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# COMPARATIVE STUDY ON THERMO-TOLERANT AND ESTIMATED BREEDING VALUES OF FOUR (4) STRAINS OF INDIGENOUS CHICKEN IN THE SAGNARIGU MUNICIPALITY OF GHANA

**Y. Amevor*[1], D. Addison[1], J. K. Sosu[2]**

[1]Department of Animal Science Education, Faculty of Agriculture Education, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development, Post Office Box 40, Mampong-Ashanti, Ghana.
[2]University for Development Studies, Department of Animal Science, Faculty of Agriculture,
[3]Food and Consumer Sciences, Post Office Box TL 1882, Nyankpala, Tamale-Northern Region.

***Corresponding Author: Y. Amevor**
Department of Animal Science Education, Faculty of Agriculture Education, Akenten Appiah- Menka University of Skills Training and Entrepreneurial Development, Post Office Box 40, Mampong-Ashanti, Ghana.

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## ABSTRACT

The study was aimed at evaluating the thermo-tolerant rate of four indigenous Ghanaian chicken genotypes. One hundred and twelve (112) mixed-sex birds made up of 28 each of the four breeds (normal feathered, silky, naked neck and frizzle) were reared for 24 weeks. Using a Randomized Complete Block Design (RCBD), the strains of the birds were replicated four times each. Data was taken on body temperature, pulse rate, respiratory rate and heat stress index. Genstat's Analysis of Variance was used to analyze the data. The body temperature, pulse rate, respiratory rate and heat stress index of the birds were genotype-dependent. Generally, the normal Feathered recorded the highest pulse rate, rectal temperature, respiratory rate, heat stress index while the silky and the Frizzle had the lowest mean values with good heat tolerant traits than the other two strains. It was concluded that the silky and the frizzle are more heat tolerant than its counterparts.

**KEYWORDS:** Naked Neck; pulse rate; Frizzle; Silky; Thermoregulation.

## INTRODUCTION

The study was undertaken from 25 July, 2021 to 11$^{th}$ January, 2022 at a section of Zaaley Commercial Poultry Farm in Sagnarigu, the capital town of the Sanarigu Municipality in Northern Ghana. The Municipality is one of sixteen (16) districts in the Northern Region of Ghana. It was carved out of Tamale Metropolis on June 24, 2012. The Municipal is found between longitudes 0$^{o}$ 36' and 0$^{o}$ 57' West and latitudes 9$^{o}$16' and 9$^{o}$34' North. Agriculture and trading are the primary economic activities in the area. The municipality has a tropical wet and dry climate. The raining season in the area is from April to September or October, with a peak in July and August. The average annual rainfall is 1100 mm, with an average relative humidity of approximately 49.9%.[1]

In the tropical and subtropical zones, an animal's ability to maintain homeostasis while under heat or thermal stress is an important feature because heat stress can result into significant economic losses in poultry production.[2, 3] Factors that significantly affect heat generation in poultry among others are, ambient temperature, level of enzymatic activities, physical activities, breed, body weight, vitamins, and circadian beats.[4, 5, 6] Because birds lack sweat glands, they transfer generated heat to the surface of the body in order to allow sensible heat losses from surfaces such as the comb, shank, wattles, and unfeathered parts such as beneath wings to the surrounding environment.[7, 4] Birds, as endotherms, can also adjust their body temperature by utilising the heat generated from their bodies. To maintain ambient temperature in chicken, the birds must increase their evaporative losses. As a result, they begin to breath more rapidly and panting vigrously (hyperventilation) at environmental temperatures around 30°C and above. Sagnarigu Municipal happens to be one of the MMDAs in the Northern Sector of Ghana which has environmental temperatures ranging sometimes above 40$^{o}$C which can greatly influence the heat stress on local chicken.

It has been proven that heat stress has a negative impact on water intake of chicken (Bruno *et al.*, 2011),[8] electrolytes,[9] their growth rate,[10, 11] feed consumption,[12] blood variables,[13] and the immune response,[14] as well as increasing number of death rate.[15] The key challenge for farm chickens exposed to extremes of temperature is how to keep their bodies in a state that allows the chemical process to function normally. As a result, it is necessary to assess, re-evaluate and consider the best breed that has the ability to withstand heat stress for better productivity.

## MATERIALS AND METHODS

### Experimental Birds and Design
A total of 112 native chickens made up of 47 males and 65 females were used. There were 28 birds of each genotype of the Naked Neck, Frizzled, Silky, and Normal/Typical Feathered Chickens. The chicks were purchased one week after hatching from three (3) commercial local poultry farmers in Kpalsi, Gurugu and Nyohini all which are suburb of the Municipality. Based on strain, the birds were replicated four (4) times, with each replicate having a total number of 7 birds in a Randomized Complete Block Design (RCBD).

### Management of Experimental Birds
**Table 1: Composition of the Diet Supplied to Birds.**

| Ingredient | Starter mash (kg) | Grower mash (kg) |
|---|---|---|
| Maize | 46.50 | 55.95 |
| Groundnut cake | 24.65 | 15 |
| Soy bean meal | 18.00 | 20 |
| Fish meal | 2.50 | 2.0 |
| Bone meal | 2.50 | 1.5 |
| Limestone | 5.00 | 5.00 |
| Vitamin & Mineral Premix | 0.250 | 0.25 |
| Salt | 0.30 | 0.30 |
| Lysine | 0.250 | 0.25 |
| Methionine | 0.250 | 0.25 |
| **Total** | **100** | **100** |
| *Calculated* CP | 20.17% | 15.85% |
| ME, Kcal/Kg | 2,995 | 2,715 |

***Housing***
The experimental birds were randomly distributed and grown on a slated net floor pen partitioned into 16 compartments, each measuring 3m x 4m x 1m. The slatted net floor is built of net with sturdy wood reapers under to support a person's weight. All the birds were subjected to the same management practices throughout the study period.

***Feeding, Watering and Medication***
Feed was supplied to birds every morning and the left over was measured every time to know the amount consumed before new feed is supplied. Birds were vaccinated as and when necessary. Throughout the trial, clean water was provided *ad libitum* on a continual basis.

### Parameters Measured and Estimated
The data was taken fortnightly or monthly depending on the parameter in question. The following parameters were measured.

***Body Temperature:*** This was determined by inserting a clinical thermometer into the cloaca for one (1) minute and taking measurements.

***Pulse Rate****:* The pulse was measured using a veterinary standard pulse oximeter by placing the instrument on the wing and recording the readings within one (1) minute.

***Respiratory Rate:*** This was measured for each bird by using a veterinary standard pulse oximeter which records the amplitude varying over respiratory cycle within one (1) minute.

***Heat Stress index (H)****:* The heat stress index was calculated using the relationship between pulse rate and respiration rate, as well as the normal average values for both. The formula was as follows.
$H= (NP/NR) \times (AR/AP)$
H=Heat Tolerant/Stress Index
AR = Value for the Average Respiratory Rate
AP = Average Pulse Rate Value
NP = The Normal Pulse Rate Value
NR = Normal Respiratory Rate Value

***Estimated Breeding Value (EBV):*** This is a determination of the genetic merit of an animal for a certain trait. Breeding values determine whether the progenies of an animal are superior or inferior. The EBV in this study was calculated as:
$EBV = P \times h^2$
Where;
$h^2$ = Heritability
P = phenotypic deviation (Deviation of the individual performance from the population mean).

### Data analysis
The data collected was analysed using the Genstat with General Linear Model (GLM) procedure of Statistical Analysis System (SAS-2008). Differences between means were separated by probability difference (PDIFF) procedure of SAS-2008 on the following fixed model:
$Y_{ijk} = \mu + T_i + B_j + e_{ijk}$
Where:

$Y_{ijk}$ = performance of the i$^{th}$ bird at a particular age
μ= General mean common to all observations
$T_i$ = i$^{th}$ replicate ($i$ = 1, 2, 3, & 4)
$B_j$= fixed or real effect of j$^{th}$ strain (j = 1, 2, 3,& 4)
$e_{ijk}$ = error term that cannot be explained.

## RESULTS

### Heat Tolerant Traits of Local Chicken

***Effects of Genotype Pulse Rate of Local Chicken***

The average pulse rate for the 1$^{st}$, 2$^{nd}$, 4$^{th}$, 5$^{th}$, and 6$^{th}$ month of the normal feathered were significantly higher than those of the Frizzle, the Silky and the Naked Neck birds. However, there were non-significant differences (P>0.05) observed in the pulse rate of the Silky, Naked Neck and the Frizzle within the period of 2$^{nd}$, 4$^{th}$ and the 6$^{th}$ months while at the 1$^{st}$ month the pulse rate of the Frizzle was found to fall between that of the Silky and the Naked Neck (Table 2). A similar trend was observed in the 5$^{th}$ month where the observed pulse rate of the Naked Neck fell between that of the Silky and the Frizzle.

**Table 2: Average Pulse Rate of Local Chicken.**

| PARAMETER | GENOTYPE | | | | |
|---|---|---|---|---|---|
| | Silky | Naked Neck | Frizzle | Normal | SEM |
| OMPR | 297.7$^c$ | 305.2$^{abc}$ | 303.6$^{bc}$ | 316.6$^a$ | 6.50 |
| TMPR | 305.6$^b$ | 304.0$^b$ | 301.0$^b$ | 331.1$^a$ | 12.60 |
| ThMPR | 310.2 | 308.0 | 307.7 | 322.2 | 6.55 |
| FMPR | 313.8$^b$ | 303.6$^b$ | 306.0$^b$ | 326.5$^a$ | 6.57 |
| FvMPR | 293.9$^c$ | 299.6$^{bc}$ | 309.4$^b$ | 333.6$^a$ | 7.45 |
| SMPR | 297.8$^b$ | 302.3$^b$ | 302.3$^b$ | 326.3$^a$ | 5.70 |

$^{abc}$*Means in the same row with different superscripts are significantly different at p<0.05.*

OMPR(1-month pulse rate), TMPR(2-month pulse rate), ThMPR(3-months pulse rate) FMPR(4-month pulse rate), FvMPR (5-month pulse rate), SMPR (6-month pulse rate)

***Influence of Genotype on the Respiratory Rate of Local Chicken***

Genotype had significant (P<0.05) influence on the respiratory rate. The respiratory rate of the birds ranged from 33.1bpm to 60.2bpm. At 2-6 months, the respiratory rate of the birds were found to differ significantly (P<0.05). Meanwhile, the normal feathered strain recorded a higher numerical total pulse rate than the other three strains (Table 3).

**Table 3: Respiratory Rate of local Chicken.**

| PARAMETER | GENOTYPE | | | | |
|---|---|---|---|---|---|
| | Silky | Naked Neck | Frizzle | Normal | SEM |
| OMRR | | | | | |
| TMRR | 39.5$^b$ | 37.3$^b$ | 36.9$^b$ | 53.9$^a$ | 1.69 |
| ThMRR | 40.4$^b$ | 37.2$^c$ | 38.6$^c$ | 45.7$^a$ | 1.20 |
| FMRR | 40.1$^b$ | 33.1$^c$ | 33.2$^c$ | 60.2$^a$ | 1.24 |
| FvMRR | 40.2$^b$ | 33.6$^c$ | 39.3$^b$ | 51.4$^a$ | 1.10 |
| SMRR | 33.1$^c$ | 38.6$^b$ | 37.0$^b$ | 57.5$^a$ | 1.85 |

$^{abc}$*Means in the same row with different superscripts are significantly different at p<0.05.*

OMRR(1-month respiratory rate), TMRR(2-month respiratory rate), ThMRR(3-month respiratory rate) FMRR(4-month respiratory rate), FvMRR (5-month respiratory rate), SMRR (6-month respiratory rate)

***4.2.3 Effects of Genotype on the Body Temperature of Local Chicken***

The observed body temperature for the various strains was found to range from 40.8°C to 42.4°C. Similar to the pulse and respiratory rates, Strain had significant influence on the body temperature of the local birds (Table 4). Apart from the 2$^{nd}$ month, where the body temperatures of the birds were similar (P>0.05), several variations/differences were observed in the body temperatures in the other months where the normal feathered recorded mostly the highest body temperature.

**Table 4: Effects of Strain on the Body Temperature of local Chicken.**

| PARAMETER | GENOTYPE | | | | |
|---|---|---|---|---|---|
| | Silky | Naked Neck | Frizzle | Normal | SEM |
| **OMTb** | $41.0^{c}$ | $40.8^{d}$ | $41.3^{b}$ | $42.0^{a}$ | 0.16 |
| **TMTb** | 41.2 | 41.9 | 41.2 | 41.0 | 0.16 |
| **ThMTb** | $42.4^{a}$ | $40.9^{c}$ | $41.3^{b}$ | $41.4^{b}$ | 0.15 |
| **FMTb** | $41.3^{bc}$ | $41.4^{b}$ | $41.1^{c}$ | $41.9^{a}$ | 0.14 |
| **FvMTb** | $41.4^{b}$ | $41.3^{b}$ | $40.8^{c}$ | $42.4^{a}$ | 0.15 |
| **SMTb** | $41.1^{c}$ | $41.1^{c}$ | $41.2^{b}$ | $42.3^{a}$ | 0.12 |

*$^{abc}$Means in the same row with different superscripts are significantly different at $p<0.05$.*
*OMTb(1-month Body Temperature), TMTb (2- month Body Temperature), ThMTb (3- Body Temperature) FMTb (4-month Body Temperature), FvMTb (5-month Body Temperature), SMTb (6-month Body Temperature)*

***Heat Stress Index for the Four Strain of Local Chicken***
The results of the heat stress index of the local chicken genotype was estimated using the pulse rate and respiratory rate together with their normal average values and presented in Figure 1. The highest heat stress index was observed for the normal feathered from the 1st month through to the 6th month. With respect to the other three strains, the Naked Neck and the Frizzle recorded the highest (1.2) at the 1st and 2nd month respectively. From the 3rd month to the 6th month, the Naked Neck maintained slightly higher heat stress index than the Silky and the frizzle while the lowest heat stress index (0.9) was recorded by the Frizzle and the Silky at the 5th and 6th month. Generally, the heat stress index decline with increasing age in all the genotype; an indication of the birds getting acclimatized to the environment as they age.

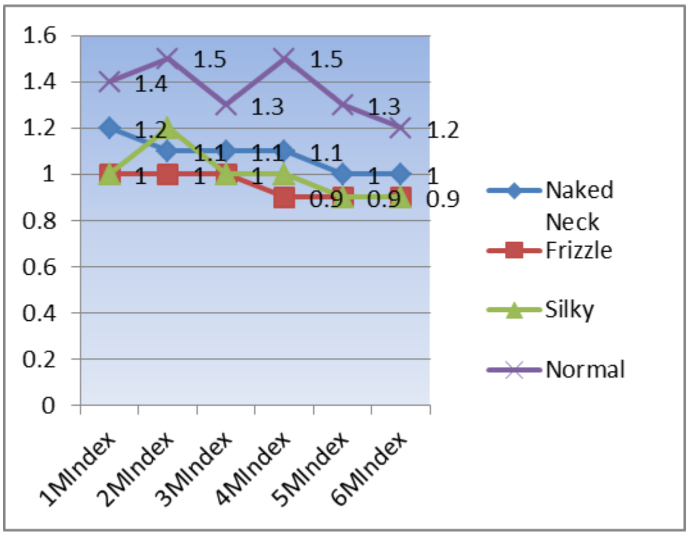


**Figure 1: Heat Stress Index for the Four Strain of Local Chicken.**

*1Mindex(1-month heat stress index) 2Mindex(2-month heat stress index), 3Mindex(3-month heat stress index), 4Mindex(4-month heat stress index), 5Mindex(5-month heat stress index), 6Mindex(6-month heat stress index)*

**Effects of Genotype on the Estimated Breeding Value (EBV) of Local Chicken**
Genotype had no significant ($p>0.05$) effect on 1 to 6 months Estimated Breeding Values (EBV) of the local birds (Table 5).

**Table 5: Estimated Breeding Value of Local Chicken.**

| PARAMETER | GENOTYPE | | | | |
|---|---|---|---|---|---|
| | Silky | Naked Neck | Frizzle | Normal | SEM |
| **OMEBV** | 0.3 | 1.1 | -4.8 | -16.8 | 13.23 |
| **TMEBV** | 1.5 | -1.1 | -0.5 | -1.4 | 10.12 |
| **ThMEBV** | 0.5 | -0.4 | -2.6 | 3.8 | 13.91 |
| **FMEBV** | -2.4 | -1.4 | -0.4 | -2.3 | 17.94 |
| **FvMEBV** | 14.8 | 0.3 | -1.0 | 16.1 | 17.40 |
| **SMEBV** | -3.3 | 3.2 | -7.2 | 3.3 | 18.85 |

*OMEBV (1-month Estimted Breeding Value), TMEBV (2-month Estimted Breeding Value), ThMEBV (3- Body Estimted Breeding Value) FMEBV (4-month Estimted Breeding Value), FvMEBV (5-month Estimted Breeding Value), SMEBV (6-month Estimted Breeding Value)*

## DISCUSSIONS

The pulse rate observed ranged from 293.90 to 333.61beats/min. The Normal Feathered genotype had the highest pulse rate, which occurred in the fifth month. There exist a variation in pulse rate month by month. The fluctuation in pulse rate as observed among the strains agrees with the results of Isidahomen *et al*.,[2] Fadare & Fanujide,[16] and Ademola *et al.*[17] The existence in fluctuation in pulse rate month by month might have been as a result of external factors such as temperature.[18] Notwithstanding, the numerical values obtained in this study differed with what was observed by Ademola et al.[17] and Fadare & Fanujide[16] but within the threshold of Isidahomen *et al.*[2] The pulse rate reported by Isidahomen *et al.*[2] ranged from 234.00±17.21 to 397.001±19.15 beats/min. with the highest pulse rate recorded for naked neck genotype in the 4$^{th}$ week.

The highest pulse rates were recorded by the Normal Feathered throughout the study period, which could be attributed to the full coverage of feathers, which allows for less heat dissipation. On the contrarily, the Naked Neck, the Silky and the Frizzle birds exhibited lower and similar pulse rates especially at 2$^{nd}$ through to the 6$^{th}$ months due to the reduced feather coverage of these birds, which has proven to increase heat dissipation, making room for a greater rate of radiation of body heat and finally resulting into a better thermo-regulation.[1,17]

The observed result with respiratory rate was significantly influenced or affected ($P<0.05$) by genotype. It follows the same pattern observed with rectal temperature and pulse rate. The Normal feathered had the highest range (60.2 breaths/min) at the fourth month while the Naked Neck and the Silky feathered recorded the least values (33.1beats/min) at the 4$^{th}$, and 6$^{th}$ months respectively. This disagrees with the earlier study of Isadahomen *et al.*[1] that the animal' size also affects the respiratory rate and the larger the animal, the higher the rate of respiration because they have a higher metabolism. In this current findings, the heavier breed, which were the Naked neck and the Silky rather had the lowest respiratory rate for most part of the experiment followed by the Frizzle, which disagrees with the general principle/rule, that the greater the mass of an animal the greater the respiratory and metabolic rates. This is because the higher metabolic rate of small animals needs a greater release of oxygen to tissues across the body, whereas larger animals have a larger surface area, which could result in a faster rate of gas exchange. This variation is most likely due to the phenotypic (hair style) of the birds in this study, which causes them to lose heat, resulting in less respiration.

Heat production according to Department for Environment, Food and Rural Affairs (Defra)[19] is influenced by species, body weight, breed, level of production, the quality of feed and to a lesser extent, by the amount of exercise and activities the animal undergoes. This implies that, as body temperature increases, birds begin to pant to lose heat which is accompanied with increased respiratory rates. However, for each genotype across the 24 weeks, an increase in respiratory rate as age progresses was observed with some few intermittent variations.

The current findings on chicken body temperature revealed that, the body temperature is genotype-dependent. The findings on body temperature of the local chickens were consistent with that reported by Isidahomen *et al.*[2] In southern part of Nigeria, the researchers observed values for body temperature within the limits of 40.4 to 41.98$^{0}$C and also unveil a similar range of values for Frizzle, Normal, Naked Neck, and other two Nigerian local chickens. In the 3rd, 4th, and 5th months, the lowest and maximum rectal temperature values reported for Frizzle, Normal, and Naked Neck were consistent with their findings. Similarly, the values of the body temperature of the local birds documented in this study also agrees with an observation made by Fadare & Fanujide[16] and Oke *et al.*[20] In their investigations, they found similar results for the Naked Neck, Frizzle and the Normal feathered. The advantage of naked neck over other strains in terms of heat tolerance was documented by N'dri *et al.*[21] and Zerjal *et al.*[22] However, the rectal temperature values obtained in this study differed from those obtained in a study conducted by Eyarefe & Oguntunde,[23] who found minor changes in values for Boran-hybrid-laying birds. This discrepancy could be due to the species of birds involved as well as the environment in which they were raised.

The heat stress/tolerant index is defined as a function of the actual temperature divergence from the environmental temperature and the age of the bird. The greater the index, the more severe the heat stress. With age, the heat tolerant index declines. The results obtained generally in this present research on the heat stress index were within the range but contrary to the works of Isidahomen & Njidda[24] who found the frizzle and the Naked Neck to be more heat stressed than the normal feathered chicken.

In this current study, the highest heat stress index was estimated for the normal feathered from the 1$^{st}$ month through to the 6$^{th}$ month while the Silky and the Frizzle had the lowest mean values (Figure 4.1). This implies that as compared to their counterparts, the normal feathered chicken used in this study were more heat stressed. The lowest heat-stress-index as observed in the Silky and the Frizzle genotypes could be an indication that the Silky and the Frizzle genotypes are tolerant to heat and can better dissipate heat than other genotypes as earlier proven by Isidahomen & Njidda.[24] This can be attributed to the fact that the frizzle and Silky have feathers design to dissipate heat effectively. Conversely, Ward *et al.*[25] indicated that the Naked Neck is more heat tolerant than its counterparts and stated that less feather coverage enhances the rate of irradiation of internally generated heat, leading to enhanced thermoregulation under moderate (22°C) and even high (30°C) external temperatures. This according to Ward et al.,[25] relieves heat stress, which improves the reproductive and productive performance of birds. When chickens reduce feed intake to avoid a deadly increase in body temperature, this results in lower growth and meat yield in birds. With respect to the Frizzle, their raised feathers give them a primary evaporative cooling technique because air circulation is facilitated closer to their bodies.[2] Similarly, the Silky and the Frizzle are less heat stressed in this study probably because they are genetically designed to respond to higher temperatures using their Autonomic Nervous System (ANS) to trigger increase respiratory rate, tachycardia (increase heart beat), and enhance the flow of blood towards the body peripheries for maximum heat loss to maintain body temperature.[27]

As the birds grew older, their heat stress decreased, indicating that they had adapted to their tropical surroundings.

Local chickens in general have been discovered to especially those with the normal feather (na), naked neck (Na), and frizzle feather (FF) genes, are known to be highly thermo-tolerance than the exotic strains.[28,17,29] This is because the native chickens have the advantage of having an innate and genetic ability to tolerate severe temperature and poor management systems.[30] This tolerance prevents native chickens from suffering significant production losses.

Heat stress is caused by variations of a multiple environmental factors such as, air temperature, humidity, thermal irradiation, metabolism rate, breed, the activity of the birds and thermoregulatory mechanisms as well as the housing conditions of bird.[31] It is worth noting that heat stress has a negative influence on poultry productivity and wellbeing. This has negative consequences for growth, livability, and immune-suppression, all of which contribute to a decline in output.[32,33]

From Table 5 it indicated that there is no significant differences recorded in the breeding values of the four strains of the chicken under study. However, positive and negative breeding values have been recorded for all the genotype. Negative (-) breeding value implies that compared to other genotype tested, the daughters of this genotype on an average, will have lower genetic capacity/ability for body weight production whereas a positive (+) breeding value means that compared to other genotype/strains tested, the daughters of this genotype on an average will exhibit higher genetic capabilities for body weight production.

In the 1st and 5th month for instance, the normal feathered strain had -16.8 and + 16.1 EBVs. This implies that on an average the daughters of the normal feathered at 1st and 5th months will have genetic capacity to produce -8.4g less weight and +8.05g more weight compared to the daughters of the other genotypes at that same period.

The results of this study is in disagreement with the discoveries of Moazeni[34] who reported EBV of Body weight at sexual maturity of three (3) selected genotypes to be significantly different. However, both negative and positive values were also recorded by these authors. According to Rajkumar *et al.*[35] the average Breeding Value of all the economic traits depicted a positive linear trend, indicating the improvement in the required direction in the population. The trend of genetic progress reflects the effectiveness of selection in the given population. In a study conducted by Rajkumar *et al.*[36] there was also a positive trend in the EBV values for body weight in 4th and 6th weeks. Rajkumar *et al.*[35] also reported EBV for body weight at weeks 20 and 40 also showing a significant positive linear trend along the positive association as both were greatly significant and positively correlated. In their study, the EBV for Age at Sexual Maturity (ASM), was similar with minor improvement over generations, which could be attributable to the previous selection for BW, which had no influence on ASM.

## Conclusion and Recommendations

The Frizzle and the Silky have good characteristics for heat tolerance. The differences in phenotypic performance may suggest some level of genetic differences in these varieties. However, Genotype did not affect estimated breeding values of the four strains of the chicken understudied. The Frizzle and the Silky could be raised in areas with higher temperatures since they have good heat tolerance ability. A cross-breeding among the genotypes is also recommended to take advantage of breeds that do not perform better.

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## Disclosure of Conflict of Interest

The Authors have declared that, no conflict of interest exist

## REFERENCES

1. Ghana Metrological Agency, (2022) Ghana Meteorological Agency's Seasonal Rainfall Forecast For The Major Rainy Seasons: March-May (Mam) And April - June (Amj) 2022 For The Country, Accra-Ghana.

2. Isidahomen, C. E., Njidda, A. A. & Olatunji, E. A. Heat Tolerant Traits Among Local and Exotic Chickens in Southern Nigerian. *IOSR Journal of Agriculture and Veterinary Science*, 2012; 1(6): 31-36.
3. Saeed, M., Abbas, G., Alagawany, M., Kamboh, A. A., Abd El-Hack, M. E., Khafaga, A. F., & Chao, S. Heat Stress Management in Poultry Farms: A Comprehensive Overview. *Journal of thermal Biology*, 2019; 84: 414-425. doi: 10.1016/j.jtherbio.2019.07.025.
4. Scanes, C. G. Sturkie's Avian Physiology (Chapter 37)-Regulation of Body Temperature: Strategies and Mechanisms. 6th ed., USA; Academic Press, 2015; 869–905.
5. Alagawany, M., Abd El-Hack, M. E., Mahrose, K.M., Arif, M., Saeed, M., Arain, M.A., Soomro, R.N., Siyal, F.A., Fazlani, S.A., Fowler, J., Productive performance, egg quality, hematological parameters and serum chemistry of laying hens fed diets supplemented with certain fat-soluble vitamins individually or combined during summer season. *Journal of Animal Nutrition*, 2018; 3(2): 218-226.
6. Madkour, M., Salman, F. M., El-Wardany, I., Abdel-Fattah, S. A., Alagawany, M., Hashem, N. M., & Dhama, K. Mitigating the detrimental effects of heat stress in poultry through thermal conditioning and nutritional manipulation. *Journal of Thermal Biology*, 2021; 10(3): 31-69.
7. Azoulay, Y., Druyan, S., Yadgary, T., Hadad, Y. and Cahaner A. The variability and performance under hot conditions of featherless broilers versus fully feathered broilers. *Poultry Science*, 2011; 90: 19-29.
8. Bruno, L. D. G., Maiorka, A., Macari, M., Furlan, R. L. & Givisiez, P. E N. (2011). Water intake behavior of broiler chickens exposed to heat stress and drinking from bell or and nipple drinkers. *Revista Brasileira de Ciência Avícola*, 2011; 13: 147-152.
9. Borges, S. A., Fischer, S. A. V., Majorka, A., Hooge, D. M., & Cummings, K. R. Physiological responses of broiler chickens to heat stress and dietary electrolyte balance (sodium plus potassium minus chloride, milliequivalents per kilogram). *Poultry Science*, 2004; 83: 1551-1558.
10. Abu-Dieyeh, Z. H. M. Effect of high temperature on growth performance of broilers. *International Journal of Poultry Science*, 2006; 5(2): 19-21.
11. Duangjinda, M., Tunim, S., Duangdaen, C., & Boonkum, W. Hsp70 genotypes and heat tolerance of commercial and native chickens reared in hot and humid conditions. *Brazilian Journal of Poultry Science*, 2017; 19(5): 07-18.
12. Cooper, M. A, & Washburn K. W. The relationships of body temperature to weight gain, feed consumption, and feed utilization in broilers under heat stress. *Poultry Science*, 1998; 77: 237-242.
13. Aengwanich, W. Pathological changes and the effects of ascorbic acid on lesion scores of bursa of Fabricius in broilers under chronic heat stress. *Reserch Journal of Veterinary Science, 2007;* 1: 62-66. http://dx.doi.org/10.3923/rjvs.2008.62.66.
14. Tirawattanawanich, C., Chantakru, S., Nimitsantiwong, W. & Tongyai, S. The effects of tropical environmental conditions on the stress and immune responses of commercial broilers, Thai indigenous chickens, and crossbred chickens. *The Journal of Applied Poultry Research,* 2011; 20: 409-420.
15. Al-Fataftah, A. A., Abu-Dieyeh, Z. H. M. Effect of chronic heat stress on broiler performance in Jordan. *International Journal of Poultry Science*, 2007; 6(2): 64-70.
16. Fadare, A. O., & Famuyide, H. O. Thermotolerance Traits and Mortality Levels of Three Strains of Broilers in Humid Tropics. *International Journal of Animal and Livestock Production Research*, 2021; *5*(1): 1-9.
17. Ademola, S. G. and Farinu, G. O. Performance of laying birds fed diets containing forage meal of Tithonia diversifolia (Hems A. Gary) and anti-biotics. *Nigeria Journal of Animal Production*, 2015; 33(1): 58-68.
18. Isadahomen, C. E. (2012). Heat Tolerant Traits among Local and Exotic Chickens in Southern NigeriaN. *IOSR Journal of Agriculture and Veterinary Science*, 2012; 1(6): 31-36. DOI:10.9790/2380-0163136.
19. Department for Environment Food and Rural Affairs, (2013),''Heat stress in poultry Solving the problem'' www.defra.gov.uk/animal/welfare/pdfhstress05.
20. Oke, O. E., A. I. Oni, P. O. Adebambo, O. M. Oso, M. M. Adeoye, T. G. Lawal, T. R. Afolayan, O. E. Ogunbajo, D. I. Ojelade, O. A. Bakre, J. O. Daramola, and O. F. Smith. Evaluation of Light Colour Manipulation on Physiological Response and Growth Performance of Broiler Chickens. *Tropical Animal Health Production*, 2021; 53: 6.
21. N'dri, A.L., Mignon-Grasteau, S., Sellier, N., Tixier-Boichard, M. and Beaumont, C. Genetic relationships between feed conversion ratio, growth curve and body composition in slow-growing chickens. *British Poultry Science*, 2013; 47: 273-280.
22. Zerjal, I., Gourichon, D., Rivet, B., & Bordas, A. (2013). Performance comparison of laying hens segregating for the frizzle gene under thermoneutral and high ambient temperature. *Poultry Science*, 2013; 92: 1474-1485. http://dx.doi.org/10.3382/ps.2012-02840.
23. Eyarefe, O. D. and Oguntoye, C. O. A Randomized Trial of low-dose ketamine and lignocaine infiltration for laparocaecectomy in layer chickens. *International Journal of Animal and Veterinary Advances*, 2012; 4(4): 252-255.
24. Isadahomen C. E. and Njidar, A. A. Haematology and Carcass Characteristics of Naked Neck, Frizzled and Normal Feathered Local Chickens in Southern

Nigeria. *Savannah Journal of Agriculture*, 2012; 7(2).

25. Ward, J.M., Houston, D.C., Ruxton, G.D., Mccafferty, D.J. & Cook, P. (2001) Thermal resistance of chicken (*Gallus domesticus*) plumage: a comparison between broiler and free-range birds. *British Poultry Science,* 2001; 42: 558-563.doi:10.1080/00071660120088335.
26. Nawaz, A. H., Amoah, K., Leng, Q. Y., Zheng, J. H., Zhang, W. L., & Zhang, L. Poultry response to heat stress: Its physiological, metabolic, and genetic implications on meat production and quality including strategies to improve broiler production in a warming world. *Frontiers in Veterinary Science*, 2021; 814.
27. Chen, N. G., Siang; Wu, Ping; Foley, John; Foley, Anne; McDonald, Merry-Lynn; Juan, Wen-Tau; Huang, Chih-Jen; Lai, Yu-Ting; Lo, Wen-Sui; Chen, Chih-Feng; Leal, Suzanne M. Roop, Dennis (ed.). "The Chicken Frizzle Feather Is Due to an α-Keratin (KRT75) Mutation That Causes a Defective Rachis". *PLoS Genetics,* 2012; 8(7): e1002748. doi:10.1371/journal.pgen.1002748.
28. Adeleke, M. A., Peters, S. O., Ozoje, M. O. Ikeobi, C. O. N., Bamgbose, A. M. & Adebambo, O. A. Growth performance of Nigerian local chickens in crosses involving an exotic broiler breeder. *Tropical Animal Health and Production,* 2011; 43(3): 643–650.
29. Adedeji, T. A., Amao, S. R., Ogundairo, O. M., & Fasoyin, O. A. (2015). Heat Tolerance attributes of Nigerian locally adapted chickens as affected by strain and some qualitative traits. *Journal of Biological Agric Healthcare*, 2015; *5*: 50-55.
30. Dessie, T. N. Dana, Ayalew W., & Hanotte, O. Current state of knowledge on indigenous chicken genetic resources of the tropics: domestication, distribution and documentation of information on the genetic resources. *World's Poultry Science Journal*, 2011; 68(1): 11-20.
31. Lara, L. J. & Rostagno, M. H. Impact of heat stress on poultry production. *Livestock Research for Rural Development*, 2013; 3: 356-369.
32. Attia, Y. A., Al-Harthhi, M. A., Al- Sharfey, A. S., Rehab, Y. A. and Kim, W. K. Enhancing tolerance of broiler chickens to heat stress by supplementation with Vitamin C and or probiotics. *Annals of Animal Science,* 2017; 17(4): 1155-1169.
33. Nassar, F. S. and El-Sherif, H. R. (2018). Increasing heat tolerance in broiler by using thermal manipulation during embryonic development. Approaches in Poultry, Dairy and Veterinary Sciences, 5(4): 447-449.
34. Moazeni, S. M., Mohammadabadi, M., Sadeghi, M., Shahrbabak, H. M., Koshkoieh, A. E., & Bordbar, F. Association between UCP gene polymorphisms and growth, breeding value of growth and reproductive traits in Mazandaran indigenous chicken. *Open Journal of Animal Sciences*, 2016; *6*(1): 1-8.
35. Rajkumar, U., Prince, L. L. L., Rajaravindra, K. S., Haunshi, S., Niranjan, M., & Chatterjee, R. N. Analysis of (co) variance components and estimation of breeding value of growth and production traits in Dahlem Red chicken using pedigree relationship in an animal model. *Plos one*, 2021; *16*(3): e0247779.
36. Rajkumar, U.., Muthukumar, M., Nirajan, M. and Haunshi, S. Comparative evaluation of carcass traits and meat quality in native Aseel chickens and commercial broilers. *British Poultry Science,* 2016; 57(3): DOI:10.1080/00071668.2016.1162282.