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Original Research Article

Behaviour, physiology and body mass of Nigerian indigenous hens during brooding

Oluwaseun Serah **Iyasere,** Oreoluwa Doyinsola **Ajayi**, Sade Opeyemi **Alade**, Victoria Omowunmi **Akinbode**

Department of Animal Physiology, Federal University of Agriculture, P.M.B.2240, Abeokuta, Ogun State, Nigeria

Correspondence to:
Dr. O. S. Iyasere, Department of Animal Physiology, Federal University of Agriculture, P.M.B.2240, Abeokuta, Ogun State, Nigeria: email: iyasereos@funaab.edu.ng, Mobile phone: +2348169004136

Abstract

This study was conducted to investigate the behaviour, selected physiological indicators and body mass changes in Nigerian indigenous broody hens. The times spent by the hens sitting on eggs and on ingestive behaviours (feeding and drinking) were monitored between 14:00 and 18:00 h twice per week for three weeks. The growth and physiological indicators monitored were body mass, rectal temperature, breast temperature and blood glucose concentration. Data collected were analysed using repeated measures ANOVA of SPSS having week as the repeated factor. The time spent by hens sitting on the eggs (88.09 ± 5.38 – 92.91 ± 2.35%) and on ingestive behaviours (0.06 ± 0.03 – 0.11 ± 0.07%) were similar at the 1st, 2nd and 3rd week of brooding. The blood glucose concentration was reduced at the 1st and 2nd but increased at the 3rd week while the breast temperature (BT) increased at the 1st and 2nd but dropped at the 3rd week. The rectal temperature and body mass did not differ significantly ($P > 0.05$) during the three weeks of the brooding process. In conclusion, natural brooding of embryos by hens under tropical conditions was accompanied by changes in body metabolism required for generation of heat which is transferred through the breast region of the hens to the eggs without necessarily resulting in higher rectal temperature of the hens.

Keywords: behaviour; broodiness; ingestion; breast temperature; rectal temperature

INTRODUCTION

Indigenous chickens are the most commonly distributed across every corner of the tropical countries of Africa where they are kept by rural poor (Ajayi, 2010; Mengesha, 2012). Indigenous chickens have shown to be more disease resistant (Minga et al., 2004). Nigerian indigenous chickens are characterized along genetic lines of feather and plumage (normal, frizzle feathered, and naked neck) and colour variant (black, white, brown and multicolor) as criteria for identifying and differentiating them. The frequency distribution of the normal feathered chicken was about 91.8% while that of frizzled and naked neck were 5.2 and 3.0%, respectively, in Bayelsa State of Nigeria (Ajayi and Agaviezor, 2009). The sizes of individual birds are different in different geographical locations, e.g. the Fulani ecotype and Yoruba ecotype chicken. The Fulani ecotype chickens are heavier than the Yoruba ecotype chicken (Olawunmi et al., 2008). They are also known for their ability to brood and hatch their eggs on their own, scavenge for major part of their food and possess appreciated immunity to endemic diseases.

Brooding (natural incubation) is a state of readiness of the hen to sit on the eggs and provide appropriate conditions (temperature, relative humidity and CO_2, egg turning) required for embryonic development and hatching of the chicks (Jiang et al., 2010). The hen rotates the eggs during brooding about 96 times in 24 h and keeps the correct humidity (60–80%) by splashing water on them from her beak. Brooding is associated with reduced feed and water intake, long-time nest occupancy, turning and retrieval of eggs, aggressive and defensive behaviour, characteristic clucking and cessation of egg production (Romanov et al., 2002). Behaviour exhibited during brooding is a key factor affecting the incubation temperature. Tree swallow females, for example, stay longer off nests under warm dry conditions but take shorter off nest during rainy and cold conditions (Hepp et al., 2015).

Most rural poultry farmers still keep indigenous chickens and rely on broody hens to hatch and rear chicks. In other countries like Bangladesh, local broody hens are used to hatch a second clutch of eggs but this result in the hen losing a considerable amount of weight (King'ori, 2011). Hens that undergo broodiness display

less feather pecking and aggressive behaviours than non-broody hens (Shimmura et al., 2015) and chicks reared by broody hens are less fearful (Shimmura et al., 2010). Studies on broodiness in chickens are few because in major commercial stocks broodiness has been selected against (Muir and Chen, 2014) since broodiness is associated with reduced egg production due to the cessation of laying during the broody period (Chen and Li, 2007). Although the numbers of eggs laid were lower in the broody hens, the percentage egg laying loss from broodiness was greater in broody than non-broody hens (Jiang et al., 2010).

Broody hens mostly leave the nest between 10:00 and 18:00 h to feed and drink (Asher and Mench, 2014). However, the duration spent on ingestive behaviours (feeding and drinking) by the hens when they are off-nests was not reported. In turkey hens, the consumption of feed and water decreased during incubation to <10% of that observed during egg laying and increased rapidly after the poults were hatched (Zadworny et al., 1985). The development of brood patches and also the continuous sitting of the eggs seem to be the major means of heat transfer from the body of the hen to the embryo; however, to the best of our knowledge, the breast temperature has not been measured in brooding hens. We hypothesized that brooding exercise will be accompanied by some behavioural, physiological and body mass changes. Hence, this study was undertaken to determine changes in the behaviour, selected physiological indicators and body mass of Nigerian indigenous hens during brooding and to establish a link between them assessing their influence during brooding.

MATERIALS AND METHODS

Experimental site and animals

The research was conducted at a Poultry unit at Camp, Abeokuta, Ogun State, Nigeria. The experimental site lies at latitude 7°25′N and longitude 3°25′E. The area is characterized with an annual rainfall of about 1037 mm. The average temperature and relative humidity are 28.5 °C and 82%, respectively.

From an established flock of Nigerian indigenous chickens, the Yoruba ecotype (domesticated on the farm for the past five years and having produced several generations), 8 cocks and 40 hens that have attained sexual maturity and just started egg laying were selected and kept in poultry pen (1 cock and 5 hens per pen), were observed daily until the hens accumulated clutches of eggs and became broody. The cocks mated naturally with the hens for the production of fertile eggs to be hatched by the hens when they became broody. Broodiness was confirmed when the hens began to sit on the egg for a longer period (Romanov et al., 2002). Once broodiness was established, each of the hens (only 12 out of the 40 became broody during the experimental period) and her clutch of eggs (average of 10 eggs) were gently transferred to a brooding pen (100 cm × 100 cm) to prevent disturbance from other hens and provided *ad libitum* with feed (layers mash in feed hopper) and water provided in cup drinkers.The behavioural data, i.e. time spent sitting on eggs and ingestion (feeding and drinking) were collected from ten of the broody hens continuously for 4 hours (14:00–18:00 h) for three weeks; week 1 (day 2 and 5), week 2 (day 8 and 14) and week 3 (day 17 and 20) by observers seated one meter away from the brooding pen to avoid disturbance.

Blood glucose concentration, rectal and breast temperatures were measured in each broody hen in the 2 h before behavioural observation. The rectal temperature was determined by inserting a digital thermometer into the cloaca of the birds until it beeped and the displayed temperature was recorded. The breast temperature was determined by pointing an infra-red thermometer at the breast patch region of the hen and the reading displayed was recorded. For the blood glucose concentration, the wing vein of the hen was pricked using a needle and a drop of blood was placed on the glucose strip already inserted into the ACCU-CHEK glucose meter, and the value displayed was recorded. The body mass of the hens was measured at the start of brooding and subsequently on a weekly basis. The study was carried out observing the animal welfare requirements.

Statistical analysis

All data collected were analysed using SPSS statistical package (version 16). Behavioural data were subjected to normality test using Shapiro-Wilk. Data on the percentage of time spent sitting on the egg and on ingestion (feeding and drinking) behaviours within the 4 h observation period, physiological indicators and body mass changes were analysed using repeated measures ANOVA having week as repeated factor, and $P < 0.05$ was considered significant. Pearson's correlation was undertaken on the all the indicators monitored (average for the three week period) to determine if there was any relationship between them assessing their influence during brooding.

RESULTS

The percentage time spent by the indigenous hens sitting on the clutch of eggs within the 4 hours observation period was not significantly different ($P > 0.05$) as brooding progresses from the 1st to the 3rd week. Similarly, percentage time spent on ingestion (feeding and drinking) was the same throughout the three weeks (Table 1). Table 2 shows the basic physiological and body mass changes in Nigerian indigenous hens during brooding. The blood glucose concentrations of the broody hens were higher at

Table 1. Time spent by Nigerian indigenous hens sitting on eggs and ingestion during three weeks of brooding

Behaviour	Week 1	Week 2	Week 3
Time sitting on eggs (%)	88.09 ± 5.38	90.79 ± 3.62	92.91 ± 2.35
Time spent on ingestion (%)	0.11 ± 0.07	0.09 ± 0.05	0.06 ± 0.03

Values are Means ± S.E.M, n = 10

Table 2. Basic physiological and body mass changes of Nigerian indigenous hens during three weeks of brooding

Physiological indicators	Week 1	Week 2	Week 3
Blood glucose (mmol/L)	124.67 ± 3.41[b]	128.59 ± 3.17[b]	141.03 ± 2.77[a]
Breast temperature (°C)	39.48 ± 0.37[a]	38.97 ± 0.44[a]	37.76 ± 0.37[b]
Rectal temperature (°C)	40.73 ± 0.14	40.72 ± 0.16	40.90 ± 0.14
Body mass changes (g)	–60.00 ± 29.47	14.88 ± 16.97	–29.54 ± 21.02

[ab]Means with different superscript across the row differ significantly at $P < 0.05$. Values are Means ± S.E.M, n = 12

Table 3. Pearson's correlation on behaviour, selected physiological indicators and body mass of brooding hens

	BM	BGC	RT	BT	TSSE	TSI
BM	1.000					
BGC	0.438	1.000				
RT	0.039	–0.172	1.000			
BT	0.727**	0.737**	-0.069	1.000		
TSSE	0.218	0.492	0.098	0.380	1.000	
TSI	–0.075	–0.320	-0.306	–0.169	–0.715**	1.000

** $P < 0.000$, n = 10. BM = body mass, BGC = blood glucose concentration, RT = rectal temperature, BT = breast temperature, TSSE = Time spent sitting on egg and TSI = time spent on ingestion.

the 3rd than at the 1st and 2nd week of brooding. On the other hand, the breast temperature was higher at the 1stand 2ndand dropped at the 3rdweek of brooding. There were no significant differences ($P > 0.05$) in the rectal temperature and body mass of broody hens as the brooding progressed from the 1st to the 3rd week.

However, there was a significant correlation between breast temperature and body mass of indigenous hens ($P < 0.001$). There was also a positive correlation between breast temperature and blood glucose concentration ($P < 0.001$), see Table 3. Time spent sitting on eggs was negatively correlated with time spent on food consumption, see Table 3.

DISCUSSION

To the author's knowledge, this is the first study to investigate the behaviour and basic physiological indicators of Nigerian indigenous hens during brooding. The behavioural observation was undertaken between 14:00 and 18:00 h based on the report of Asher and Mench (2014) that hens mainly left the nest between 10:00 and 18:00 h majorly to feed and drink. The results of the current study, however, showed no difference in the time spent by the hen sitting on the eggs as brooding progressed from the 1st to the 3rd week (88–92%), probably because of the need to provide adequate temperature and relative humidity (RH) needed for the embryonic development of the eggs (Reid et al., 2002). Sitting on the eggs is necessary for the transfer of heat from their body to the developing embryos (Bertin et al., 2018). The longer the bird spends off the nest the cooler the eggs become (Calder III, 2002) which is detrimental to the development of the embryo. Eggs subjected to suboptimal incubation temperature of 27.2 °C for 1 h twice a day delayed hatching and decreased growth rate and showed greater neophobic responses in hatchlings (Bertin et al., 2018)

Before the commencement of brooding, the hens pluck feathers from their breast and abdomen (brood patches) on the ventral surface, these reddish well-vascularized areas of skin to facilitate heat transfer to the eggs. Interestingly, this study observed that the BT (region of the body that comes in contact with the eggs) of the hens ranged from 37.8 °C to 39.5 °C which is just appropriate for the embryonic development.According to Lourens (2001) and Lourens et al. (2007), incubation temperature of 37.8 °C is the thermal homeostasis in the chick embryo and ensures the best embryonic development and hatchability. Webb (1987) reported that the optimal incubation temperature for avian embryos ranges between 35.5–38.5 °C. The increased BT at the 1st and 2nd week of brooding suggests the need for greater heat transfer to the eggs at the early and mid stage than the late embryonic development (3rd week), because as the embryo develops beyond day 18, it generates more heat than is required and may even need cooling (King'ori, 2011); probably this explains the decline in the BT of the hens at this period. According to Romanov et al. (2002), broodiness is

associated with increased body temperature, however, in the current study, the rectal temperature of the hens which is a measure of the core body temperature remained similar during the three weeks of brooding period but the BT increased at the 1st and 2nd and declined during the 3rd week.

In the current study, the elevated breast temperature of the hens at the 1st and 2nd week of brooding was accompanied by reduced blood glucose concentration. This could be explained by the need for increased body metabolism for the generation of body heat from the breakdown of body reserves (Hepp et al., 2015) especially at the first two weeks of the brooding process. This shows that the period of brooding by hens is associated with high energy expenditure. Their metabolic rate during brooding (incubation) is on average 3.4 times greater than the basal metabolism (Nord and Williams, 2015). The wasting and loss of pectoral muscle and body mass during brooding is due to anorexia induced by the effect of hormones on the hypothalamo-pituitary axis (Cunnighams and Klein, 2007). Despite the fact that the percentage of time spent by the hen sitting on egg and ingestive behaviours did not change as brooding progressed from the 1st to the 3rd week of brooding, the body metabolism regulating the amount of heat generated was controlled with respect to the developmental stages of the developing embryo.

The current study established a positive correlation between body mass and breast temperature. This relationship could be explained by the fact that the main purpose of brooding is to keep the eggs warm. The hen develops a brood patch towards the end of the egg laying period, and the skin becomes oedematous and highly vascularized. The blood flow to the brood patch is greatly increased, such that the heat from skin in this area incubates the eggs. Sensory fibres detect skin temperature where there is skin-to-egg contact. If the hen's body temperature falls she will shiver to generate heat and increase her metabolism to ensure that eggs are at the optimal temperature for incubation (Clark, 2019).

CONCLUSION

Broodiness is one of the natural behaviour of poultry. Till date, there has not been any report on broodiness in Nigerian indigenous hens with respect to their behaviour and physiological status. Their breast temperature was higher at the first and second week compared to the third week while blood glucose concentration was lower at the first and second week compared to the third week of brooding. Body mass of seven hens decreased during the brooding time but five hens gained body mass which was not expected and the reason for this is yet to be understood. Other basic behaviours, namely time spent sitting and ingesting, and rectal temperature did not change significantly as the brooding progressed.

REFERENCES

Ajayi F. O. (2010): Nigeria indigenous chicken: A valuable Genetic Resource for meat and egg production. Asian Journal of Poultry Science 4: 164–172.

Ajayi F. O., Agaviezor B. O. (2009): Phenotype characteristics of indigenous chicken in selected: local Government Areas in Bayelsa State, Nigeria International Poultry summit February 22–26, Abeokuta, pp. 75–78.

Asher G. S., Mench J. A. (2014): Natural incubation patterns and the effects of exposing eggs to light at various times during incubation on post-hatch fear and stress responses in broiler (meat) chickens. Applied Animal Behaviour Science 152: 44–51.

Bertin A., Calandreau L., Meurisse M., Georgelin M., Palme R., Lumineau S., Houdelier C., Darmailacq A., Dickel L., Colson V., Cornilleau F., Rat C., Delaveau J., Arnould C. (2018): Incubation temperature affects the expression of young precocial birds' fear-related behaviours and neuroendocrine correlates. Scientific Reports 8, article number 1857.

Calder III W. A. (2002): Characteristics and constraints of incubation in hummingbirds. In Deeming DC (Ed.): Avian incubation: behaviour, environment and evolution. Oxford University Press, pp. 207–221.

Chen S. J., Li W. B. (2007): Studies on the broodiness in Wumeng black-bone chicken. Bulletin of Shanghai Husbandry and Veterinary 5: 84.

Clark M. I. (2019): Management of breeding in small poultry production units: in Veterinary Reproduction and Obstetrics (tenth edition), pp. 531–532.

Cunninghams J. G., Klein B. G. (2007): Textbook of Veterinary Physiology. Fourth Edition. Published by Saunders, Elsevier, pp. 412–418.

Hepp G. R., DuRant S. E., Hopkins W. A. (2015): Influence of incubation temperature on offspring phenotype and fitness in birds. In Nests, Eggs, and Incubation (Deeming DC, Reynolds SJ) Oxford University Press, pp. 171–178.

Jiang R. S., Chen X. Y., Geng Z. Y. (2010): Broodiness, egg production, and correlations between broody traits in an indigenous chicken breed. PoultryScience 89: 1094–1096.

King'ori A. M. (2011): Review of the factors that influence egg fertility and hatchability in poultry. International Journal of Poultry Science 10: 483–492,

Lourens A. (2001): The importance of air meteorology in animal production. International Journal of Biometeorology 2: 139–156.

Lourens A., Van den Brand H., Heetkamp M. J. W., Meijerhof R., Kemp B. (2007): Effects of egg shell temperature and oxygen concentration on embryo growth and metabolism during incubation. Poultry Science 86: 2194–2199.

Mengesha M. (2012): Indigenous chicken production and the innate characteristics. Asian Journal of Poultry Science 6: 56–64.

Minga U. M., Msoffe P. L., Gwasika P. S. (2004): Biodiversity (variation) in disease resistance and in pathogens within rural chickens. Proceedings of XXII World's Poultry Congress, Istanbul, Turkey.

Muir W. M., Chen H. W. (2014): Genetic Influences on the Behavior of Chickens Associated with Welfare and Productivity: In Genetics and the Behavior of Domestic Animals (Second Edition) Academic Press, pp. 317–359.

Nord A., Williams J. B. (2015): The energetic costs of incubation: In Nests, Eggs, and Incubation (Deeming D. C., Reynolds S. J., Eds) Oxford University Press, pp. 152–170.

Olawunmi O. O., Salako A. E., Afuwape A. A. (2008): Morphometric differentiation and assessment of function of the Fulani and Yoruba ecotype indigenous chickens. Nigeria International Journal of Morphology 26: 975–980.

Reid J. M., Monaghan P., Nager R. G. (2002): Incubation and the costs of reproduction: In D. C. Deeming (ed.) Aavian incubation: behavior, environment, and evolution. Oxford University Press, New York, pp. 314–325.

Romanov M. N., Talbot R. T., Wilson P. W., Sharp P. J. (2002): Genetic control of incubation behavior in the domestic hen. Poultry Science 81: 928–931.

Shimmura T., Kamimura E., Azuma T., Kansaku N., Uetake K., Tanaka T. (2010): Effect of broody hens on behaviour of chicks. Applied Animal Behaviour Science 126: 1125–1133.

Shimmura T., Maruyama Y., Fujino S., Kamimura E., Uetake K., Tanaka T. (2015): Persistent effect of broody hens on behavior of chickens. Animal Science Journal 86: 214–220.

Webb D. R. (1987): Thermal tolerance of avian embryo: a review. Condor, 89: 874–898.

Zadworny D., Walton J. S., Etches R. J. (1985): The relationship between plasma concentrations of prolactin and consumption of feed and water during the reproductive cycle of the domestic turkey. Poultry Science 64: 401–410.

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