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Genotype-Sex Interaction in Relation to Heat Tolerance Attributes of Pure and Crossbred Chicken Progenies

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Abstract
The study was carried out to evaluate the genotype-sex interaction in relation to heat toleranceattribute of pure and crossbred chicken progenies in a 12-week study. A total of twohundred and seventy two chickens were used for this study. These consisted of 150purebred chickens consisting of Isa Brown, Fulani Ecotype,Naked Neck, Normal Feather and Frizzled Feather; and 122 crossbred comprising, NN x IB, FF x IB, IB x NF and IB x FE progenies. Under natural heat stress environment genotype were significantly ($P<0.05$) affected by rectal temperature, pulse rate and respiratory rate. The Isa Brown had the highest value of rectal temperature (41.74°C), respiratory rate (56.76 breath/min), pulse rate (56.83beat/min) while normal feather obtained the lowest values of these traits. Crossbred of FF x IB had the highest value of rectal temperature, respiratory and pulse rates of 41.75°C,58.67 breath/min and 54.49beat/min respectively. Significant ($P<0.05$) effect was obtained among the sexes of pure and crossbred chicken progenies in response to heat tolerance trait, with female chickens of pure and crossbred progenies had higher responsesto heat tolerance attributes than their female counterparts. It can be concluded that Isa brown chickens were more stress among the pure and FF x IB among the crossbred with female chickens due to their physiological activities.
Keywords: Heat tolerance, Genotype, sex, local chickens, exotic birds, crossbred progenies

Introduction

The tropics are characterized with high ambient temperature, rainfall, high direct and indirect solar radiation and humidity while their interaction with air speed and radiant heat have deleterious effects on productive performance of different poultry species. Poultry flocks are particularly vulnerable to climate change because there is a range of thermal conditions within which animals are able to maintain a relatively stable body temperature in their behavioural and physiological activities. Hence, birds can only tolerate narrow temperature ranges to sustain the peak of their production for human consumption and any unpredictable climatic changes will therefore trigger a series of adjustment and readjustments by livestock and poultry birds in the struggle for survival which may have negative consequence on the viability of poultry production (Etches et al 2008).

The body temperature of domestic chickens is maintained within a relative narrow range that is usually reflected by the upper and lower limits of a circadian rhythm. A comfortable temperature range for chickens is between 21-26^{0}C (Mashaly et al 2004). High ambient temperature has a negative effect on growth rate and egg production of commercial chickens due to the difficulty of dissipating metabolic heat, which leads to an increase in body temperature that can be lethal in extreme cases (Cahaner et al 2008). Heat dissipation capacity is hindered by the insulating property of feathers, which is advantageous in cold conditions (Leeson and Walsh 2004) but has a negative effect on thermoregulation in hot climates (Yahav et al 1998).The reduction of feather coverage has proved to increase heat dissipation, allowing a greater rate of radiation of body heat and a better thermoregulation (Eberhart and Washburn, 1993).

The indigenous Nigerian strain of chickens have been reported to have many advantageous gene complexes or gene markers, that could be harnessed in the development of meat or egg type chickens suitable for used in the tropics (Machebe and Ezekwe, 2004). Measures of rectal temperature (RT), pulse-rate (PR) and respiratory rate (RR) are some of the most important determinants of the adaptation of poultry to the tropical environment. They also, to a large extent, determine the profitability of the poultry enterprise (Ilori*et al*., 2012). Animal is considered to be stressed when it has to alter its physiology and behaviour to adapt to adverse environmental and management conditions. This adaptation involves a series of neuroendocrinological, physiological, and behavioural responses which act to equilibrate animal functions. The maintenance of body temperature within physiological limits is necessary for the animal to remain healthy, survive, and maintain its productivity and longevity (Marai et al 2007). The aim of this present study seeks to determine the genotype – sex interactionin relation to heat tolerance attributes of pure and crossbred chicken progenies.

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° 15' East and latitude 8° 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 Animal and Management
Before the arrival of the birds, the pen was washed, disinfected and sanitized with formalin® and morigad®. The battery cage used was locally built (Galvanized metal) and it was a two-tier cage. On arrival, the birds were housed for seven days in an adequate room for proper adaptation. In the adaptation norm, the birds were given adequate treatment as delousing, deworming, vitamins and anti-stress etc. The experimental birds were fulani ecotype, normal feather, frizzle feather and naked neck chickens sourced from villages around the study site.A total of 80 experimental birds consisting 15 fulani ecotype, 30 normal feather, 15 frizzle feather and naked neck were sourced and used for the study.However, 20 Isa Brown breeder cock (5) and hens (15) were purchased from a reputable farm at 14 weeks of age.

Experimental Feed and Feeding
The birds were fed *ad libitum* with commercial breeder mashcontaining 16.5% crude protein and 2500Kcal/kg Metabolizable Energy and clean water was also provided. Medications and vaccinations were done as required.

Mating Procedure
All mating was done when the cocks were at 20 weeks and hen at 23 weeks of age by artificial insemination. The massage technique described by Lake (1962) was used to collect semen from the sires. Each dam was inseminated with 0.1ml of undiluted semen twice a week in the evening (016hours). The birds were mated as follows;

Purebreds
Isa Brown x Isa Brown
Fulani ecotype x Fulani ecotype
Naked neck x Naked neck
Normal feather x Normal feather
Frizzle feather x Frizzle feather

Crossbreds
Naked neck (male) × Isa brown (female): NN x IB
Frizzle feather (male) × Isa brown (female): FF x IB
Isa Brown (male)× Normal feather (female): IB x NF
Isa Brown (male) x Fulani ecotype (female): IB x FE

Egg collection and Incubation
The fertile eggs were collected, pedigreed along each genotype every day for six days. Eggs collected were stored at room temperature of 14-20^{0}c and relatives humidity of 75% before they were sent to a reputable hatchery for incubation. The eggs were set in cabinet type incubator with adequate temperature(38-39^{0}C) and relative humidity of 55-56% for the first 18th days. The temperature was increased to a range between 39-40^{0}Cand relative humidity (70 – 75%) from 19th days to hatching time. Candling of the eggs was done twice at 3rd and 19th days of incubation fertilized eggs were sorted out before hatching.

Housing and management of chicks
All chicks resulting from each genotype were properly identified by wing tagged with an industrial galvanised aluminium tags at the wing web at day old. All the birds were raised under the same intensive management system.The day old chicks were transferred to a separate and previously disinfected brooders pen. Every batch was brooded for four weeks period. The chicks were fed with a commercial chicks mash that supplied 22% crude protein and 11.1KJ/g Metablizable Energy up to 6 weeks of age. Thereafter, they were fed with commercial grower's ration that supplied 16% crude protein and 10.48KJ/g Metabolizable Energy. Clean water was supplied *ad-libitum.* Medication and vaccination were done as at when due. At 13weeks, the birds were sorted out based on genotype and they were moved into already cleaned and disinfected 2-tier battery the cage.

Data collection
Data on rectal temperature, respiratory and pulse rates were collected on 272 birds. The data were collected when the birds were 14 weeks of age and it was done on weekly basis till when the birds were 17 weeks old. Physiological parameters were measured as follows,
Rectal temperature: This was measured using a clean clinical thermometer inserted it into the vent for one (1)

minute after which the readings were taken at ^{0}C.

Respiration rate: This was determined for each bird by counting the number of movements of abdominal region or vent for a minute using a stopwatch and recorded as breaths/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.

Heat stress index: The heat stress index (HSI) was derived from the relationship between pulse rate and respiratory rate together with their normal average values. The formula is as follows

H= (AR/AP) × (NP/NR)
H=Heat stress index
AR=Average respiratory rate value
AP=Average pulse value
NP=Normal pulse rate value
NR=Normal respiratory rate (Isidahomen et al 2012)

Statistical Analysis

Data obtained on heat tolerance traits were analysed for the fixed effect of genotype, sex and genotype x sex interaction using the General Linear Model Procedure of SAS (2003). Significant differences were separated using Duncan Multiple Range Test of the same software. The model adopted is as specified below;

$Y_{ijk} = \mu + G_i + \alpha_j + (G\alpha)_{ij} + e_{ijk}$

Where

Y_{ijk}=kth individual measurements at jth sex and ith genotype
μ= Overall mean for the parameter of interest
G_i= fixed effect of the ith genotype (1, 2, 3, 4, 5)
α_j=fixed effect of the jthsex (1,2)
$(G\alpha)_{ij}$= interaction effect of ithgenotype and jthsex
e_{ijk}= Random residual error normally distributed

RESULTS

Table 1 showed the mean values of rectal temperature, respiratory rate, pulse rate and heat stress index of pure and crossbred chickens. Significant($p<0.05$) differences in the physiological parameters were observed in each of the genetic groups. In the purebred chickens, rectal temperature values observed ranged from 41.59^{o}C to 41.74^{o}C.Isa brown genotype had the highest value (41.74^{o}C) of rectal temperature followed by Fulani ecotype and the lowest value (41.59^{o}C) was obtained in the frizzle feather birds. Values observed for respiratory rateranged from 46.16 - 56.76 breaths/min withIsa Brown recording the highest value (56.76 breaths/min)and normal feather had the lowest value (46.16 breaths/min). Similarly, Isa brown had the highest pulse rate (56.83beats/min) but not significantly different ($P > 0.05$) from the value obtained in the naked neck. However, the lowest pulse rate was observed in the Fulani ecotype (42.75beats/min). Heat stress index ranged from 0.74 – 0.90 with the highest heat stress occurring in the Isa brown followed by Fulani ecotype while the least stressed was the frizzle feather birds (0.74). Amongst the crossbreds, FF x IB had the highest rectal temperature (41.75^{0}C) and respiratory rate (58.67 breaths/min). However, the highest pulse rate (54.91 beats/min) and heat stress index (1.15) were observed in the crosses between NN x IB and IB x FE respectively. The lowest rectal temperature (41.63^{0}C) and heat stress index (1.05) occurred the NN x IB crossbreds.

Significant ($P <0.05$) effect was observed for the pooled mean valuesof respiratory rate, pulse rate and heat stress index of both pure and crossbred progenies in Table 2. Purebred female chickens had higher values of 51.13 breaths/min, 51.69 beats/min and 0.79 heat stress index. Similar trend was also observed with the crossbred progenies.

The means values of heat tolerance attributes of purebred chickens as affected by genotype and sex interaction is as shown in Table 3. Significant ($P <0.05$) genotype x sex interaction effect was observed on physiological parameters understudy. The table revealed no particular trend but generally male chickens in each genotype had more of rectal temperature and pulse rates. In contrast, more of pulse rate and heat stress index were obtained in the female of all genotypes.

Genotype – sex interaction effect on heat tolerance attributes of crossbred chickens is presented in Table 4. Significant ($P < 0.05$) variations were observed in all the heat attribute indices within each genotype. Male progenies of NN x IB, FF x IB, IB x NF and IB x FEcrossbreds had the higher rectal temperature while their females counterpart had higher values of respiratory, pulse rates and heat stress index.

DISCUSSION

The ability of birds to reproduce and produce under adverse environments has been found to be a breed and sex dependent, expressing genetic-environment interaction. Therefore, the permanent and biologically founded genetic-environment interaction can be employed to maximize the efficiency ofpoultry production under sub-optimal environments by means of identifying and exploiting genotypes specifically adapted to these environments. The results of rectal temperature, respiratory and pulse ratesas expressed by the purebreds correspond with the reports of Yalcin et al (1997) that the size of the animal also affects the respiratory rate. The heavier breed, which were the Isa brown, had the highest respiratory rate for most part of the traits followed by fulani ecotype and naked neck, which could beattributed to the fact that the rate of metabolism is higher in heavier birds since they possess larger surface areaand which could leads to increase in rate of exchange of gases. The present result also agreed with the work of Isidahomen et al (2012) for Nigerian locally adapted chickens and exotic chickens. The observed differencesin rectal temperature among the genotypesin this current study corroboratedwith the findings that notable difference between breeds in their ability to regulate rectal temperature (Finch 1986) atnormal environmental conditions.The Isa brown chickens had the highest mean values for physiological traits while the local had the least. This implies that the exotic chickensused in this study were more stressed than their counterparts. This observations was in line with the documentation of Justin (2004) who describe heat stress index as a function of the deviation of actual from targeted environmental temperature and the higher the index, the higher the severity of the heat stress and Isidahomen et al (2012) who also reported higher heat stress for Dominant blue and black chickens against the local birds in their study. Thus, the pattern of heat attribute displayed among the genotypes chickens was in harmony with the notice of Lara and Rostagno (2013). The authors reported variations in different poultry species in respect to heat stress. However, Sharifi et al (2010), in the studyon the effect of high ambient temperature on reproductive performances in homozygous and heterozygous frizzle broilers, found no significant advantage for the heterozygous genotype. The frizzle homozygous hens instead maintained higher reproduction performances under heat stress compared with the normally feathered hens, whereas they were less efficient under temperate conditions.

Meanwhile, results of current study on the heat tolerance traits for crossbred progenies was in line with works of Chen et al (2004) on the study of high ambient temperature and naked neck genotype on performance of dwarf brown-egg layers selected for improved clutch length and the authorsnoted that different genotypes variation for the traits measured in relation to heat tolerance traits were due to different genetic make-up of the genotypes involved.The findings reported by Ilori et al (2012) on physiological adaptation crossbred turkeys to the hot and humid tropical environment of Nigeria was also similar to the results on crossbred chicken progenies in this present study with suggestion that heat tolerance attribute can be easily controlled and minimal when combination of genes were involved.

Significant differences of genotype x sex interaction in favoured of females may be attributed to various physiological factors associated with females. For example, during egg formation and egg-laying, females are in restless and excited condition (Iheukwumere and Herbert 2003). The pattern and variation of responses of heat tolerance of the genotypes in this present study in respect to sexes were in line with the Cahaner and Leenstra (1992) whoreported that female broilers were more reacted to heat tolerance than male broilers in their observation on high temperature on growth and efficiency of male and female broilers from lines selected for high weight gain, favorable feed conversion, and high or low fat content.The earlier documentation of N'dri et al (2007) on interactions between naked neck gene, sex, and fluctuating ambient temperature on heat tolerance, growth, body composition, meat quality, and sensory analysis of slow growing meat-type broilers was similar to this present study that favoured female birds.

Conclusion

The findings reveals an indication that rectal temperature, pulse rate, respiratory rate, heat stress index can be used in the classification of birds into genetically distinct sub-group in the tropical environment characterized by heat stress. Hence, to achieve ultimate improvement in poultry production, breeding programs must target the genotypes that perform quite well in relevant regions. For this, local breeds currently receive much concern in research and their crossbred.

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Table 1: Mean values of physiological parameters of pure and crossbred chicken progenies

GENOTYPE	OBS	RECTAL TEMPERATURE (^OC)	RESPIRATORY RATE (Breaths/min)	PULSE RATE (Beats/min)	HEAT STRESS INDEX
		Purebred			
IB x IB	30	41.74±0.03[a]	56.76±0.86[a]	56.83±0.84[a]	0.90±0.55[a]
FE x FE	30	41.70±0.03[ab]	48.09±0.85[b]	42.75±0.97[d]	0.80±0.66[b]
NN x NN	30	41.67±0.05[ab]	49.54±0.88[b]	52.80±0.75[ab]	0.75±0.42[c]
NF x FE	30	41.61±0.03[bc]	46.16±0.79[c]	48.52±0.77[c]	0.76±0.34[c]
FF x FF	30	41.59±0.02[c]	54.78±0.78[a]	51.94±0.93[b]	0.74±0.65[c]
	Crossbred				
NN x IB	25	41.63±0.02[b]	55.06±0.75[ab]	54.91±0.71[ab]	1.05±0.75[c]
FF x IB	20	41.75±0.03[a]	58.67±0.86[a]	54.49±1.29[ab]	1.05±1.23[c]
IB x NF	35	41.65±0.04[b]	46.32±1.09[c]	50.55±0.95[b]	1.13±1.12[b]
IB x FE	32	41.87±0.09[a]	43.62±1.30[d]	48.37±1.42[c]	1.15±1.22[a]

[a,b,c,d]Means occupying each column within each genetic group having different superscripts are significantly ($p<0.05$) different.

IB x IB = Isa brown x Isa brown, FE x FE = Fulani ecotype x Fulani ecotype, NN x NN = Naked neck x Naked neck, NF x NF = Normal feather x Normal feather, FF x FF = Frizzle feather x Frizzle feather, NN x IB = Naked neck x Isa brown, FF x IB = Frizzle feather xIsa brown, IB x NF = Isa brown x Normal feather, IB x FE = Isa brown x Fulani Ecotype, OBS= Number of Observation.

Table 2: Pooled mean values of physiological parameters of pure and crossbred chicken progenies as affected by sex of the chicken.

Sex	Obs	Rectal temperature (°C)	Resp. rate (breaths/min)	Pulse rate (beats/min)	Heat stress Index
Purebreds					
Male	70	41.68±0.82	50.00±0.53[b]	45.56±0.56[b]	0.71±0.62
Female	80	41.65±0.02	51.13±0.59[a]	51.69±0.60[a]	0.79±0.39
		Crossbreds			
Male	55	41.60±0.03	45.50±0.58[b]	49.69±0.61[b]	0.91±0.62
Female	67	41.65±0.02	51.72±0.53[a]	52.03±0.53[a]	0.97±0.62

[a, b,] Means occupying each column within each variable having different superscripts are significantly($p<0.05$) different
Obs. = Number of Observation.

Table 3: Mean values of heat tolerance attributes of purebred chickens as affected by genotype x sex interaction.

Genotype	Obs.	Sex	R.T. (^0C)	R.R (breaths/min)	P.R. (beats/min)	H.S.I
IB x IB	12	Male	41.77±0.05	58.11±1.13[a]	54.85±1.33[b]	1.04±0.05[b]
	18	Female	41.77±0.04	55.57±1.28[b]	58.57±1.03[a]	1.12±0.12[a]
FE x FE	17	Male	41.67±0.39[b]	48.81±1.08[a]	42.15±1.22[b]	1.07±0.04[b]
	13	Female	41.74±0.06[a]	47.03±1.37[b]	43.65±1.59[a]	1.22±0.15[a]
NN x NN	16	Male	41.73±0.07[a]	49.22±1.08[b]	53.60±0.95[a]	1.02±0.10[b]
	14	Female	41.61±0.05[b]	49.92±1.43[a]	51.88±1.18[b]	1.10±0.01[a]
FF x FF	15	Male	41.61±0.03[a]	55.10±1.07[a]	51.28±1.32[b]	1.11±0.32[b]
	15	Female	41.57±0.03[b]	54.40±1.14[b]	52.70±1.30[a]	1.24±0.45[a]
NF x NF	14	Male	41.61±0.04	44.97±1.14[b]	47.67±0.98[b]	1.08±0.01[b]
	16	Female	41.61±0.06	47.52±1.09[a]	49.50±1.22[a]	1.29±0.05[a]

[a, b,] Means occupying each column within each genetic grouphaving different superscripts are significantly($p<0.05$) different

IB x IB = Isa brown x Isa brown, FE x FE = Fulani ecotype x Fulani ecotype, NN x NN = Naked neck x Naked neck, NF x NF = Normal feather x Normal feather, FF x FF = Frizzle feather x Frizzle feather, OBS= Number of Observation, R.T. = Rectal Temperature, R.R. = Respiratory Rate, P.R = Pulse Rate, H.S.I. = Heat Stress Index.

Table 4: Mean values of heat tolerance attributes of crossbred chicken as affected by genotype x sex interaction.

Genotype	Obs.	Sex	R.T. (^{0}C)	R.R. (breaths/min)	P.R. (beats/min)	H.S.I
NN x IB	10	Male	41.77 ± 0.04^a	53.24 ± 1.02^b	53.61 ± 1.09^b	1.24 ± 1.15^b
	15	Female	41.74 ± 0.03^b	56.11 ± 1.01^a	55.65 ± 0.92^a	1.26 ± 1.72^a
FF x IB	16	Male	41.68 ± 0.04^a	58.43 ± 1.11^b	53.67 ± 1.80^b	1.30 ± 1.12^b
	14	Female	41.57 ± 0.04^b	58.96 ± 1.37^a	55.52 ± 1.84^a	1.33 ± 1.12^a
IB x NF	16	Male	41.78 ± 0.06^a	41.73 ± 1.49^b	49.69 ± 1.33^b	1.04 ± 1.10^b
	19	Female	41.53 ± 0.03^b	50.92 ± 1.30^a	51.42 ± 1.35^a	1.29 ± 1.40^a
IB x FE	18	Male	42.03 ± 0.16^a	46.58 ± 1.87^a	44.79 ± 2.03^b	1.02 ± 1.40^b
	14	Female	41.66 ± 0.04^b	39.67 ± 1.49^b	53.14 ± 1.63^a	1.45 ± 1.57^a

[a, b,] Means occupying each column within each genotype having different superscripts are significantly ($p<0.05$) different

NN x IB = Naked neck x Isa brown, FF x IB = Frizzle feather xIsa brown, IB x NF = Isa brown x Normal feather, IB x FE = Isa brown x Fulani Ecotype, OBS= Number of Observation. R.T. = Rectal Temperature, R.R. = Respiratory Rate, P.R = Pulse Rate, H.S.I. = Heat Stress Index.