics of local chicken and the performances of growth of the commercial stock, to satisfy the requirements out of animal proteins for an unceasingly increasing human population.

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