Animal Breeding and Genetics

ASSESSMENT OF EGG PRODUCTION PERFORMANCE IN TWO GENETIC LINES OF SHIKABROWN® CHICKEN UNDER THE PREVAILING CLIMATE CHANGE IN ZARIA, NIGERIA

By
Patrick, O.L, Kabir, M. and Olutunmogun, A.K.
Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria
Corresponding author: larinaobadiah@gmail.com, Tel: 08136571323

Abstract

Climate change poses a growing threat to livestock productivity, particularly in poultry systems reliant on optimal thermal conditions. Meteorological data on selected weather variables - temperature and relative humidity – were collected at the National Animal Production Institute weather station over twenty (20) weeks laying period to determine its real-time effects on Hen-house egg production of 100 progenies each from the two genetic lines (Sire and Dam line) of ShikaBrown® breed. The research employed multiple regression analysis and descriptive statistics to estimate short-term impacts of weather elements over the period. The study found significant ($p<0.01$) real-time effects of temperature (–7.685) and humidity (–3.568) on egg production. Temperature showed a decreasing trend with the minimum (19.10°C) and maximum temperature (35.00°C) in the month of January at weeks 12 and in November at weeks 4. A minimum of 10% humidity is observed across all weeks, while the highest of 41% was recorded in November at week 1. The findings emphasized production planning with seasonal forecasts and the need for timely climate-adapted management strategies to sustain productivity under changing climatic conditions in tropical regions.

Key words: egg production, ShikaBrown®, climate change, weather, regression

Description of Problem

The influence of weather elements such as temperature and humidity on poultry production is profound, particularly in the context of climate change. ShikaBrown® layer is the result of over twenty years of active breeding and selection work at the National Animal Production Research Institute. The breed is known for its brown eggs, excellent shell quality, high production rate, persistency, egg weight, liveability, feed conversion efficiency and large egg size (1). However, productivity in laying birds is negatively affected by elevation in temperature, reducing the number and size of eggs produced. Changes in humidity work synergistically with high environmental temperature to impact negatively on poultry birds. Livestock has optimum temperature confines for growth, development and coziness known as the Thermos-Neutral Zone (TNZ) based on the species, livestock age and physiological stature, relative humidity and other determinants (2). Various thermal discomfort and bioclimatic indices have been used to characterize the comfort and discomfort level (3; 4). Laying birds have specific thermal comfort ranges which indicate the range of ambient temperatures (AT) where energy requirement is minimal and constant (5). In laying hens, the ideal ambient temperature ranges between 21 and 28 °C (6). Another report indicates that maintaining temperatures between 18°C and 27°C supports optimal egg production, while severe heat stress (33°C, 66% RH) led to a 30% reduction in feed intake and 11% decrease in egg production (7). Conversely, (8) reported that the productivity of laying hens increased under environments with relative humidity ranging from 40 to 70%. Laying hens exposed to ambient temperatures above the TNZ experience heat stress that triggers physiological defense mechanisms, including panting (9). (10) observed constant high temperatures of 34°C negatively affected egg weight and quality, with significant reductions in egg mass. Laying hens exposed to lower TNZ of 12°C show impaired performance compared to those at normal temperatures of 24°C (11). Most of the research efforts on the effects of extreme weather conditions on poultry production examined the broader implications of climate change on agriculture in Nigeria (12; 13). While studies of (14) examined the effect of high temperature on body weight gain, egg production and eggshell formation process in laying hen, comprehensive research focusing on the combined impact of temperature, humidity, and extreme weather events on egg production remains limited. Even then, fewer reports have appeared in literature regarding the precise nature and magnitude of real-time weather influences on poultry egg production (15; 16). Existing studies (17; 18) often provide conflicting or inconclusive findings regarding the precise nature and magnitude of climatic influences on poultry egg production. However, an attempt is made in this paper to provide up-to-date information on the effect of selected weather elements on egg output of ShikaBrown® breed. Thus, contributing positively to knowledge of the problem that climate change poses to the poultry sector which bears the contribution to the economy of developing countries as well as suggest potential targeted adaptation and mitigation strategies for the Nigerian poultry farmers and industry.

Materials and Methods

Experimental site: The study was conducted at the National Animal Production Research Institute Poultry Research Programme Unit Zaria, Nigeria. The Institute is situated at a height of 640 meters above sea level in the Northern Guinea Savannah zone of Nigeria, at latitude 11º 12′42′′N and longitude 7º 33′14′′E, Nigerian Meteorological Agency (19). Its location in a semi-arid area contributes to its mean annual precipitation of 1,107 mm, which falls over 120–170 days from late April to early October.

Management of progeny lines: One hundred (100) progeny hens each from the two ShikaBrown® Strains (Sire and Dam line) were utilized for the experiment. All the birds were kept in single cages and received feed and water ad libitum. An institutional diet containing 2,700 kcal of ME/kg and 17% CP (18 to 40 weeks of age) was provided for the birds.

Egg production and weather data: Egg production data from one hundred (100) progenies each of two genetic lines (Sire and Dam line) of ShikaBrown® grandparents was collected on weekly Hen-house egg production. These were taken along with real-time macroclimatic condition in the pen on temperature and relative humidity.

Analytical techniques: Descriptive statistics of weather variables on average humidity, temperature and the corresponding standard deviations in relation to egg output during a 20-week laying period were taken. Minimum and maximum values on both variables were recorded, respectively. Data obtained from this study was analyzed using linear regression and trend analysis.

Trend analysis: The models for the trend analysis were in the linear form, semi log form and exponential form. The best fit was chosen based on the value of the adjusted coefficient of determination, R^2.

Linear Form: $C_i = b_0 + b_1T$
Semi log: $C_i = b_0 + b_1 \ln T$
Exponential: $\ln C_i = b_0 + b_1T$

C_i = weather variables (Temperature and Relative Humidity), T = time, b_0 and b_1 = parameters to be estimated. In this study, trend analysis was used to examine and establish the pattern for weather variables (Temperature and Relative Humidity).

Multiple regression analysis: Regression analysis was used to determine the effect of climate elements on egg production in the study area. The implicit form of the regression model is given as; Y = f (X1, X2, X3, X4, e)

Where: -
Y = egg output (No of Crates or Hen-house production)
X_1 = Total annual rainfall/precipitation (mm)

X_2 = Mean annual temperature (°C)
X_3 = Mean annual relative humidity (%)
X_4 = Time period
e = error term

Various functional forms of the model were estimated in order to choose the lead equation

Linear function: $Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$

Semi-log function: $Y = \log b_0 + b_1\log X_1 + b_2\log X_2 + b_3\log X_3 + b_4\log X_4$

Exponential function: $\log Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$

The *a priori* expectations of the regression model were
X_2 – Temperature above or below this range (11°C-26°C) is hypothesized to affect the rate of egg droppings. This is according to (20). X_3 – Relative humidity level above or below 75% is hypothesized to cause a reduction in egg laying (21).

Unit root and co-integration tests: The co-integration analysis involves a unit roots test performed on both level and first difference to determine whether the individual input series are stationary and exhibit similar statistical properties. It should be noted that regressing a non-stationary time series data over another non-stationary time series data gives a spurious or nonsense regression (22). To correct this, a unit root test was performed.

Results and Discussion

Table 1 presents descriptive statistics of selected weather variables in relation to egg output over a 20-week laying period. The highest humidity of 41% was recorded in week 1, while a 10% minimum is observed across all weeks. Temperature across weeks of laying shows a decreasing trend with the minimum (19.10°C) and maximum temperature (35.00°C) values in weeks 12 and 4, respectively. The average value of temperature and its standard deviation over the period were 27.82°C and 3.60°C, indicating a slight variability in temperature values from week to week. Rainfall remained constant at zero value throughout the laying period due to dry season. Trend analysis shows relative humidity had a trend coefficient of -19.65 ($p<0.01$), while temperature had a trend coefficient of -6.84 ($p<0.01$), suggesting that both weather variables decreased significantly between the months of November to March. Relative humidity had a strong negative correlation with egg production ($r = -0.89$, $p<0.01$), while temperature showed a moderate negative correlation ($r = -0.58$, $p<0.01$). Regression results using three functional forms is presented in Table 2**.** Effects of weather variables on weekly egg output had R^2 of 0.94, implying that 94% of the variance in egg production was explained by temperature, relative humidity and time (in weeks). The coefficient for temperature in the regression analysis is – 7.685 ($p<0.01$), indicating a significant negative relationship between temperature and egg production over the study period. This suggests that a 1% increase in temperature led to a corresponding 7.7% decrease in egg production due to heat. Rainfall was excluded from all models and set to zero due to the dry season. The linear function, stated below was chosen as the lead equation ($Y = 314.954 + 0X_1 - 7.685X_2 - 3.568X_3 + 16.678X_4$). It was chosen because it had the highest adjusted R^2 (0.9357). This result buttresses the studies of (23) who stated that high temperatures above 27°C led to a 30% decrease in egg production and a 30-50% reduction in feed intake. (7) further emphasized that severe heat stress of 33°C leads to a 30% reduction in feed intake and an 11% decrease in egg production. (24) also opined that high temperature also results to a reduction in poultry live weight, growth speed and high mortality in addition to a decrease in productivity and quality of the eggs. The coefficient for relative humidity in the regression analysis is -3.57($p>0.01$). The negative coefficient indicates that an increase in relative humidity by one unit (holding other variables constant) is associated with a decrease of approximately 3.57 units in egg production. According to (25) elevated humidity levels, particularly in humid tropical environments, can worsen heat stress in poultry, leading to reduced egg production and compromised bird welfare. Despite the rising temperatures, there exists a positive relationship between egg output and time, implying that egg production increased significantly ($p<0.01$) over 20-weeks laying period among the ShikaBrown® hens (20-40 weeks of age), reenforcing the high productivity and adaptability of the breed to tropical environment noted by (1). Conversely, this could be attributed to the optimal humidity level (41%) recorded during the study period, which is consistent with the findings of (8) who opined that productivity of laying hens increased under environments with relative humidity ranging from 40 to 70%.

Table 1: Descriptive and trend analysis of data on weather variables in 20 weeks of laying

	Relative Humidity (%)	**Temperature (°C)**
Mean	16.65	27.82
Standard deviation	8.06	3.60
Maximum value	41.00	35.00
Minimum value	10.00	19.10
Trend coefficient	-19.65***	-6.84***
Correlation coefficient	-0.89***	-0.58***

Table 2: Regression estimates of weather variables and egg output in 20 weeks of laying

Variables	**Linear Form**		**Semi-log Form**		**Exponential Form**	
	Coefficient	T ratio	Coefficient	T ratio	Coefficient	T ratio
Constant	314.954	8.71	7.756	13.36	7.756	13.36
RF (X_1)	0 (set to 0)	-	0 (set to 0)	-	0 (set to 0)	-
T^0 (X_2)	-7.685***	-5.93	-0.0834	-4.01	-0.0834	-4.01
RH (X_3)	-3.568	-3.50	-0.1005***	-6.14	-0.1005***	-6.14
Week (X_4)	16.678***	13.03	0.0917***	4.46	0.0917***	4.46
R^2	0.9378		0.8726		0.8726	
Adjusted R^2	0.9357		0.8683		0.8683	
F ratio	442.27		200.94		200.94	

** P< = 0.05, *** P< = 0.001; RF: Rainfall, T^0: Temperature, RH: Relative humidity

Conclusion and Application

Regression result in 20 weeks egg laying indicated that temperature and relative humidity negatively affected egg production, with the linear model explaining over 94% of the variance in egg production. The coefficient for temperature in the regression analysis is –7.685, implying that 1% increase in temperature led to a corresponding 7.7% decrease in ShikaBrown® egg production. Therefore, farmers should align production planning with seasonal forecasts and prepare for adverse weather conditions that could impair laying performance. Nutritional strategies during hot weather should be adjusted to include energy-dense, electrolyte-balanced feeds that reduce metabolic heat. Furthermore, enhanced poultry housing systems with climate-smart designs, incorporating ventilation, targeted heat mitigation strategies, such as foggers, evaporative coolers, and shaded enclosures, especially during peak heat periods, should be adopted.

References

1. Dessie, T., and Getachew, F. (2016). Shika brown breed. *African Chicken Genetic Gains Factsheet*.
2. Aroyehun, A. (2023). Perceived effects of climate change on poultry egg production in rivers state Nigeria. *Black Sea Journal of Agriculture*, *6*(1), 54–59. https://doi.org/10.47115/bsagriculture.1189204.
3. Pandey, Vyas (2018). The discomfort levels in Gujarat-A comparison of different thermal stress indices. J. Agrometeorol., 20(1): 1-10. https://doi.org/10.54386/jam.v20i1.494.
4. Saha, S., D. Chakraborty, S. B. Singh, S. Chowdhury, E.K. Syiem, S.K. Dutta, Lungmuana, B.U. Choudhury, T. Boopathi, A.R. Singh, Y. Ramakrishna, and A. Roy. (2016). Analyzing the trend in thermal discomfort and other bioclimatic indices at Kolasib, Mizoram. J. Agrometeorol., 18(1): 57-61. https://doi.org/10.54386/jam.v18i1.900.
5. Pontara Vilas Boas Ribeiro, B., Yanagi Junior, T., Duarte de Oliveira, D., Ribeiro de Lima, R., and Gilberto Zangeronimo, M. (2020). “Thermoneutral zone for laying hens based on environmental conditions, enthalpy and thermal comfort indexes.” *Journal of thermal biology*, *93*, 102678. https://doi.org/10.1016/j.jtherbio.2020.102678.
6. Castilho, V.A.R., Garcia, R.G., Lima, N.D.S., Nunes, K.C., Caldara, F.R., N¨a¨as, I.A., Barreto and B., and Jacob, F.G., (2015). Bem-estar de galinhas poedeiras em diferentes densidades de alojamento. Rev. Bras. Eng. Biossistemas 9 (2), 122–131.
7. H., Kim., C., Ryu., Sung-Dae, Lee., Jin-Ho, Cho., and Hwanku, Kang. (2024). 4. Effects of Heat Stress on the Laying Performance, Egg Quality, and Physiological Response of Laying Hens. Animals, doi: 10.3390/ani14071076.
8. Ferreira, R.A., (2016). Maior produç˜ao com melhor ambiente para aves, suínos e bovinos.
9. Mignon-Grasteau, S., Moreri, U., Narcy, A., Rousseau, X., Rodenburg, T.B., Tixier-Boichard, M., and Zerjal, T. (2015). Robustness to chronic heat stress in laying hens: A meta-analysis. *Poultry Science,* 94, 586–600.
10. Xiudong, Liao., Wenxiang, Li., Yongwen, Zhu., Liyang, Zhang., Lin, Lu., Xi, Lin., and Xugang, Luo. (2018). 5. Effects of environmental temperature and dietary zinc on egg production performance, egg quality and antioxidant status and expression of heat-shock proteins in tissues of broiler breeders. British Journal of Nutrition, doi: 10.1017/S0007114518001368.
11. Da-Hye, Kim., Ju-Yong, Song., Jin, Ern, Park., Byung, Yeon, Kwon., and Kyung-Woo, Lee. (2023). 3. The Effect of Low Temperature on Laying Performance and Physiological Stress Responses in Laying Hens. Animals, doi: 10.3390/ani13243824.
12. Ayanlade, A., Radeny, M. and Morton, J.F. (2017). Comparing smallholder farmers’ perception of climate change with

meteorological data: A case study from southwestern Nigeria. *Weather Clim. Extrem.,* 15: 24-33. https://doi.org/10.1016/j.wace.2016.12.001.

13. Idumah, F.O., Mangodo, C., Ighodaro, U.B. and Owombo, P.T. (2016). Climate change and food production in Nigeria: implication for food security in Nigeria. *J. Agric. Sci.,* 8 (2): 74-83. http://dx.doi.org/10.5539/jas.v8n2p74.
14. Getabalew, M. and Negash, A., (2020). Effect of high temperature on body weight gain, egg production and eggshell formation process in laying hen: A review. *Br. J. Poultry Sci.,* 9: 42-47. https://doi.org/10.5829/idosi.bjps.2020.42.47.
15. Otuisi, l., oyita, g. E., and ikenga, v. U. (2024). Effect of changes in climatic variables on poultry egg production in Nigeria. *Journal of Agrometeorology*, *26*(4), 447–453. https://doi.org/10.54386/jam.v26i4.2762.
16. Fatoki, O. A., Oguntoye, T. O., Arowolo, O. V., and Omidiji, O. A. (2020). Effect of climate change on poultry egg production in Ogun State, Nigeria. *Tanzania Journal of Agricultural Sciences*, *19*(2), 138-147.
17. Oguntunji, A.O. and Alabi, O.M. (2010). Influence of high environmental temperature on egg production and shell quality: a review. *Worlds Poult. Sci. J.,* 66(4): 739-750. https://doi.org/10.1017/S004393391000070X.
18. Ghoname, M., Elnaggar, A., Hassan, S. and Habashy, W. (2022). Effect of acute heat stress on production performance and egg quality in four strains of chickens. *South African J. Anim. Sci.,* 52(2): 168-176. https://journals.co.za/doi/pdf/10.4314/sajas.v52i2.6. Retrieved on 4th September 2024.
19. NiMET (2024). Seasonal Climate Prediction. https://nimet.gov.ng/document.
20. Kekeocha, C.C. (1985). Poultry Production Handbook. Macmillan Publishers Ltd., London.
21. Obayelu, A.E. and Adedapo, A. (2006). The Effect of climate on poultry productivity in Ilorin Kwara State, Nigeria. *International Journal of Poultry Science*. 5 (11): 1061-1068.
22. Ayinde O.E., Muchie M. and Olatunji G.B. (2011). Effect of climate change on agricultural productivity in Nigeria: *A Co-integration Model Approach. Journal of Human Ecology.* 35(3): 189-194.
23. Gençoğlan, Serpil (2023). "The effects of heat stress on yield and fertility of laying hens and precautions to be taken." *Turkish Journal of Agriculture-Food Science and Technology* 11.1: 140-150.
24. El-Hack, A., Mohamed, E., Alagawany, M. and Noreldin, A.E. (2018). Managerial and nutritional trends to mitigate heat stress risks in poultry farms. *Sustain. Agric. Environ. Egypt: Part II*, 325-338. https://doi.org/10.1007/698_2018_290.
25. Cheng, M., McCarl, B. and Fei, C. (2022). Climate change and livestock production: A literature review. *Atmosphere*, 13(1): 140. https://doi.org/10.3390/atmos13010140.