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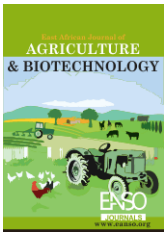

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Original Article

Effect of Egg Characteristics on Subsequent Egg Laying Performance of F1 Guinea Hens (Numida meleagris) in the Western Highlands of Cameroon

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Egg Characteristics, Egg Laying Performance, Numida meleagris, Egg Weight, Shape Index.

ABSTRACT

To evaluate the effect of egg characteristics on subsequent egg laying performance by F1 guinea hens (Numida meleagris) in the Western Highlands of Cameroon, a study was carried out from March to September 2024. Keets obtained from the incubation of eggs grouped into three categories; small (40-45 g); medium (46-49 g) and large (>50 g) categories were collected at hatch and raised on a maintenance diet until the onset of lay in March (at 32 weeks of age) followed by a layer diet containing 17.5% CP and 2,800 Kcal ME/kg throughout their laying period. Eggs from F1 guinea hens were collected, counted, and weighed. Egg lengths and widths were measured and used to compute egg shape indices from 32 WOA up to 56 WOA. Average egg yields per hen and hen-day-egg production (HDEP%) in 26 weeks (March to September) were evaluated. Data collected were subjected to descriptive statistical procedures and One-way ANOVA. Results showed that F1 egg weights ranged from 13 g to 56 g, with a mean egg weight of 44.12 g, and egg shape indices ranged from 70.30% to 85.10 with a mean shape index of 77.92% across all categories. Shape indices of F1 eggs from the small and medium categories showed no significant differences but were significantly lower ($p<0.05$) compared to the large category. Likewise, eggs from the small and large categories showed no significant differences in average egg weights, but both had higher ($p<0.05$) weights than eggs from the medium category. Average egg yield per hen per category in 26 weeks (March to September) were 87.75, 73.00 and 80.50 for hens from small, medium and large categories respectively. Hen-day-egg production (HDEP %) in 26 weeks (March to September) were 43.04±3.27, 39.15±3.56 and 42.99±2.7 for the small, medium and large categories respectively. In conclusion, helmeted guinea fowls could lay up to 87 eggs with over 43% HDEP in a 26-week laying period (rainy season; March to September),

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under intensive rearing conditions. Hens from smaller eggs have better egg laying performance than hens from large eggs.

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INTRODUCTION

Poultry production is a huge economic activity in developing countries (Atawalna *et al.*, 2022) and in Cameroon in particular. The contribution of the guinea fowl in Cameroon is still lagging as its exploitation is mostly under the scavenging system and hunting of wild strains (Massawa *et al*., 2020). Guinea fowls are resistant to common poultry diseases and thrive well in harsh nutritional and environmental conditions (Moreki & Seabo, 2012; Massawa *et al*., 2020). Guinea fowl meat and eggs are important sources of animal protein in low-income farm families, especially in the Northern Regions of Cameroon (Massawa *et al.*, 2020), and are in high demand due to their low-fat content and higher content of essential amino acids (Moreki, 2009). In these Northern Regions of Cameroon, guinea fowls provide income, especially for the rural population, and are used for some cultural and religious rites (Massawa *et al.*, 2020; Dongmo *et al.*, 2023, Djiotsa *et al.*, 2023).

Despite the important role the helmeted guinea fowl (HGF) plays in the agrarian economy in the Northern Regions, some challenges have limited its contributions to the economy of these regions and the country at large. A major challenge is the seasonality in their breeding, which is further compounded by a free-range rearing system practised by most farmers (Massawa *et al.*, 2020; Dongmo *et al.*, 2023; Djiotsa *et al.*, 2023). This has led to low productivity of this bird species. Compared with the domestic hen species, HGFs start laying eggs later and have lower egg productivity, partly due to seasonality in their laying behaviour (Moreki, 2010; Sodjedo *et al.*, 2022; Portillo-Salgado, 2022). Indigenous guinea fowl have been reported to start laying eggs between 28 and 42 weeks of age, with 15 to 20 eggs being laid each season in the wild (Sodjedo *et al.*, 2022). The Guinea fowl propagation period in their natural distribution range begins in August and lasts for about two months. They start laying eggs at 28-32 weeks of age, depending on their breed, husbandry, and environment (Hien, 2002). Guinea fowl layers could be used for 7 years or more. According to Sodjedo *et al.* (2022), the production period during the first laying year is 38-40 weeks in an intensive

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production system and 28-33 weeks in semi-intensive systems. Meanwhile, under extensive rearing conditions, the duration of the laying period is 22-25 weeks. Some authors have reported that under the conditions of extensive and semi-intensive production systems, the reproduction period lasts for 22 weeks. Abdul-Rahman *et al.* (2018) recorded a 9-month reproduction period, in which 80-90% of the eggs were laid between April and September.

In almost all poultry species, egg laying is a key performance metric in assessing productivity in females. Key traits of economic importance include: age at sexual maturity, number of eggs laid, hen day egg production, egg yield per hen per season, egg weight, egg quality, and other indices like persistence and length of laying season (Oluyemi & Robert, 2000; Okoro & Onunkwo, 2015).

Some researchers have reported the effects of egg characteristics like egg weights and shape indices on fertility, hatchability, and post-hatch early growth performances. However, the relationship between parental egg characteristics and subsequent F1 laying performance is yet to be investigated. There paucity of information on the effect of egg characteristics on the subsequent egg laying performances of the F1 hens in semi-intensive and intensive systems in the Western Highlands of Cameroon (WHC). To improve the knowledge of egg characteristics useful for selecting guinea fowl strains for subsequent laying, a study of the effect of egg characteristics on the subsequent egg laying performance of F1 hens was necessary. It is with the foregoing considerations that this study was designed to examine the effect of egg characteristics (egg weight/sizes and egg shape indices) on the subsequent egg laying performance of F1 guinea hens. Specifically, the study sought to assess parent egg characteristics as well as F1 egg characteristics for the small, medium and large categories, compare F1 egg characteristics to parent egg characteristics and evaluate egg laying performance along with laying trends for hens from the small, medium and large categories.

MATERIALS AND METHODS

Study Period and Site

This study was carried out from March to September 2024 at the poultry unit of SALI (Sustainable Agriculture/Livestock Enterprise), Mile 4 Nkwen, Bamenda in the Western Highlands of Cameroon (Latitude 5^{o} 98’ N and longitude 10^{o}19’ E and an altitude of 1,258 m). The study area was characterized by a Sudano-Guinean climate of tropical type with two distinct seasons. The wet season went from March to October and the dry season, from November to February. The mean annual rainfall was 2,145 mm and the mean annual temperature was 21.5 ^{o}C, with the highest temperatures recorded in March (23 °C) and the lowest temperatures recorded in July and August. The average relative humidity stood at 75%, with February recording the lowest mean relative humidity and July being the most humid month (IRAD, 2016, Guedjeo *et al.*, 2017; Tuncha *et al*., 2021). The study involved monitoring age at first lay and season of lay as well as collection, counting and characterization of eggs from hens raised in their respective categories of small (40-45 g); medium (46-49 g) and large (>50 g) of eggs from which they were obtained.

Egg Laying Performance

Bird Management

F1 guinea fowl pullets (obtained from hatching of characterized eggs from small, medium and large egg categories) were raised on a maintenance diet from 13 weeks of age (WOA) to sexual maturity (onset of lay). At the onset of lay, a layer ration with 17.5% CP and 2,800 kcal ME/kg (Abdul-Rahman *et al.*, 2018), determined through calculation, was formulated and served *Ad libitum*. The birds were reared under natural daylight conditions on deep litter until the end of the experiment with a stocking density of 4 birds per sq.m. Standard biosecurity and

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prophylactic procedures recommended for poultry production systems were followed. Birds were treated humanely, taking into account their natural behaviour of flightiness and perching in housing design and rearing equipment.

Egg Collection and Management

Egg laying by guinea hens in all categories was monitored for 27 Weeks from the onset of lay. Eggs were collected, counted and characterized daily from 32 WOA up to 56 WOA. Egg lengths and widths were taken with the aid of an eisco vernier caliper (150±0.2 mm). Eggs were also weighed with an SF-400 type digital electronic balance (accuracy of g±0.01 g). Using the egg lengths and widths, the egg shape indices were computed according to the formula used, by Alasaha & Copur (2016) and Banla *et al.* (2021).

The parameters that were evaluated include:

- The age of a hen at first lay corresponds to the average age of hens at which their first egg was recorded.
- Total and Average weight of eggs obtained by weighing eggs laid in each category and computing the averages.
- Number of eggs laid by hens in each category.

(Nahashon *et al.*, 2007; Okoro & Onunkwo, 2015; Abdul-Rahman *et al.*, 2018)

- Daily feed intake

$$\text{Feed Intake} = \text{Feed served} - \text{Leftovers}$$

Feed Conversion Ratio (FCR)

$$\text{FCR} = \frac{Quantity\ of\ feed\ consumed}{Weight\ of\ eggs\ produced}$$

Egg number: This was determined by counting the weekly number of eggs from the first to the last week of the experiment (Nahashon *et al.*, 2007; Okoro & Onunkwo, 2015; Abdul-Rahman *et al.*, 2018).

Percent Hen-day egg production (HDEP %): Total number of eggs laid by the flock in a given period divided by the product of the number of days and the number of hens alive on each of the days.

This was calculated as follows:

$$\text{HDEP\%} = \frac{Number\ of\ eggs\ laid}{Number\ of\ Hen\ days} \times 100$$

Number of Hen days = Number of days x number of hens

This parameter reflects the production capacity of the available birds in the house. A farm average of 85% or more per annum is said to be desirable.

Data Analyses

Data collected were subjected to descriptive statistics (means, percentages) and analysis of variance (Bluman, 2012). Means that showed significant differences were separated using the Duncan's Test. Statistical analyses were done using MS Excel 2010 and SPSS 20.

RESULTS AND DISCUSSION

Egg Characteristics from F1 Hens by Category of Small, Medium, and Large

The characteristics of eggs subsequently laid by F1 hens are presented in Table 1.

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Table 1: Egg Characteristics of F1 Hen Eggs

Category	Egg characteristics	Range	Mean ± STD*
Small (S)	Egg Length (cm)	4.00 – 6.00	4.81 ± 0.40
	Egg width (cm)	3.00 – 4.00	3.92 ± 0.2.8
	Egg weight (g)	33.00 – 53.00	44.11 ± 4.59 [a,b]
	Egg Shape Index (%)	70.30 – 85.10	77.58 ± 2.70[*]
Medium (M)	Egg Length (cm)	2.00 - 5.00	4.75 ± 0.48
	Egg width (cm)	1.00 - 4.00	3.90 ± 0.34
	Egg weight (g)	13.00 – 53.00	43.47 ± 5.11[b]
	Egg Shape Index (%)	72.70 - 82.60	77.50 ± 2.41[*]
Large (L)	Egg Length (cm)	2.00 - 5.00	4.75 ± 0.50
	Egg width (cm)	1.00 - 4.00	3.92 ± 0.36
	Egg weight (g)	14.00 – 56.00	44.71 ±5.39[a]
	Egg Shape Index (%)	72.50 - 85.10	78.65 ± 3.06[**]
Overall	Egg Length (cm)	2.00 - 6.00	4.77 ± 0.46
	Egg width (cm)	1.00 - 4.00	3.92 ± 0.32
	Egg weight (g)	13.00 – 56.00	44.12 ± 5.04
	Egg Shape Index (%)	70.30 – 85.10	77.92 ± 2.80

[a,b,c] mean weights with different superscripts in the same column are significantly ($p<0.05$) different

[*,**] mean shape indices with different superscripts in the same column are significantly ($p<0.05$) different

Means of egg lengths and widths showed no significant differences for all categories ($p<0.05$);

**SD: Standard deviation*

The egg weights ranged from 13 g to 56 g. The lowest weights were obtained in hens at the start of their laying career. The egg shape indices ranged from 70.3% to 85%. Eggs from the F1 hens in the small and medium categories showed no significant differences in shape indices but had significantly lower ($p<0.05$) shape indices compared with eggs from the F1 hens in the large category. Eggs from the F1 hens in the small and large categories showed no significant differences ($p>0.05$) in average egg weights, but both had significantly higher weights ($p< 0.05$) compared to eggs of F1 hens from the medium category.

Egg weights obtained in this study fall within the range reported by other authors (Alasaha & Copur, 2016, Kouame *et al.*, 2019; Ivanova *et al.*, 2020; Djiotsa, 2023). Much lower weight ranges of guinea fowl eggs from 32 g to 42 g, with an average egg weight of 38 g (Khairunnesa *et al.*, 2016), and 38 to 45 g (Fani *et al.*, 2004) have been reported. Ivanova *et al.* (2020) reported shape indices between 76% and 78%, whereas in this study, egg shape indices of 77.58±2.70, 77.50±2.41, and 78.65±32.06 for small, medium, and large categories, respectively. The guinea hen eggs are characterized by a more rounded shape compared to the local chicken eggs, which are oval. This translates to the higher egg shape indices obtained in the study. These findings were corroborated by Ivanova *et al.* (2020). The parent egg characteristics did not influence the subsequent F1 egg characteristics.

Parent Egg Characteristics versus F1 Egg Characteristics

Egg characteristics of F1 hens showed wider variations compared to parent eggs. Subsequent F1 hens and parent egg characteristics as presented in Table 2.

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Table 2: Characteristics of F1 Hen Eggs Compared to Parents Egg

Category	Egg characteristics	Parent Eggs		F1 Eggs	
		Range	Mean ± STD*	Range	Mean ± STD*
Small (S)	Egg Length (cm)	4.3 - 5.0	4.75 ± 0.16[1]	4.00 – 6.00	4.81 ± 0.40
	Egg width (cm)	3.6 - 3.9	3.72 ± 0.09*	3.00 – 4.00	3.92 ± 0.2.8
	Egg weight (g)	40 – 45	43.75 ± 1.53 [a]	33.00 – 53.00	44.11 ± 4.59[a,b]
	Egg Shape Index (%)	72.00 - 86.00	78.42 ± 3.00	70.30 – 85.10	77.58 ± 2.70*
Medium (M)	Egg Length (cm)	3.8 - 5.2	4.86 ± 0.21 [2]	2.00 - 5.00	4.75 ± 0.48
	Egg width (cm)	3.5 - 4.8	3.82 ± 0.23 *	1.00 - 4.00	3.90 ± 0.34
	Egg weight (g)	46 – 49	47.66 ±1.02 [b]	13.00 – 53.00	43.47 ± 5.11[b]
	Egg Shape Index (%)	70.59 - 96.00	78.68 ± 5.34	72.70 - 82.60	77.50 ± 2.41*
Large (L)	Egg Length (cm)	4.5 - 5.6	5.03 ± 0.18 [3]	2.00 - 5.00	4.75 ± 0.50
	Egg width (cm)	3.2 - 5.0	3.99 ± 0.37 **	1.00 - 4.00	3.92 ± 0.36
	Egg weight (g)	50 – 59	51.60 ±1.79[c]	14.00 – 56.00	44.71 ±5.39[a]
	Egg Shape Index (%)	60.58 - 98.00	79.32 ± 7.16	72.50 - 85.10	78.65 ± 3.06**
Overall	Egg Length (cm)	3.8 - 5.6	4.91 ± 0.22	2.00 - 6.00	4.77 ± 0.46
	Egg width (cm)	3.2 - 5.0	3.87 ± 0.29	1.00 - 4.00	3.92 ± 0.32
	Egg weight (g)	40 – 59	48.52 ± 2.92	13.00 – 56.00	44.12 ± 5.04
	Egg Shape Index (%)	60.58 – 98.00	78.91 ± 5.82	70.30 – 85.10	77.92 ± 2.80

[a,b,c]Parent mean egg weights with different superscripts in the same column are significantly ($p<0.05$) different

[*,**]Parent means egg widths with different superscripts in the same column are significantly ($p<0.05$) different

[1,2,3]Parent means egg lengths with different superscripts in the same column are significantly($p<0.05$) different

Means of parents' shape indices showed no significant differences for all categories ($p<0.05$)

[a,b,c] F1 mean weights with different superscripts in the same column are significantly ($p<0.05$) different

[*,**] F1 mean shape indices with different superscripts in the same column are significantly ($p<0.05$) different

F1 Means of egg lengths and widths showed no significant differences for all categories ($p<0.05$);

**STD: Standard deviation*

The parent egg characteristics and F1 egg characteristics were very similar for the small category. However, the parent eggs showed higher average weights because parent eggs were already graded at purchase before weighing and incubating. Mean egg weights from F1 guinea hens of the small category were higher than mean egg weights from their corresponding parents. The mean egg weights of parents were higher than the mean egg weights of their F1 counterparts. The egg shape indices for parents and F1 guinea hens were slightly higher in the parents for each category because the parent eggs were sorted and graded at purchase, whereas eggs from F1 guinea hens were characterized as they were laid by the hens. This also explains the wide range in egg weights, widths, and lengths

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observed with eggs from F1 hens compared to their parent counterparts. No direct relationship could be made between parent egg characteristics and F1 egg characteristics.

F1 Egg Laying Performance and Trends

a) Egg laying performance

Parameters such as age at first egg, average feed intake, total number of eggs laid, number of eggs laid in 26 weeks, hen-day egg production, and feed conversion ratio were determined with the results presented in Table 3.

Table 3: Egg Laying Performance Parameters

Category	Age at first egg (WOA)	Average Feed intake g/hen per day	Total number of eggs laid	Eggs/hen in 26 weeks	Hen day egg production (HDEP%) Mean ±SEM	Feed Conversion Ratio (FCR)
Small	32	129.4	319	87.75	43.04±3.27[a]	1.52[a]
Medium	34	129.8	287	73.00	39.15±3.56[a]	1.75[b]
Large	33	130.5	348	80.50	42.99±2.7[a]	1.58[c]
Overall	33	129.9	954	80.42	41.73±1.8[a]	1.61

Mean ±SEM: Mean ± Standard error of the mean

FCR: weight of feed to weight of eggs

> *HDEP (also known as the rate of lay) reflects the production capacity of the available birds in the house. A farm average of 85% or more per annum is desirable. It was evaluated for half a year in this study.*

No significant differences ($p>0.05$) were observed in HDEP between F1 hens in the small, medium, and large categories. However, hens in the small category laid a higher number (87.75%) of eggs in 26 weeks, followed by hens in the large category (80.50%) and lastly by hens in the medium category (73.0%). Mean feed conversion ratio, i.e., the feed consumed per unit weight of eggs showed significant differences ($p<0.05$) across all categories.

b) Egg laying trends for small, medium, and large categories

i) Egg laying trends in the subsequent F1 hens of the large category

Hen-day egg production (HDEP%) for F1 hens in the large category increased from the second week of lay up to the 6th week of lay and stayed constant from the 6th week of lay until the 17th week of lay before witnessing an irregular evolution up to the 26th week (Figure 1).

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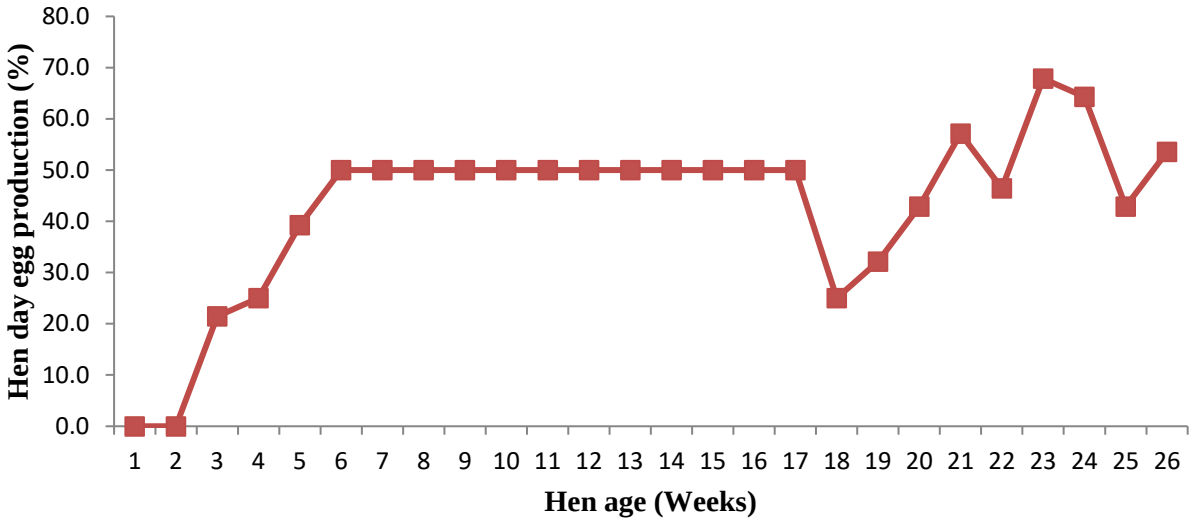
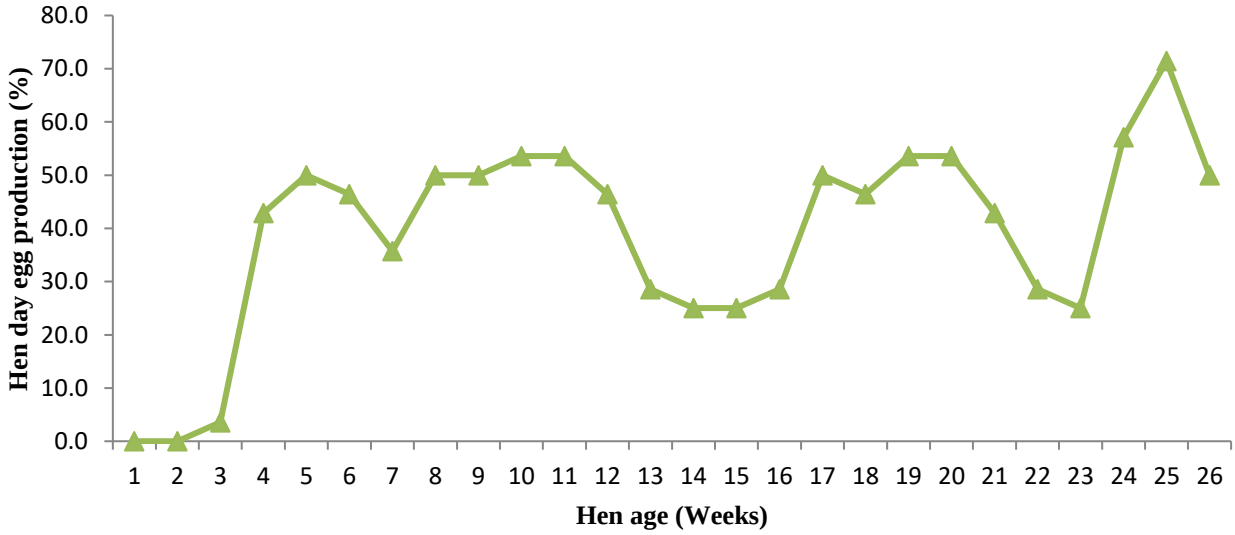
Figure 1: Egg Laying Curve for Large Category



ii) Egg laying trends in the subsequent F1 hens of the medium category

Hen day egg production (HDEP%) for F1 hens in the medium category witnessed a more irregular pattern of evolution compared to the large category as seen in Figure 2.

Figure 2: Egg Laying Curve for Medium Category



iii) Egg laying trends in the subsequent F1 hens of the Small category

Hen-day egg production (HDEP%) rapidly increased up to a peak at the 5th week of lay in the small category. This was followed by an irregular decrease up to the 26th week of lay (Figure 3).

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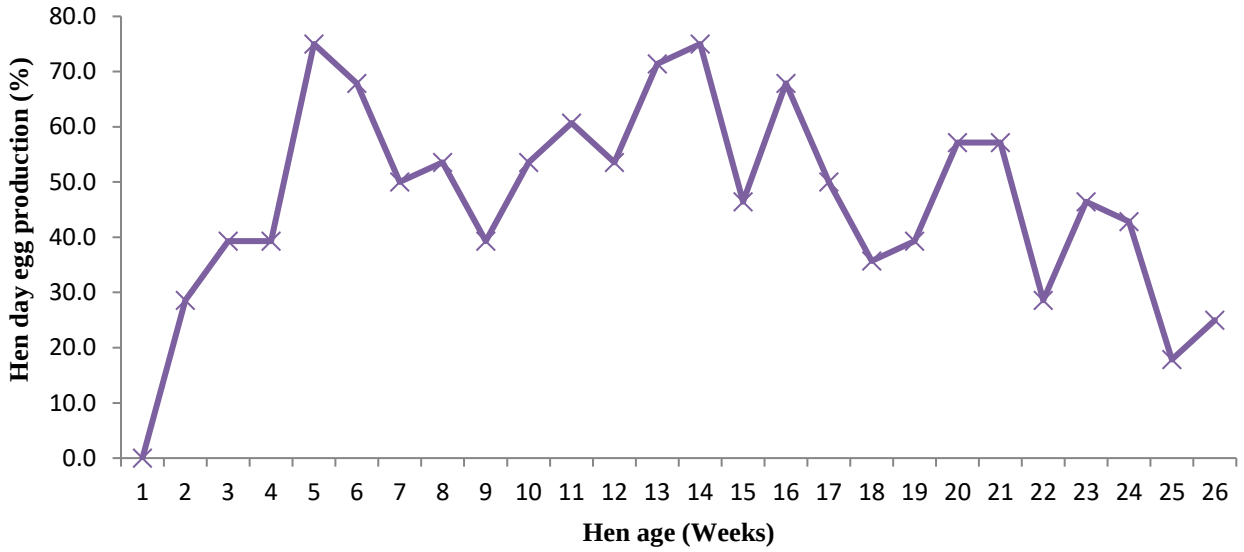
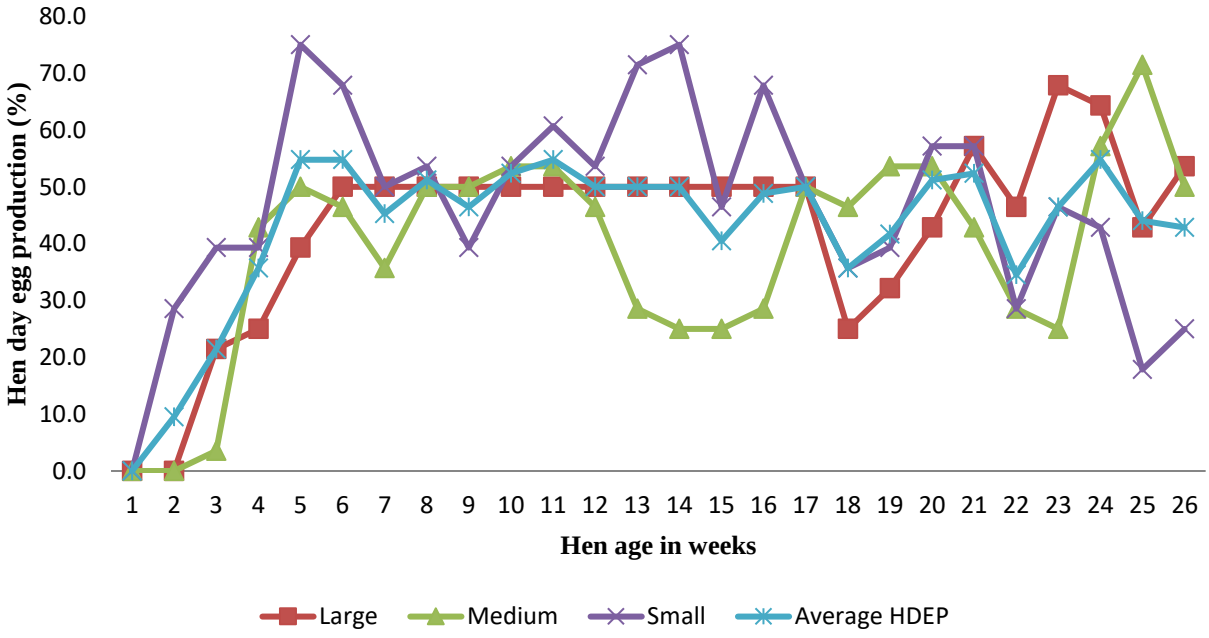
Figure 3: Egg Laying Curve for Small Category



iv) **Comparing egg laying profile by category to average hen-day egg production**

Figure 4: Comparing Egg Laying Profile by Category to Average HDEP



Comparing egg laying in the various categories showed that hens from the small category had a better HDEP compared to hens in the medium and large categories.

v) Average hen-day egg production for all the categories

The average hen day egg production followed the standard egg laying curve of poultry. However, variations were observed for some weeks between

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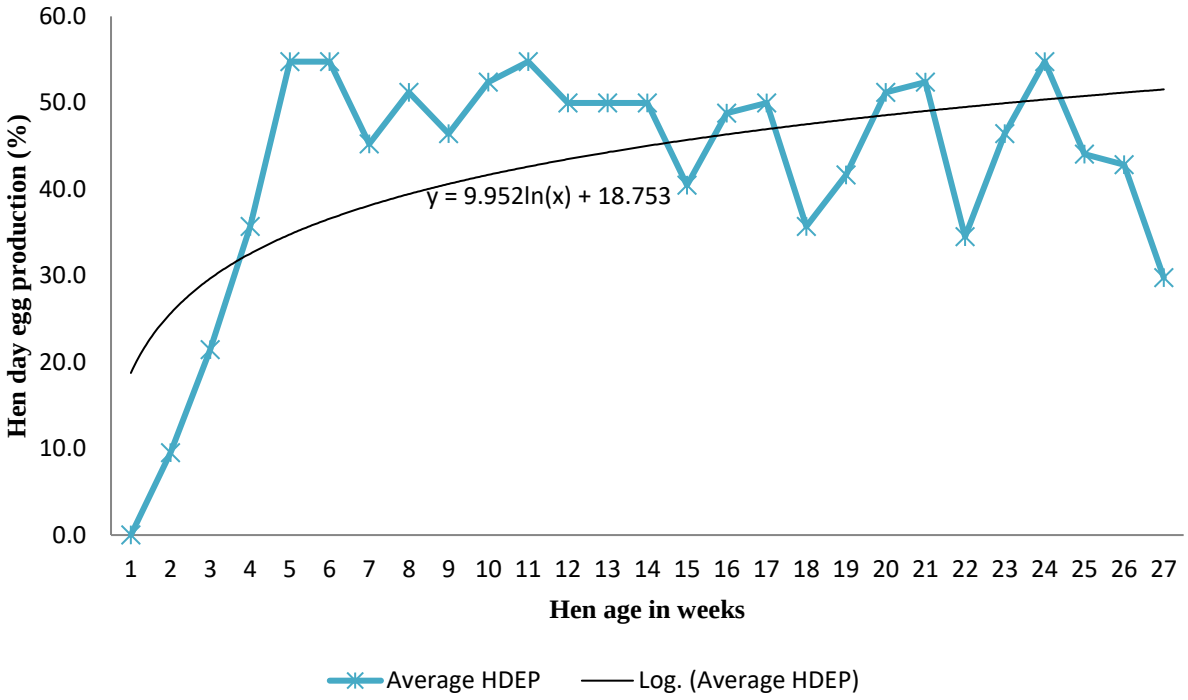
the categories as seen in Figure 4 above. The hen-day egg production attains its highest peak at the 4th week into lay (hens at 35 WOA), followed by a very gradual decline, with the peak repeating at the 23rd week of lay (hens at 53 WOA).

Figure 5: Average HDEP Curve



This second peak was followed by a drastic drop in the hen-day egg production. The prediction equation is:

$$y = 9.952\ln(x) + 18.753$$

Where y represents the hen-day egg production and x represents the time in weeks.

The onset of lay in the F1 helmeted guinea hens was 32, 34, and 33 WOA for the small, medium, and large categories. This age at first egg corresponds to those reported by Avornyo (2007), Dahouda (2009), and Halbouche *et al*. (2010). Reproductive performances have been reported to be strongly affected by the strain, the climate, and the quality of feed. It's been reported that sexual maturity in females can theoretically be reached at 24 weeks (Sanfo *et al.*, 2007a; Abdul-Rahman *et al.*, 2018), but in traditional systems, it has been reported to take between 32, 36, and 37 weeks in Nigeria (Avornyo, 2007), Benin (Dahouda, 2009), and Algeria (Halbouche *et al.*, 2010), respectively. Abdul-Rahman *et al.* (2018) reported that, except for 2 birds that laid exactly at 21 WOA, all birds laid between 27 and 28 WOA, marking the onset of sexual maturity in these birds.

The overall average number of eggs laid per hen within the study period (26 Weeks) was 79.5. F1 guinea hens of the small category recorded the highest number of eggs laid per hen at 87.75 eggs, followed by guinea hens from the large category with 80.50, and tailed by F1 guinea hens from the medium category with 73 eggs per hen. This corroborates the reports of Dogmo *et al*. (2023) and Djiotsa (2023), who each posited that a guinea hen could lay from 40 to 80 eggs and 80 to 100 eggs per year, respectively, with average weights of 43 g. The hen-day egg production (HDEP%) followed the same trend of 43.04±3.27, 39.15±3.56, and

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42.99±2.7 for F1 hens from the small, medium, and large categories, although no significant differences ($p>0.05$) were recorded.

In Nigeria, it has been reported that the number of eggs laid each year per female reached 97 (Avornyo, 2007), higher than the values of 72 and 68 reported in Benin (Dahouda, 2009). In Burkina Faso, Sanfo *et al.* (2007a) reported 103.8±9.6 eggs/female/year and in a study by Halbouche *et al*. (2010), up to 107 eggs/female/year were reported. The results obtained in the present study within 26 weeks are relatively higher than those reported by these authors. The duration of the laying season is 7 months (Dahouda, 2009). Sanfo *et al.* (2012), reported the duration of the laying season in the improved system to be 5 months for the first year and 7.5 months for the second laying year.

F1 hens in all categories (small, medium, and large) showed significant differences ($p<0.05$) in their feed conversion ratios. The rate of conversion of feed to eggs was better in hens in the small category, followed by those in the large and tailed by hens in the medium category. The values of feed conversion obtained in this study were better than those reported by Nahashon *et al.* (2007). Guinea fowls have lower nutritional needs (energy needs) in terms of cost, as they can utilize high fibre feeds. This implies that they have an increased potential to digest fibre, as can be seen from a relatively larger and longer cecum compared to that of the common domestic chicken. This fibre fermentation has as the end product, among others, volatile fatty acids (VGAs), which are high-energy metabolites, increasing the energy available from the diet. In situations where the animals are raised in confinement, this high energy is not used up and tends to be converted and deposited as abdominal fat. This situation can have adverse effects on egg laying in the laying strains and meat quality in the meat strains of guinea fowls. Feed restriction is essential from a relatively early age to allow the birds to reach their full genetic.

The weekly egg laying evolved in an irregular but decreasing pattern characterized by spikes and dips after the peak of lay was attained, as can be seen in the curves (Figures 1 to 5). The average overall hen-day egg production curve followed the standard poultry egg laying curve. During this study, the rainy season was marked by short periods of droughts, almost reaching up to 3 weeks in July (week 16 through 18 on the laying curve). There was a slight drop in egg yield during this short period. Although we didn't evaluate the estradiol profiles at the time of the short dry periods, it can be concluded that plasma estradiol concentrations were reduced, as can be confirmed by the mild drop in egg laying in the categories. Guinea fowls are seasonal breeders (Moreki, 2010; Sodjedo *et al.*, 2022; Portillo-Salgado, 2022).

CONCLUSION

Overall mean egg weight and shape index were 44.12 g and 77.92%, respectively, during the 27-week laying period. There could be a relationship between parent egg weight and age at the onset of lay, but no direct link could be made between parent egg characteristics and subsequent F1 egg characteristics, as these characteristics are more dependent on nutrition and feeding than on pedigree. Helmeted guinea fowl could lay up to 87 eggs with an HDEP of over 43% in 26 weeks of laying (rainy season; March to September) under intensive rearing conditions. Average HDEP could be up to 42% in 6 months of layoff. From the results, we recommend that farmers should grade eggs prior to incubation and preferably incubate eggs with weights between 40 g and 45 g (small category) if the keets are destined for egg production. Guinea fowl farmers could program production activities such that the hens attain sexual maturity at the onset of the rainy season to improve their laying performances.

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