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Original Research Article

Effect of Plumage Colour Genes on Body Measurements and Heat Tolerant Traits of Indigenous Chicken

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Abstract: This study was aimed to examine the effect of plumage colour genes on the body measurements and heat tolerant traits of indigenous chicken. A total of two hundred (200) adult chicken with different plumage colours comprising of black, white, red, brown and grey of both sexes reared by smallholder farmers with similar management system in Lafia, Nasarawa state, Nigeria were randomly sampled. Data were collected randomly at five (5) different locations in Lafia as thus: Kwandere, Shabu, Sabon Pegi, Tudun Gwandara and Tudun Amba respectively. Six body traits and four heat tolerant traits were measured on each bird: body length, breast circumference, thigh circumference, foot length, total leg length, wing length and Body temperature, Rectal temperature, pulse rate and respiratory rate. There was significant difference ($P<0.05$) for thigh circumference. The highest values for thigh circumference was observed for the white and grey plumage coloured chicken although not significantly different for those of brown plumage coloured. No significant differences were observed for the body length, breast circumference, wing length, foot length and total leg length for all the plumage coloured chicken. There was significant difference ($P<0.05$) for respiratory rate and heat stress index. The highest respiratory rate and heat stress index was observed for the white plumage coloured chicken. The white plumage coloured chicken were thermally stressed due to their inability to absorbed and withstand heat. No significant differences were observed for the remaining four plumage colours. Higher values of thigh circumference are the characteristics of meatiness in chicken. The coloured plumage chicken (Black, red, brown and grey) from this study possess the ability to better survive and adapt to heat stress due to their tendencies to absorbed heat compared to their white plumage coloured counterpart.

Keywords: Plumage colours, body measurement, heat tolerant traits, indigenous chicken.

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INTRODUCTION

Chickens are characterized by a wide variety of colour plumage (Negro *et al.*, 2016). Plumage colour is an important feature in birds, often determining assignment to a particular species or breed. The colour of the plumage largely determines how animals communicate with each other and plays an important role in adapting to environmental conditions and birds have a variety of feather colour patterns, which gave rise under the pressure of natural selection (Roulin and Ducrest, 2013). The pigments responsible for this diversity of plumage colours are deposited not only in the feathers but also in the most feathered parts of the body such as the beak and legs (Roulin and Ducrest, 2013). In birds, three groups of pigments that give variations in the colour of the plumage are melanin, carotenoids and unusual colours (for example, porphyrin). Most of these pigments are present only in certain groups of birds (Cooke *et al*., 2017). The most widespread in chickens are melanins and carotenoids. In poultry, including chickens, plumage colour can serve as a genetic marker, useful for the identification of breeds, populations and breeding groups with their characteristic features (Mitrofanova *et al*., 2017). The molecular genetic mechanism of the appearance of a particular type of colour is not yet fully understood, since several genes can have pleiotropic effect on the

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same trait. Some genes cause primary effects of colour, others play the role of modifiers and regulators that affect the zonal and regional distribution of the pigment and its distribution within the individual feathers (banding, spotting, edging and other patterns) (Yurchenko *et al*., 2015). This division is conditional and the manifestation of the pigment may differ in the colour of down, juvenile and adult plumage of chickens (Yang *et al.*, 2017).

Heat stress occurs mainly in the hot – dry season and during this period, birds have limited physical resource (nutrient) for growth and reproduction in response to environmental change and voluntary feed consumption is drastically reduced (Khan *et al*., 2011). The adaptation to this new challenge requires redistribution of body reserve of energy and protein to thermoregulation at the cost of decreased growth and reproductive efficiency (Kadim *et al*., 2008). The knowledge of the response of different plumage colour types on heat stress will help in the selection of suitable breeds/strain for each ecological niche. Therefore this study was aimed to examine the effect of plumage colour genes on the body measurements and heat tolerant traits of indigenous chicken.

MATERIALS AND METHODS

Experimental Birds and Sampling

A total of two hundred (200) adult chicken with different plumage colours comprising of black, white, red, brown and grey of both sexes reared by smallholder farmers with similar management system in Lafia, Nasarawa state, Nigeria were randomly sampled. Data were collected randomly at five (5) different locations in Lafia as thus: Kwandere, Shabu, Sabon Pegi, Tudun Gwandara and Tudun Amba respectively. In each location a total of forty (40) chicken were sampled.

Description of Study Location

Lafia lies within the Guinea savanna zone of Nigeria at Latitude 8.33^0N and Longitude 8.33^0E. It is positioned at altitude 181.35m above sea level with an average rainfall of 1182mm annually (NIMET, 2017). It enjoys two separate seasonal periods namely; rainy season (April- September) and dry season between (October-March).

Six (6) body traits were measured on each bird: body length (BL):-this was taken between the tip of the Rostrum maxillare (bill) and that of the Cauda (tail, without feathers), breast circumference (BC):- this was taken under the wings at the edge of the sternum, thigh circumference (TC):-this was measured as the circumference of the drumstick at the coxa region, foot length (FL):-this was taken as the distance from the shank joint to the extremity of the Digitus pedis, total leg length (TLL):-this was taken as the length of the femur, shank and metatarsal and wing length (WL) this was taken from the shoulder joint to the extremity of the terminal phalanx, digit 111.

Heat-tolerant data collection

Four (4) heat tolerant traits were measured on each bird as described by Yahav and McMurtry (2001): Body temperature (BT):- this was measured using a clean clinical thermometer placed under the wing for one minute after which the readings were taken (˚C), Rectal temperature (RT):- this was measured using a clean clinical thermometer inserted into the vent for one minute after which the readings were taken (˚C), pulse rate (PR):- this was determined by placing the finger tips under the wing vein and counting the number of beats using a stop watch and recorded as beats/minute and respiratory rate (RR):- this was determined for each bird by counting the number of movements of abdominal region or vent for one minute using a stopwatch and recorded as breath/minute.

Statistical analysis

The General Linear model (GLM) of SPSS version 22 (2015) was adopted to test the fixed effects of plumage colour genes on body measurements traits (BL), (BC), (TC), (FL), (TLL), (WL) and heat- tolerant parameters (BT, RT, PR and RR). The following linear model was employed:

$Y_{ij} = \mu + P_i + e_{ij}$

Where;
Y= individual observation
μ = general mean of the population
$P_{i=}$ plumage colour genes (i=1, i=2,i=3, i=4, i=5) i.e 1= Black, 2= White, 3=Red, 4=Brown, 5=Grey
e_{ij}= error term.

RESULTS

Table 1: Effect of plumage colour genes on body measurement traits of indigenous chicken

Traits (cm)	Black (BB)	White (W^{wt})	Red (RR)	Brown (Bb)	Grey (A^g)	Sig
Body Length (BL)	39.64±0.91	40.18±0.90	38.42±0.90	39.63±0.89	39.12±0.91	NS
Breast Circumference (BC)	39.53±0.67	40.34±0.67	39.28±0.67	40.07±0.66	40.39±0.67	NS
Thigh Circumference (TC)	$10.23±0.37^{bc}$	$11.43±0.37^{a}$	$9.60±0.0.37^{c}$	$11.07±0.36^{ab}$	$11.39±0.37^{a}$	**
Wing Length (WL)	31.92±0.50	33.26±0.49	32.03±0.49	33.44±0.49	32.56±0.50	NS
Foot Length (FL)	7.01±0.23	7.18±0.22	6.90±0.22	7.54±0.22	7.51±0.23	NS
Total Leg Length (TLL)	30.65±0.70	31.23±0.69	30.85±0.69	31.80±0.68	31.90±0.70	NS

[ab]means within the same row with different superscripts are significant (P<0.05). ** Significant at 95%. NS- Not significant, Mean ± S.E- standard error of the mean

The result of (Table 1) showed the effect of plumage colour genes on the body measurement traits of indigenous chicken. There was significant difference (P<0.05) for thigh circumference. The highest values for thigh circumference was observed for the white and grey plumage coloured chicken. However the result were no significantly different for those of brown plumage coloured chicken. No significant differences were observed for the body length, breast circumference, wing length, foot length and total leg length for all the plumage coloured chicken.

Table 2: Effect of plumage colour genes on heat- tolerant traits of indigenous chicken

Traits	Black (BB)	White (W^{wt})	Red (RR)	Brown (Bb)	Grey (A^{g})	Sig
Body temperature (^{0}C)	40.17±0.16	40.12±0.16	40.43±0.16	40.56±0.16	40.52±0.16	NS
Rectal temperature(^{0}C)	41.74±0.12	41.42±0.12	41.78±0.12	41.64±0.12	41.63±0.12	NS
Pulse rate (^{0}bpm)	75.40±0.77	74.60±0.77	75.10±0.77	74.78±0.77	74.73±0.77	NS
Respiratory rate (bpm)	25.58±0.58^b	27.95±0.58^a	26.30±0.58^b	25.15±0.58^b	24.83±0.58^b	**
Heat stress index (HSI)	2.83±0.07^b	3.15±0.07^a	2.92±0.07^b	2.79±0.07^b	2.77±0.07^b	**

^{ab}means within the same row with different superscripts are significant (P<0.05). ** Significant at 95%, NS- Not significant, Mean ± S.E- standard error of the mean, ^{0}bpm- beats per minute, bpm- breaths per minute.

The result of (Table 2) showed the effect of plumage colour genes on the heat tolerant traits of indigenous chicken. There was significant difference (P<0.05) for respiratory rate and heat stress index. The highest respiratory rate and heat stress index was observed for the white plumage coloured chicken. This means that the white plumage coloured chicken were thermally stressed due to their inability to absorbed and withstand heat. No significant differences were observed for the remaining four plumage colours. This means that the other plumage coloured chicken were not thermally stressed and can better adapt to the environment changes. The result of body temperature, rectal temperature and pulse rate were not significant for all the selected plumage colours respectively.

Table 3: Test of homogeneity of variance of biometric traits

Traits (cm)	Levene statistics	Sig
Body Length (BL)	0.39	0.82^{NS}
Breast Circumference (BC)	1.35	0.25^{NS}
Thigh Circumference (TC)	0.41	0.80^{NS}
Wing Length (WL)	0.82	0.51^{NS}
Foot Length (FL)	1.68	0.16^{NS}
Total Leg Length (TLL)	1.67	0.16^{NS}

The result of (Table 3) showed the homogeneity of the experimental materials for the biometric measurements. The result of all the body measurement traits were not significant (P<0.05). This means that the experimental materials were homogenous.

Table 4: Test of homogeneity of variance of heat tolerant traits

Traits	Levene statistics	Sig
Body temperature (^{0}C)	2.18	0.07^{NS}
Rectal temperature(^{0}C)	1.09	0.36^{NS}
Pulse rate (^{0}bpm)	1.56	0.19^{NS}
Respiratory rate (bpm)	6.56	0.00**
Heat stress index (HSI)	6.85	0.00**

The result of (Table 4) showed the homogeneity of the experimental materials. The result of body temperature, rectal temperature and pulse rate were homogenous whereas Respiratory rate and Heat stress index were not homogenous and this could be due to the variation in the location of the experimental materials (chicken).

DISCUSSION

The colour of the plumage is a trait that is used as a key factor in the interaction of chicken with each other due to their well-developed visual perception of the world. Poultry plumage colour determines the decorative qualities and is a marker for the identification of breeds, populations and breeding groups. The variety of plumage colour is formed as a result of two interrelated physical processes – chemical and optical, through which pigment and structural colours are formed.

The highest values for thigh circumference was observed for the white and grey plumage coloured chicken. The significant difference obtained for thigh circumference of this study is in agreement with the

report of Faith *et al.,* 2018 who reported significant difference in the thigh circumference of indigenous normal feathered chicken of both sexes. Deeb and Cahaner, (2001) also reported significant difference for thigh circumference between males and females indigenous normal feathered chicken. No significant differences were observed for the body length, breast circumference, wing length, foot length and total leg length for all the plumage coloured chicken.

Plumage colour as a genetic factor is known to adapt chicken to different climatic zones and also has considerable influence on the performance of various stocks. High temperature is as a result of the effect of the high absorption rate of the ultraviolet rays of the sunlight by the pigments on the plumage of the chicken and the influence of the environmental temperature. The result of this study agrees with the result of Sanusi, (2012) who reported that body temperature of white plumage was consistently lower than coloured plumage. The highest respiratory rate and heat stress index was observed for the white plumage coloured chicken. The white plumage coloured chicken were thermally stressed due to their inability to absorbed and withstand heat. No significant differences were observed for the remaining four plumage colours. The result of body temperature, rectal temperature and pulse rate were not significant for all the selected plumage colours respectively.

It has been reported that elevated temperature and high relative humidity could result in heat stress which could lead to elevated pulse rate (Ayo *et al*., 2011). In the present study, the values of other heat tolerant parameters other than pulse rate indicate the ability of the chicken to cope with the vagaries of weather in Lafia, Nasarawa State found within the tropical guinea savanna zone of Nigeria. According to Isidahomen *et al.,* (2012), the possession of genes for adaptability might have aided birds in withstanding harsh environmental conditions. The importance of heat tolerance parameters in assessing stress has also been reported in chickens (Adedeji *et al*., 2015; Yakubu *et al*., 2018). The highest pulse rate was recorded for Black (BB) colour gene. This result agreed with the report of Butswat *et al*., 2000 which showed that heat flow from the environment into the body of a black steer on a hot sunny day was 30% greater than that of a white steer thereby resulting in an increase in the pulse rate of the black steer. The possible reason for this result could be due to the environmental influence on the animals. The influence of the plumage colour genes on chicken could determine their adaptability and survivability in a particular environment. The genetic potential of a chicken could be predetermined through the influence of the plumage colour on heat stress traits. White plumage coloured chickens were more thermally stressed due to their high values of the heat stress index (HSI) compared to their counterparts. It could be concluded that black, red, brown and grey plumage coloured genes were found to better withstand heat than the white plumage coloured genes thereby providing them with better advantage for adaptability and survivability.

CONCLUSION

The coloured plumage chicken from this study possess the ability to better survive and adapt to heat stress due to their tendencies to absorbed heat than their white plumage coloured counterparts.

Conflict of Interest: The authors have declared no conflict of interest.

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