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Heat Tolerance Attributes of Nigerian Locally Adapted Chickens as Affected by Strain and Some Qualitative Traits

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Abstract
This study was undertaken to determine the heat tolerance attributes of Nigerian locally adapted chicken as affected by strain and some qualitative traits. The experimental birds consisted of four matured strains. A total number of 120 healthy matured birds consist of30 each of Naked Neck, Normal Feather, Fulani and Frizzle feather. Each bird was monitored and measured for the number of comb cups, comb length, comb height, wattle height and width at the beginning of the experiment and recorded for each strain. Data were obtained on a daily basis (afternoon) for 12 weeks. The measurement taken include: Numbers of comb cups, Comb length, Comb height, Wattle height, and Wattle width. The heat tolerance attributes considered were the rectal temperature, pulse rate and respiratory rate. Chicken strain and sex had significant effect ($P<0.05$) on pulse and respiratory rates. The lowest heat stress index, pulse and respiratory occurred in the naked neck with corresponding values of 0.84, 42.65beats/min and 40.26breath/min. Female birds had higher physiological values. Comb length and height differed significantly ($P<0.05$) with pulse and respiratory rates while no significant ($P>0.05$) effect was shown in rectal temperature. Comb cups also affected ($P < 0.05$) pulse and respiratory rates. The lowest pulse rates were obtained in chicken with measuring 5cm high and 4cm long. Regarding respiratory rate and heat stress index, the lowest values were recorded in chicken having combs that measured 8cm high 7cm long. The lowest respiratory and pulse rates were observed in chicken whose comb had 14 and 8 cups respectively. There was significant ($P < 0.05$) wattle size variation in pulse and respiratory rate and heat stress index. The lowest pulse respiratory rates were observed in 7cm wattle height while the lowest respiratory and heat stress index occurred in chicken whose wattle measured 7cm in diameter. However, 6 cm wattle width had the lowest pulse rate. It can therefore, concluded that strain, sex and some qualitative traits in chickens affect heat tolerance attribute.
Keywords : Heat tolerant, local chickens, physiological traits, qualitative traits, strain.

Introduction

In the tropical environment, periods of high temperatures have a negative effect on the health and performance of domestic animals. Poultry farming is no exception and the effect of stress caused by elevated temperatures can result in heavy economic losses from increased mortality and reduced productivity. For birds to perform at their optimum capacity they need to among other factors be in homeostasis with their environment through the maintenance of thermobalance (Zerjal et al 2013). Birds, like mammals are homoeothermic, they produce heat to maintain a relatively constant body temperature and may permit certain variations within their temperature range without significant perturbation. Normally, the chicken's body temperature is 41.5°C, but will fluctuate somewhat depending upon the temperature of its environment. Altan et al (2003) reported that high ambient temperature and relative humidity, increases heat stress and are responsible for the increase in rectal/body temperature (RT) of animals.Heat stress may result from exposure to high ambient temperature or from the inability to dissipate the metabolically generated heat.

Birds gain heat from the environment and their metabolism. They regulate the balance between heat production and heat loss to maintain their deep body temperature at approximately 40°C. Birds transport the generated heat to the body surface to allow sensible heat losses from surfaces such as wattles, combs, shanks, and unfeathered areas i.e. under wings to the surrounding environment because they do not have sweat glands (Azoulay et al 2011). Sensible heat loss is effective when the environmental temperature is below or within the thermoneutral zone ranging from 13 to 24°C (Schmidt-Nielsen 1997). Heat loss mechanism begins to shift to panting when the environmental temperature reaches more than 25°C. Birds have to increase their evaporative losses to maintain body temperature and therefore start to breath more rapidly and panting (hyperventilation) normally occurs at about 30°C (Azoulay et al 2011).

Heat stress is considered to be one of the most important variables affecting feed intake, body weight gain, mortality rate of chickens and reduced profitability of poultry meat production, particularly in hot climate (Deeb and Cahaner 2001). The change in climate that the earth is currently experiencing is dangerous to poultry farming (Isidahomen et al 2012). The purpose of this study therefore is to compare the heat tolerance attributes of the indigenous chickens in respect strain and some qualitative traits.

MATERIALS AND METHODS

EXPERIMENTAL SITE

The experiment was carried out at the Poultry Unit of Teaching and Research Farm, LadokeAkintola University of Technology, Ogbomoso, Oyo State, Nigeria. Ogbomoso is situated in the derived savannah zone of Nigeria on longitude 4^{o} 15$^{'}$ East and latitude 8^{o} 15$^{'}$ North east of the Greenwich meridian. The altitude is between 300 and 600m above sea level. The mean annual rainfall and temperature are 1247mm and 27^{o}C respectively (Ojedapo and Amao 2014).

EXPERIMENTAL BIRDS AND MANAGEMENT

The experimental birds consisted of one hundred and twenty (120) healthy matured twenty five weeks old Nigerian chicken. The strains were the naked neck (30), normal feather(30), fulani (30), and frizzle feather (30). The chickens were randomly selected from the population of local chicken reared at the study area. They were caged individually in a locally made galvanized metal 2-tier cage having a cell dimension of 15cm by 7.5cm.

EXPERIMENTAL FEEDS AND FEEDING

The male birds were fed *ad- libitum* with grower mash containing 16% Crude protein and 2450 kcal/kg Metabolizable Energy while the hens were fed layers mash containing 16.5% Crude protein and 2500kcal/kg Metabolizable Energy. Water was provided *ad- libitum*.

DATA COLLECTION AND DURATION

Each bird was monitored at 26 weeks of age for rectal temperature, pulse and respiratory rates three days a week for 12 weeks period (36 days) between January – March, 2015. Also, birds were observed and measured for the following qualitative parameters, namely, number of comb cups, comb length, comb height, wattle height and widthwithin sex and age. The measurements were carried out as follows,

Comb cups:- This was measured by counting the number of valley in each comb by visual appraisal

Comb length:-This was measured by placing a tape rule from where the comb starts on the head to where its end (cm).

Comb height:- This was done by measuring from the highest base (pointing attachment to the head)laterallyby a tape rule (cm).

Wattle height:- This was measured by placing a tape from the pointits attachment to the neck region downward to the tip (cm) and averaged.

Wattle diameter:- This was measured by a tape placed horizontally on each wattle (cm) and averaged.

Rectal Temperature: This was measured using a clean clinical thermometer inserted into the vent for one (1) minute after which the readings were taken (t˚C).

Respiration Rate: This was determined for each bird by counting the number of movements of abdominal region or ventfor one minute using a stopwatch and recorded as breadths/minute.

Pulse Rate: This was determined by placing the finger tips under the wing vein and counting the number of beats per minute using a stop watch and recorded as beats/minute.

Heat Stress Index: This was derived from the relationship between observed pulse and respiratory rate together with their normal values. The formula is as follow:

$$H = AR/AP \times NP/NR$$

Where; H=Heat stress index

AR= Observed respiratory rate
AP= Observed pulse rate
NP= Normal pulse rate
NR= Normal respiratory rate.

STATISTICAL ANALYSIS

Data obtained on each of the heat tolerance traits (rectal temperature, pulse rate, respiratory rate and heat stress index) were analyzed using the General Linear Model of SAS (2003). Significant means were separated using Duncan's Multiple Range Test of the same software. The model adopted is as specified below:

The data obtained on each of the physiological parameters were firstly analysed for the fixed effect of strain within each age and the model was shown below

$$Y_{ij} = \mu + A_i + e_{ij} \quad \text{...} (1)$$

Where

Y_{ij}= Individual measurements
μ = Overall mean for the parameter of interest

A_i= Fixed effect of the i^{th} age (i, = 1- 3)
e_{ij} = Random residual error normally distributed
Subsequently, the raw data was corrected for age effect, pooled and analysed for the fixed effects of strain and sex as shown in the model below:
$Y_{ijk} = \mu + S_i + Se_j + e_{ijk}$…………………………..(2)
Where
Y_{ijk} =Individual measurements
μ = Overall mean for the parameter of interest
S_i= Fixed effect of the i^{th} strain (i, = 1, 2, 3, 4)
Se_j =Fixed effect of the j^{th} sex (j = 1, 2)
e_{ij} = Random residual error normally distributed
The pooled data were corrected for the fixed effect of strain and sex and then analysed for the fixed effect of comb cups, comb length, comb height, wattle length and wattle width
$Y_{ijklmn} = \mu + Cc_i + Cl_j + Ch_k + Wh_l + Ww_m + e_{ijklmn}$ ------------------------------------ (3)
Where;
Y_{ijklmn}= individual measurement
μ = Overall mean for the parameter of interest
Cc_i = fixed effect of comb cups (i = 1, 2, 3, 4, 5, 6)
Cl_j= fixed effect of comb length (j = 1,2, 3, 4, 5, 6, 7)
Ch_k = fixed effect of comb height (k = 1, 2, 3. 4, 5, 6, 7, 8)
Wh_l = fixed effect of wattle height (l = 1, 2, 3, 4, 5, 6, 7, 8)
Ww_m= fixed effect of wattle width (m = 1, 2, 3, 4, 5, 6, 7)
e_{ijklmn}= error term normal distributed

RESULTS

Table 1 showed pooled mean values of physiological parameters as affected by strainand sex. Significant (P<0.05) differences were observed in strains and sex for the physiological parameters except rectal temperature. Frizzle birds had the highest values of pulse (52.72 beats/min) and respiratory rates (48.75breaths/min) while lowest values were obtained in the naked necks. Fulani ecotype and Normal feather birds were mostly stressed in term of heat. Female birds had more pulse (49.38 beats/min) and respiratory (47.11 breath/min) rates.

Pooled mean values of physiological parameters as affected by number of comb cups and comb size are shown in table 2. Number of comb cups affected (P < 0.05) heat stress index, pulse and respiratory rates.For comb cups, rectal temperature, pulse rate, respiratory rate and heat stress index varied from 40.83^{0}C to 41.09^{0}C, 43.00 to 62.25 beats/min, 41.57 – 50.25breaths/min and 0.72 – 0.99 respectively. The highest pulse and respiratory rates were obtained in chickens with five (5) comb cups while chicken with 14 and 8 comb cups had the lowest values of pulse and respiratory rates respectively. Though the values of pulse and respiratory rates did not follow a specific trend, however, observations revealed that increased pulse rate usually resulted in corresponding increased respiratory rate. Heat stress index was high in chicken with 14 comb cup but low in 5 comb cups.

Mean values of physiological parameters as affected by chicken's comb height and length are shown in Table 2. Comb length and height differed significantly (P < 0.05) with pulse and respiratory rates while no effect was shown in rectal temperature. The highest and lowest pulse rates occurred in chicken whose comb heights were 3 and 5cm respectively and 3 and 4 cmrespectively for comb length. Chickens having combs that were 3cm long and 2cm high had the highest respiratory rate. Respiratory rate and heat stress index decrease with increased number of comb height and length. Also, increased pulse rate usually led to decreased respiratory rate (negative correlation). Significant differences existed in heat stress index regarding comb height and length. The stressed chickens were those having comb measuring 8cm high and 7cm long.

Significant (P < 0.05) difference obtained in the pulse and respiratory rates regarding wattle sizes are as shown in table 3. Wattle length and width affected pulse and respiratory rates significantly (P < 0.05). Birds whose wattles were 8cm long had the highest pulse rate while those with 2cm long had more of respiratory rate. Birds having 1cm wattle length by 1cm wattle width had the highest pulse and respiratory rates. Respiratory rate decreased with increasing length and width of wattle. Generally, increased pulse rates resulted in decreased respiratory rate in the study.

DISCUSSION

The present findings on the physiological responses of chickens indicated that the responses are genotypes dependent. The current results on rectal temperature on the locally adapted chickens were in line with the work of Isidahomen et al (2012). The authors observed values for rectal temperature within the limits of 41^{0}C (106^{0}F) and also noted a similar range of values for normal, naked neck, frizzle, dominant blue and dominant black chickens in southern part of Nigeria. Meanwhile, the values as documented in this study for rectal temperature agree with the observation made by Oso et al (2013). The authors reported a similar range of values for local Nigerian turkeys offered dietary vitamins. The lowest and highest values of rectal temperature obtained for normal and naked neckin the 30th and 34th weeks were in line with the findings of Isidahomen et al (2012). The authors reported similar findings for naked neck and normal feather in their studies. The potential of naked neck over the other strains in respect of heat tolerant conformed to the documentations of Zerjal et al (2013) and N'dri et al (2007). However, values obtained in the present study for rectal temperature were not in line with the study of Eyarefe and Oguntunde (2012) who noted slight differences in values for Boran hybrid laying birds. This variation might due to the type of birds involved and the environment where the birds were managed.

Pulse rate as obtained in the present study, were not in agreement with the finding of Isidahomen et al (2012). These researchers although noted that genotypes variation in pulse rate, however, the values obtained in this study differed with what reported.The lowest heat stress index as witnessed in the naked neck genotype could be an indication that naked neck genotypes are tolerance to heat and can dissipate heat better than other genotypes as earlier documented by Eberhart and Washburn (1993) for naked neck chickens. The bare head and neck to dissipate heat effectively. Thevalues obtained generally in this present study on the heat stress index were in accordance with the works of El- Genoy et al (2007) on their findingson genotype-environment interaction in relationto heat tolerance in chickens.

The genotypes related responses on physiological traits in this current finding were in line with the study of N'dri et al (2007) for naked neck broiler chickens. This might due to the reducing feather coverage that has proved to increaseheat dissipation, allowing for a greater rate of radiation of body heat and a better thermoregulation. The results of sex effect on physiological parameters revealing that females were significantly higher than in pulse and respiratory rates suggests hormonal differences and possibly the egg laying processes the female birds witnessed their male counterparts. This sexual difference was in accordance with the findings of Uzma et al (2008) and Sayed and Scott (2008). They noticed differences on pulse rate of pigeon and broiler chickens favouring the females.

However, variation in pulse rateas observed amongst the strains agreed with the findings of Chen et al (2004). They reported that genotypes varied significantly in pulse rate but the values observed in their study differed with wide range from what was obtained in the present study. The general physiological response that existed in this presented study was in accordance withthe direct observation of Oke (2011) in local pullets reared in humid tropical environments.

Combs are important traits and they function in keeping the chickens cool and the blood that circulates between the comb and the wattle serve to cool the chicken down most especially during the hot period. Combsas a surface area where heat can be lost through evaporation. Comb cup in chicken further increase the surface area of the comb and the higher the number of comb cups, the higher the surface area. Numbers of comb cups significantly affectedpulse rate and respiratory rate with no significant effect on rectal temperature. Pulse rate decreases generally but later increase in birds with 8 and 10 cups and later decreases in bird's with14 cups. Respiratory rate followed the same trend. The low value of pulse rate and respiratory rate observed in birds with more number of cups may be as a result of increase surface area that confers a means of heat dissipation in the birds. Decrease in respiratory and pulse rate as the comb height and length increased may be due to large surface area which increased therefore providing more surfaces through which heat is loss via evaporation. Decreases pulse and respiratory rate as wattle length and breadth increases may be as a result of possession no more blood vessel and an increase in surface area which serves to cool the birds during hot period. Egahi et al (2010) concluded that the population of Nigerian local chickens had heterogeneity in qualitative traits measured and these variations may confer on individual birds differentials levels of tolerance in a stressful environment.

Conclusion

The study showed that genetic, sex, comb cups, comb and wattle sizes variation of the birds accounted for observed differences in pulse rate, respiratory rate, heat stress index. This is an indication that pulse and respiratory rates, values can be used in the classification of birds into genetically distinct subgroups of heat tolerance attributes. Attention should be paid to the qualitative traits as a means of reducing heat stress in chickens.

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Table 1: Pooled mean values of physiological parameters as affected by strain and sex of locally adapted chicken.

Variable	Obs	Rectal temp (T^0C)	Pulse rate (beats/minute)	Resp. rate (breaths/minute)	Heat Stress Index
Overall mean	228	41.04±0.04	47.50±0.51	44.39±0.64	0.84
Fulani	54	41.4±0.06	$43.76±0.78^c$	$42.78±1.28^{bc}$	0.87^a
NF	60	41.05±0.07	$50.03±0.65^b$	$45.18±1.19^b$	0.86^a
FF	60	40.95±0.09	$52.72±1.04^a$	$48.75±1.33^a$	0.83^b
NN	54	41.05±0.08	$42.65±0.92^c$	$40.26±1.04^c$	0.84^b
Sex:					
Male	84	41.03±0.06	$44.29±0.76^b$	$39.71±0.92^b$	0.80^b
Female	144	41.05±0.05	$49.38±0.63^a$	$47.11±0.78^a$	0.85^a

[a,b,c,d]Means occupying the same column having different superscripts are significantly different (P<0.05)
Obs.= Number of Observation, Resp. rate = Respiratory rate, NF = Normal feather, FF = Frizzle feather, NN = Naked neck.

Table 2: Pooled mean values of physiological parameters as affected by number of comb cups and comb size, comb height and comb length

Variables	Obs	Rectal Temp (T^0C)	Pulse rate (beats/minute)	Respiratory rate (breaths/minute)	Heat Stress Index
Overall mean		41.04±0.04	47.50±0.51	44.39±0.64	0.84
No of comb cups					
5	12	40.86±0.16	62.25±3.14^{a}	50.25±3.35^{a}	0.72^{d}
6	84	41.04±0.07	48.11±0.67^{c}	45.02±1.07^{ab}	0.84^{b}
7	84	41.09±0.06	45.75±0.69^{dc}	43.35±1.05^{ab}	0.85^{b}
8	30	41.03±0.09	45.97±1.41^{dc}	41.57±1.69^{b}	0.81^{c}
10	6	41.03±0.09	54.50±0.02^{b}	50.00±3.193^{a}	0.82^{c}
14	6	40.93±0.22	43.00±2.24^{d}	47.33±3.21^{ab}	0.99^{a}
Comb height (cm)					
1	42	40.96±0.09	48.36±0.98^{a}	45.21±1.62^{b}	0.84^{ab}
2	72	41.13±0.07	49.72±1.07^{a}	48.28±1.07^{a}	0.87^{a}
3	30	40.98±0.14	50.00±0.74^{a}	46.97±1.47^{b}	0.84^{ab}
5	6	40.87±0.32	41.33±0.84^{e}	43.50±3.36^{b}	0.94^{a}
6	30	40.96±0.10	46.1±1.40^{bc}	42.97±1.50^{c}	0.83^{ab}
7	30	41.17±0.09	42.73±0.78^{de}	37.43±1.39^{d}	0.78^{b}
8	18	40.97±0.13	44.83±2.28^{dc}	36.83±1.99^{d}	0.73^{b}
Comb length (cm)					
1	66	41.03±0.07	49.95±1.11^{ab}	47.47±1.29^{b}	0.85^{ab}
2	72	41.04±0.08	48.69±1.11^{ab}	46.00±0.93^{bc}	0.85^{ab}
3	6	41.33±0.13	51.33±1.61^{a}	56.50±3.08^{a}	0.99^{a}
4	6	40.93±0.22	43.00±2.24^{d}	47.33±3.21^{b}	0.99^{a}
5	36	41.11±0.09	43.67±1.01^{dc}	39.67±1.16^{cd}	0.81^{ab}
6	30	40.85±0.11	44.33±1.56^{dc}	39.67±1.73^{cd}	0.80^{b}
7	12	41.28±0.11	46.67±1.80b^{c}	36.17±2.43^{d}	0.67^{c}

[a,b,c,d]Means occupying the same column having different superscripts are significantly (P < 0.05)

Table 3: Mean values of physiological parameters as affected by chickens wattle size

Variable	Obs	Rectal Temp (T°C)	Pulse rate (beats/min)	Respiratory rate (breaths/min)	Heat Stress Index
Overall means		41.04±0.04	47.50±0.51	44.39±0.64	0.84^{a}
Wattle length (cm):					
1	102	41.03±0.07	49.43±0.81^{ab}	47.35±0.95^{a}	0.86^{a}
2	42	41.10±0.08	49.26±0.88^{ab}	46.52±1.37^{a}	0.84^{a}
5	24	40.98±0.12	46.25±1.12^{bc}	42.08±1.86^{ab}	0.81^{b}
6	48	41.02±0.88	43.39±0.99^{c}	39.46±1.14^{b}	0.81^{b}
7	6	41.12±0.36	37.17±3.18^{d}	36.00±0.03^{b}	0.87^{a}
8	6	41.27±0.19	50.67±2.32^{a}	36.00±4.13^{b}	0.63^{c}
Wattle width (cm):					
1	18	41.11±0.13	53.67±1.34^{a}	49.50±2.40^{a}	0.83^{ab}
2	11	41.03±0.06	48.68±0.74^{b}	46.56±0.85^{a}	0.86^{a}
3	12	41.13±0.14	49.58±1.03^{b}	48.75±3.11^{a}	0.88^{a}
4	18	40.89±0.14	49.22±1.42^{b}	45.00±1.81^{ab}	0.82^{ab}
5	12	40.98±0.16	47.33±1.65^{b}	40.58±2.24^{bc}	0.77^{b}
6	42	41.06±0.08	41.40±0.82^{c}	38.26±1.25^{c}	0.83^{ab}
7	12	41.19±0.19	43.92±2.77^{c}	36.00±2.43^{c}	0.73^{b}

[a,b,c]Means occupying the same column having different superscripts are significantly (P<0.05) different