INCREASING PRODUCTIVITY OF LOCAL CHICKEN FROM LOCAL FARMERS THROUGH EARLY SEPARATION OF CHICKS FROM BROODING HEN IN DODOMA, TANZANIA

[1]NGONGOLO, Kelvin, [2]CHOTA, Andrew and [1]SIGALA, Atuhombye

[1]Department of Biology, College of Natural and Mathematical Sciences, The University of Dodoma (UDOM), Box 338, Dodoma, Tanzania.

[2]Tanzania Veterinary Laboratory Agency (TVLA) - Tanzania Vaccine Institute (TVI), Kibaha-Bagamoyo via Baobab Road, Mitamba Area, PO Box 30137, Kibaha-Pwani, Tanzania.

Corresponding Author: Ngongolo, K. Department of Biology, College of Natural and Mathematic Science, The University of Dodoma, Box 338, Dodoma, Tanzania. **Email:** kelvinkngongolo@yahoo.com **Phone:** +255 686 820 180

Received *October 15, 2023;* ***Revised*** *November 02, 2023;* ***Accepted*** *January 09, 2024*

ABSTRACT

Low production of local chicken was among the challenges faced by small-scale local chicken farmers in Dodoma, Tanzania, as reported in a previous study. In this case, this study stressed that understanding the manipulation of broody hens through early separation from chicks can increase the productivity of local chickens for farmers. Laying hens were monitored from the start of laying until they finished the circle and started laying again. The hen was allowed to lay, incubate, and hatch eggs. Following hatching, the chicks were separated from the hen by varying distances of 3 – 10 m. Eggs were laid, incubated and hatched, and the time interval taken for the hen to start laying again after the chick's separation was recorded. The average number of eggs laid, incubated and hatched per hen per circle varied significantly (p<0.05) between wet and dry seasons. About 60% of the hens lost their brooding behaviour in the first week, while about 40% did so in the second week. The average time it took for the hen to resume laying after chicks' separation ranged from 14 to 15 days, depending on factors such as season, distance between chicks and hen. The calling of hens to chicks decreased significantly (p<0.001) in the third week. In this study, the single laying circle lasted about 30 – 34 days. Early chicks' separation from hens can increase local chicken productivity for farmers, thus improving food security, income and employment.

Keywords: Chicks separation, Brooding hen, Increase laying city, Increase chicken productivity

INTRODUCTION

Improving the productivity of local chicken in Tanzania is necessary in order to achieve the Sustainable Development Goals of 1 - eliminating poverty, 2 - eradicate hunger, 3 - establish good health and well-being, and 5 - enforce gender equality (UN, 2015). Local chicken production is popularly known to increase food security, income, improve health through nutrition and create employment for women and youth (Sonaiya and Swan, 2004; Kryger *et al.*, 2010; Kabir *et al.*, 2015; Ngongolo *et al.*, 2021). The majority of Tanzanians practice local chicken keeping in all ranges, from villages to suburban and urban areas. Among the major challenges facing local chicken production in Tanzania is low productivity that can be associated with various factors such as diseases, theft, poor management systems, and the longevity utilized by hens to care for the chicks raised under a free-range system (Mutua, 2018; Ngongolo *et al.*, 2019; Ngongolo and Chota, 2021). A finding coping strategy to increase the productivity of

local chickens at a scale that is affordable to the local farmer is essential.

Local farmers in small-scale farming have taken a different approach to increasing chicken productivity. Among the approaches used are supplementary feeding, control of diseases and predation using improved breeds, and modification of management systems like semi-intensive systems and intensive systems (Ngongolo and Chota, 2021; Wilson *et al.*, 2022). For example, Mwalusanya *et al.* (2002) found that supplementing feed for local chickens is one of the strategies farmers use to increase chicken productivity. In addition, a study in Dodoma by Chota *et al.* (2021) revealed that farmers have been using vaccination, maintenance of flock size, and good banda (hut) as strategies to improve the productivity of chickens for local farmers in small-scale farming. Regardless of the different strategies used by farmers to improve the productivity of chicken at a local scale, little has been done in Dodoma to understand whether the productivity of local chicken can be enhanced through shortening the length of blooding hens so as to increase the laying and hatching cycle per year.

Chicken starts to lay eggs at 18 – 22 weeks old (4.5 – 5.5 months), depending on the breed of chicken kept, nutrition, housing and management (FAO, 2003; Stuttgen, 2022). Another study has reported the age of 6 – 8 months as the starting point for laying in local chicken (Mwalusanya *et al.*, 2002). They may stay in the backyard for 6 – 8 years, although they may effectively produce eggs for 3 – 4 years (Stuttgen, 2022). Mwalusanya *et al.* (2002) have shown that the average hen has three laying cycles per year. This implies that, the time interval used by chickens from the day of starting to lay eggs through incubation and chick layering until they start to lay again is about 4 months for local chickens. A previous report in Dodoma showed that, if a hen is left to keep their chicks until their natural weaning, it can take 3 – 4 months for one cycle to get finished and start laying again (Ngongolo *et al.*, 2021). More research is needed to determine the best way to shorten the laying cycle in chickens so that they can lay more eggs per year and increase their productivity.

This study focused on understanding how early separation of chicks from brooding hens can increase the productivity of local chickens by shortening the laying circle. Other factors and information, such as flock size, season, number of eggs layered, time taken for hens to lose their blooding behaviour, management system, and estimated number of chickens called per hour over a period of time, were also recorded.

MATERIAL AND METHODS

Study Areas: The study took place in Dodoma City specifically in Nkuhungu ward. Dodoma City is found in the Dodoma region (Figure 1).

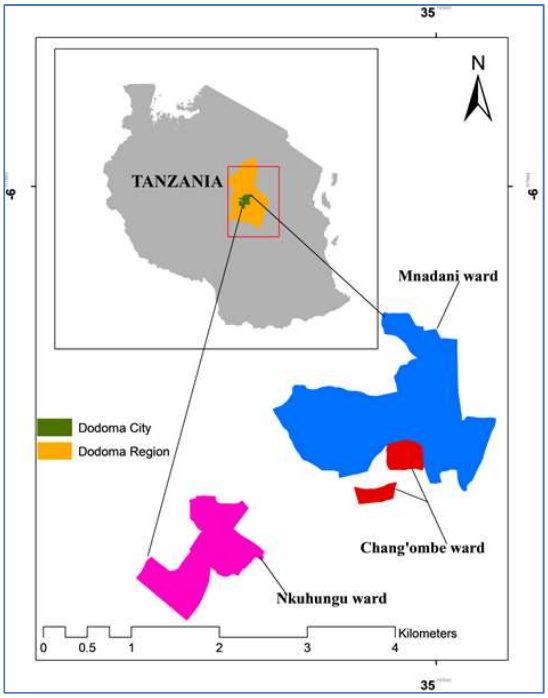

Figure 1: Dodoma City showing the Nkuhungu ward where the study took place (QGIS, 2022)

Dodoma is located at 6° 57' and 3° 82' latitude and 36° 26' and 35° 26' longitude. It is estimated that it is 1120 m above sea level. The environment is semi-arid, with Oxisol sandy loam soil dominating. The area's annual rainfall averages 447 mm. Temperatures vary by season, with average minimum and maximum temperatures of 18°C and 32°C, respectively. This study area was selected purposefully because, it was observed and reported that local

chicken is kept by small farmers Ngongolo and Chota (2021).

Study Design and Methods: A longitudinal cohort study was employed to monitor the laying circles of local chickens from two farmers. The two farmers were chosen because they kept chickens under free-range and had training on proper record keeping for the chickens kept. A total of 40 hens with at least 3 laying circle (n = 120) were involved in the study. The monitoring and data collection took place from January 2020 to December 2022. Each hen in the study was tracked from the time it began laying eggs until it hatched. After hatching, the chicks were separated from the hen and provided with the management required for chick growth, such as heat, feed and water. The growth performance of chicks after separation was also monitored for one month. Under the free-range system, the hatched hen in which the chicks were isolated was left to scavenge like other chickens. The isolation effort was done to ensure that the hen and chicks do not see or hear each other.

Data Collection: Data collected in this study were the number of eggs laid, incubated and hatched, and the growth performance of the hatched chicks. In addition, the day of separation with the chicks from brooding hen (mother), the time interval taken by the hen to lose its bloody behaviour, the time interval for the hen to start laying again were recorded. Furthermore, the number of eggs laid, incubated and hatched in the next cycle (e.g., the second, third, etc.), the management system used and the number of calls made by the hen per hour (calling chicks) in the first, second, third and fourth week was also considered. Also, the time interval taken for the hen to lose the brooding behaviour in the first, second, third, and fourth weeks, the season (wet or dry), and the month of the laying circle were considered and recorded. Furthermore, the number of chickens kept by the farmers during that particular time was recorded based on sex and age (cocks, hens, cockles, pullets and chicks). More information was asked of the farmers to supplement any information that was required at that time.

Data Analysis: The seasonal variation in growth performance of chicks, number of eggs laid and incubated among the hen under the study consideration was analyzed using t-test because the data were parametric. Furthermore, the variation in time interval taken by hen to make calling, lose brooding behaviour, start laying, incubation, hatching was analyzed using one-way ANOVA. The statistical analysis was performed using PAST Version 4.03 (Hammer *et al.*, 2001). The association between the time interval per laying cycle (laying after separation with chicks) and other factors such as flock size, number eggs laid, incubated, hatched, management system, losing brooding behaviour were determined using a generalized linear mixed effect model (GLM).

RESULTS

Eggs Laid, Incubated and Laying Success: There was variation in the number of eggs laid, incubated, hatched, and the time interval taken for the chicken to start laying again. For instance, during the dry season, chickens laid fewer eggs, while the hatching rate was higher than that in the wet season ($P < 0.005$) (Table 1). The time interval for separation of chicks from hens was 1 – 2 days after hatching. In comparison to the wet season, the dry season had more eggs laid, incubated, and hatched (Table 1). Time interval taken by the hen to start laying again was longer in the dry season than in the wet season (Table 1). In this case, it took a chicken 30 – 34 days to complete one laying cycle and begin another. These suggest that the hen can have 6 – 7 laying cycles per year.

Growth Performance of Chicks Hatched: The growth of chicks significantly increased ($p<0.001$) with time (ages). This trend was observed for all the different body parts considered for measurement. For instance, the highest growth performance was noted in older chicks aged 61 days and above. Conversely, less growth was recorded for very young chicks (0 – 20 days) (Figure 2).

Table 1: Differences of number of eggs laid, incubated, hatched and the time interval taken by hen to start laying again in dry and wet season

S/N	Variables	Classification	Mean ± SE
1	Eggs laid	Dry season	4.66 ± 0.3
		Wet season	5.98 ± 0.34**
2	Eggs incubated	Dry season	1.59 ± 0.11***
		Wet season	0.61 ± 0.10
3	Eggs hatched	Dry season	10.04 ± 0.82***
		Wet season	3.85 ± 0.66
4	Time taken to start laying again	Dry season	71.98 ± 4.38***
		Wet season	45.67 ± 2.13

*Note: ** and *** = significantly different at p<0.01 and p<0.001 respectively*

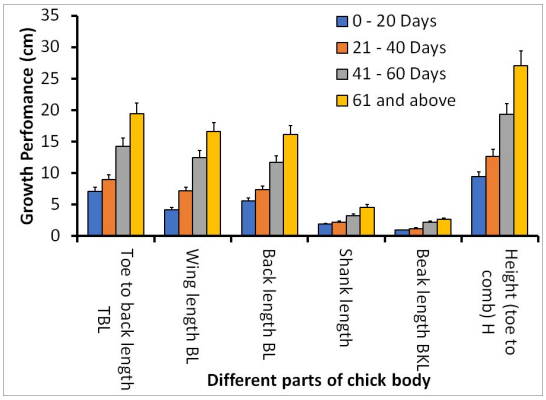

Figure 2: Growth performance under different age group in terms if toe to back length, wing length, back length, shank length, beak length, height and weight

Brooding Behavioural Changes in Hen after Chicks Separation

Losing brooding behaviour over time and number of calls for chicken made by hen with time interval: The brooding behaviour was associated with the calling of chicks, the willingness to care for chicks, and the response to chicks' calls. About 60% of the hens in the study lost their brooding behaviour in the first week, while about 40% lost their brooding behaviour in the second week after separation from their chicks. The first week saw the most calls for chicks from the hen (275.71 ± 7.49 calls/hour), followed by the second week (75.71 ± 6.48 calls/hour), and the third week (5.71 ± 1.54 calls/hour), with no calls recorded during the fourth week (completely lost the brooding behaviour) immediately after separation from their chocks. The variation in calls among the four weeks (1st, 2nd, 3rd and 4th) was statistically significant (Table 2).

The brooding behaviour varied between wet and dry season. For instance, the brooding activeness was reported to be higher in the first week in dry season than in wet season. However, the trend for brooding showed to decrease from the first week to the fourth week in both season (Table 2).

Distance of Separation Between the Hen and Chicks: The separation distance between hens and chicks has an impact on the communication calls from hens to chicks at different time intervals. The highest distance for separation was observed to be 10 m, with 240, 40 and 0 calls in the first, second and third weeks respectively. The shortest distance was observed at 3 m, with 390, 200 and 40 calls in the first, second, and third weeks respectively. This indicated that the greater the distance between hens and chicks were (at least 10 m), the faster was the loss of brooding behaviors (hens' calls to chicks) whether, the distance was far, moderate or near, yet, the brooding behavior revealed to change and decreases significantly from the first week to the fourth week ($p<0.001$) (Table 2).

Association of Start Laying Eggs After Separation with Distance Between Hen and Chicks, Season, Losing of Brooding Behaviour with Time: The time it took for chickens to resume laying was related to the separation interval and the time the chickens had stopped brooding. The frequency of laying increased as the chickens lost their brooding behaviour and early separation, particularly in the dry season (Table 3).

DISCUSSION

An Overview: The general overview from this study is that manipulating brooding behaviour in hens can potentially help boost the chicken productivity for local farmers, particularly those who are involved in keeping local chicken in a free-range system.

Table 2: The change and variation of the brooding behaviour of hen in four consecutive weeks from the day they were hatched across the season and distance between hen and chicks

S/N	Variables	Classification	Mean ± SE (calls/hour)
1	The overall brooding behaviour without considering seasons	Week 1	275.71 ± 7.49^{d}
		Week 2	75.71 ± 6.48^{c}
		Week 3	5.71 ± 1.54^{b}
		Week 4	0.00 ± 0.00^{a}
2	The brooding behaviour in dry season	Week 1	323.33 ± 10.54^{d}
		Week 2	113.33 ± 11.16^{c}
		Week 3	13.33 ± 3.19^{b}
		Week 4	0.00 ± 0.00^{a}
3	The brooding behaviour in wet season	Week 1	240.00 ± 6.92^{c}
		Week 2	47.5 ± 4.54^{b}
		Week 3	0.00 ± 0.00^{a}
		Week 4	0.00 ± 0.00^{a}
4	Distances between chicks and hen (Near 0 – 3 m)	Week 1	253.33 ± 8.43^{c}
		Week 2	56.66 ± 5.23^{b}
		Week 3	0.00 ± 0.00^{a}
		Week 4	0.00 ± 0.00^{a}
5	Distances between chicks and hen (Moderate 3.1 – 6.0 m)	Week 1	254.17 ± 12.00^{c}
		Week 2	53.33 ± 5.75^{b}
		Week 3	0.00 ± 0.00^{a}
		Week 4	0.00 ± 0.00^{a}
6	Distances between chicks and hen (Far 6.1 m and above)	Week 1	390.00 ± 0.01^{d}
		Week 2	200.00 ± 0.01^{c}
		Week 3	40.00 ± 0.03^{b}
		Week 4	0.00 ± 0.00^{a}

a-d Mean with different letter superscript along a column are significantly different ($p<0.05$)

In this study, it was clear that, 30 – 34 days were required for completing the laying circle and starting to lay again, which indicated that 6 – 7 laying circles per year can be done by a single hen. With an average of 13 eggs in each laying circle, a total of 78 eggs can be laid. This is contrasted with natural means where a laying circle can go up to 3 – 4 months for one cycle to get finished and start laying again, suggesting, only 4 – 3 cycles can be finished per year and produce a total of 39 eggs per hen (Ngongolo *et al.*, 2021). Other reports showed that a hen can be potentially productive for 3 – 4 years, which indicated that under manipulative brooding behaviour, a total of at least 300 eggs can be produced from a single local chicken (Stuttgen, 2022).

Eggs Laid, Incubated and Hatching Success: The average number of eggs laid, incubated and hatched was significantly higher in the dry season. Different seasons can affect the laying, incubation, and hatching success due to variation in weather partners, nutrition, egg storage duration, availability, diversity of feed, and the occurrence of diseases and parasite infestations. This was in agreement with a study of King'ori (2011) which showed that factors influencing hatchability in hens were strain, flock wellbeing, diet, age, egg size, weight, quality, egg storage duration and conditions. The ideal temperature range for poultry is 12 to 26°C. Fertile eggs should be kept for no longer than 10 to 14 days. Hatchability begins to decline significantly after fourteen days of storage. The change in seasons is anticipated to alter the majority of these factors, which could in turn impair the laying, incubation and hatchability success rates. Another study indicated that feed quality, water, management, climate, the number and quality of males, temperature (environmental, housing, storage and transportation) and egg disinfection had impact on egg hatchability (Ogbu and Oguike, 2018).

Growth Performance of Chicks Hatched: The growth performance of chicks showed good progress over time. This indicated that the separation of chicks from the hen did not have any effects, provided other factors needed for chick growth were provided. The factors for chicks' growth include temperature, feeding, proper housing, protection against diseases and parasites, and the nutrition value of the feed given.

Table 3: Association of start laying eggs after separation with distance between hen and chicks, season, losing of brooding behaviour with time

S/N	Variable	Classification	Coefficient Estimate	Z-value	P-Value
1	Distance	Far	1.39	3.40	0.001***
		Moderate	-2.63×10^{-16}	0.00	1.00
		Near	-0.69	-1.01	0.31
2	Losing brooding behaviour	Week 2	0.69	1.96	0.04*
3	Laying circle	No classification	4.54×10^{-16}	0.00	1.00
4	Season	Wet season	-6.08×10^{-16}	0.00	1.00
5	Separation day	No classification (only number of days)	-6.93×10^{-1}	-2.47	0.01**

***Note**: *, ** and *** = significantly different at p<0.05, p<0.01 and p<0.001 respectively*

The variability in growth among age groups may be explained by the differences in the nutritional value of the feed given to the chick. For example, Hagan *et al.* (2016) concluded that protein feed intake from a 20 g *Samanea saman* dietary treatment yielded the best results in chicken growth performance. This indicated that the nutritional value of chicken feed, specifically the protein content has significant impact on chick growth performance.

Brooding Behavioural Changes of Hen after Separation from Chicks: The hen's brooding behaviour decreased over time, with the peak observed in the first week. Calling for chicks was also linked to a reduction in brooding behaviour. Furthermore, separation distance was required for the hen to stop brooding. The number of calls significantly decreased in the third week when the distance between chicks and hens was kept at a level where they couldn't hear or see each other, according to this study. This may be due to changes in the amount of hormone that regulates brooding behaviour in chickens. Prolactin regulates brooding behaviour in chickens as it plays an important role in the onset of broodiness (Reddy *et al.*, 2002; PoultryDVM, 2022). When these hormone levels rise, it inhibits the production of gonadotropin, which stimulates ovarian follicles (what eggs are made from). Whenever an actively laying hen has been injected with prolactin, she stops laying eggs and becomes broody after a few days. Broodiness in chickens is triggered by certain environmental factors. In this regard, the separation of the hen from the chick lowered the production of prolactin, while stimulating the production of gonadotropin, which triggers the production of eggs. Broodiness can be induced by hot weather, allowing eggs to accumulate in the nesting box, limiting light exposure, and seeing baby chicks (Geng *et al.*, 2014; PoultryDVM, 2022; Shimmura *et al.*, 2015). Shimmura *et al.* (2015) found that the existence of broody hens at an early stage in the lives of chicks has a long-term effect on behaviour. Although brooded chickens produced fewer eggs than non-brooded chickens, feather pecking and aggressive interactions were reduced in brooded hens. This means that the more time a hen spends brooding, the lower her egg production and overall chicken productivity, particularly among local chicken.

Conclusion: The early chicks' separation in 1 – 2 days caused the hen to resume laying, and the separated chicks were observed to grow normally if they were provided with the basic conditions and environment required for growth. Furthermore, starting to lay again for chicks was associated with the loss of brooding behaviour over time, the separation date, and the season, with the dry season having the highest significance. In local chickens, early separation of chicks and their hen increases production twice as much as natural means. For instance, when early separation (1 – 2 days) was made for local chickens, they were able to have 6 – 7 laying circles per year, while under natural means (allowing the hen to make her own weaning and separation), the maximum laying circle per year was 3 – 4 laying circles per year. The study recommends that the local farmers adopt these techniques for higher production of local chicken. The techniques will enable the farmer to produce

twice as much chicken as before. Separating days, on the other hand, must be considered for more effective production, a longer growing season and proper chick management.

ACKNOWLEDGMENTS

The authors highly appreciate the University of Dodoma for provision of space and technical support during the implementation of this project. The authors equally appreciate the support by Mr. Zackaria Kibandike who helped in measuring and monitoring growth performance of chicks. The famers who willfully participated in the project and provided their flock for sampling are greatly appreciated.

REFERENCES

CHOTA, A., KITOJO, O. and NGONGOLO, K. (2021). Knowledge on diseases, practices, and threats of drugs residues in chicken food chains in selected districts of Dodoma region, Tanzania. *Journal of Applied Poultry Research*, 30(4): 100186. https://doi.org/10.1016/j.japr.2021.100186

FAO (2003). *Egg Production*. *Chapter 1. In:* Egg Marketing - A Guide for the Production and Sale of Eggs. FAO Agricultural Services Bulletin 150, Food and Agriculture Organization of the United Nations, Rome, Italy. https://www.fao.org/3/y4628e/y4628e02.htm# Accessed November 21, 2022.

GENG, A. L., XU, S. F., ZHANG, Y., ZHANG, J., CHU, Q. and LIU, H. G. (2014). Effects of photoperiod on broodiness, egg-laying and endocrine responses in native laying hens. *British Poultry Science*, 55(2): 264 – 269.

HAGAN, M. A. S., DONKOH, A. and AWUNYO-VITOR, D. (2016). Growth performance and economic evaluation of broiler chicken fed with rain tree (*Samanea saman*) seed meal. *Cogent Food and Agriculture*, 2(1): 1277445. https://doi.org/10.1080/23311932.2016.1277445

HAMMER, Ø., HARPER, D. A. T. and RYAN, P. D. (2001). Past: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica*, 4(1): 4. http://palaeo-electronica.org/2001_1/past/issue1_01.htm

KABIR, M. S., ASADUZZAMAN, M. and DEV, D. S. (2015). Livelihood improvement through family poultry farming in Mymensingh district. *Journal of the Bangladesh Agricultural University*, 13(2): 247 – 256.

KING'ORI, A. M. (2011). Review of the factors that influence egg fertility and hatchability in poultry. *International Journal of Poultry Science*, 10(6): 483 – 492.

KRYGER, K. N., THOMSEN, K. A., WHYTE, M. A. and DISSING, M. (2010). *Smallholder Poultry Production–Livelihoods, Food Security and Sociocultural Significance.* FAO Smallholder Poultry Production, Paper 4, Food and Agriculture Organization of the United Nations, Rome, Italy.

MUTUA, B. M. (2018). *Challenges Facing Indigenous Chicken Production and Adoption Levels of Biosecurity Measures in Selected Areas of Makueni County, Kenya*. Master's Thesis and Dissertation, School of Agriculture, Environment, Water and Natural Resources Management, South Eastern Kenya University, Kitui, Kenya. http://repository.seku.ac.ke/handle/123456789/4126

MWALUSANYA, N. A., KATULE, A. M., MUTAYOBA, S. K., MTAMBO, M. M. A., OLSEN, J. E. and MINGA, U. M. (2002). Productivity of local chickens under village management conditions. *Tropical Animal Health and Production*, 34: 405 – 416.

NGONGOLO, K., and CHOTA, A. (2021). Chicken production, flock size, management systems, and challenges in the Dodoma region in Tanzania. *Poultry Science,* 100(6): 101136. https://doi.org/10.1016/j.psj.2021.101136

NGONGOLO, K., OMARY, K. and CHOTA, A. (2021). Social-economic impact of chicken production on resource-constrained communities in Dodoma, Tanzania. *Poultry Science*, 100(3): 100921. https://doi.org/10.1016/j.psj.2020.12.019

NGONGOLO, K., SIGALA, E. and MTOKA, S. (2019). Community poultry project for conserving the wildlife species in magombera forest, Tanzania. *Asian Journal of Research in Agriculture and Forestry*, 2(4): 1 – 7.

OGBU, O. C. and OGUIKE, M. A. (2018). Hatchability of fertile eggs in poultry industry. *Journal of Agriculture and Sustainability*, 12(1): 107 – 123.

POULTRYDVM (2022). Broodiness. http://www.poultrydvm.com/condition/broodiness Accessed December 3, 2022.

QGIS (2022). *QGIS Geographic Information System.* Open Source Geospatial Foundation Project, QGIS Development Team. https://www.qgis.org/en/site/forusers/download.html Accessed August 10, 2022.

REDDY, I. J., DAVID, C. G., SARMA, P. V. and SINGH, K. (2002). The possible role of prolactin in laying performance and steroid hormone secretion in domestic hen (*Gallus domesticus*). *General and Comparative Endocrinology*, 127(3): 249 – 255.

SHIMMURA, T., MARUYAMA, Y., FUJINO, S., KAMIMURA, E., UETAKE, K. and TANAKA, T. (2015). Persistent effect of broody hens on behaviour of chickens. *Animal Science Journal*, 86(2): 214 – 220.

SONAIYA, E. B. and SWAN, S. E. J. (2004). *Manual Small-Scale Poultry Production: Technical Guide*. Food and Agriculture Organization of the United Nations, Rome, Italy.

STUTTGEN, S. (2022). *Life Cycle of a Laying Hen.* https://livestock.extension.wisc.edu/articles/life-cycle-of-a-laying-hen/ Accessed November 21, 2022.

UN (2015). *Transforming our World: the 2030 Agenda for Sustainable Development.* Resolution adopted by the General Assembly on 25 September 2015, Seventieth Session Agenda Items 15 and 116, United Nations. https://documents-dds-ny.un.org/doc/UNDOC/GEN/N15/291/89/PDF/N1529189.pdf?OpenElement Accessed November 21, 2022.

WILSON, W. C., SLINGERLAND, M., OOSTING, S., BAIJUKYA, F. P., SMITS, A. J. and GILLER, K. E. (2022). The diversity of smallholder chicken farming in the southern highlands of Tanzania reveals a range of underlying production constraints. *Poultry Science*, 101(10): 102062. https://doi.org/10.1016/j.psj.2022.102062