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Effect of different lighting regime on growth and reproductive performance of the Guinea fowl (*Numida meleagris*)

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Abstract

This study was conducted to investigate the influence of different lighting regime on reproductive and growth performance of the pearl Guinea fowl (*Numida meleagris*) in Ghana. A total of five hundred (500) eggs were collected from an ongoing photoperiod experiment which were hatched and used for the study. The experimental birds were randomly assigned to a lighting programme of 12 hours of light: 12 hours of darkness (12L: 12D), 14 hours of light: 10 hours of darkness (14L: 10D), 16 hours of light: 8 hours of darkness (16L: 8D), and 18 hours of light: 6 hours of darkness (18L: 6D). A total of two-hundred and forty (240) day one old keets were divided into four treatment groups and each treatment was replicated three times in a Completely Randomize Design (CRD). The data collected were subjected to analysis of variance (ANOVA) using GenStat version 11.1 (2008). Least significant difference (LSD) at 5 % was used to separate the means. Results from the study revealed that, Percentage fertility, hatchability and hen-day egg production was highest ($P<0.05$) among Guinea fowls subjected to 16L: 8D photoperiodic lighting schedule. Egg weight, dead in shell and piped eggs were highest ($P<0.05$) among Guinea fowls subjected to 12L: 12D photoperiodic lighting schedule. Guinea fowls subjected to 18L: 6D lighting schedule had the highest ($P<0.05$) body weight, body weight gain, feed intake with better feed conversion ratio. This study concludes that 16L: 8D improves fertility, hatchability and hen-day egg production while 18L: 6D ensures rapid growth with better feed conversion.

Keywords: Day length; Maturity; Laying performance; Fertility; Hatchability

1. Introduction

Among all the poultry species raised in West Africa, Guinea fowl is gaining much popularity [1]. The bird is domesticated and commonly found in West and Central Africa and many European countries such as France and Italy [2]. Guinea fowl production in Ghana is regarded as an alternative way to reduce poverty among the people living in the rural areas. This is due to the fact that, the meat and eggs of local Guinea fowl is accepted for food locally without any restrictions [1, 3]. This indicates that there is the need for local farmers to increase the productivity of the bird. The performance of the bird can be improve through good management practices such as day length management, nutrition, suitable Guinea fowl production systems among others [4].

Suitable Guinea fowl production system such as good housing, good feeding practices and adequate day length result in high growth and productivity [5]. Globally, poultry birds are reared in a variety of production systems which include outdoor enclosures that basically utilize natural climatic conditions, production house of various sizes and

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constructions that have little to extensive control over light and other environmental factors [6]. Increased in environmental complexity in poultry production and management is recognized as a means to achieve maximum productivity of Guinea fowl meat and eggs which also aim to resolve welfare concerns [4].

The major constrains to Guinea fowl production are poor nutrition, egg size, changes in day length and poor management practices [4, 7]. Differences in day length across the three different seasons in Ghana are single out as the major hindrance affecting Guinea fowl productivity. Guinea fowls are known to be seasonal breeders and therefore, their productivity depends on proper nutrition and day length. For instance, considering egg laying, Guinea hens do not lay eggs during shorter day length observed in some seasons in the year [4, 8]. According to Lien *et al.* [9] the production and reproductive performance of commercial layer birds is influence by day length. In Guinea fowl production, light is one of the most influential microclimatic factors which enhance growth, physiological functioning and reproductive performance [4]. Light plays an important role in the physiological and behavioural processes in Guinea fowls and other poultry species. Light is integral to vision in birds, including both visual acuity and colour discrimination [10].

The supply of artificial light allows the bird to establish rhythmicity and synchronize many essential functions, including body temperature and metabolic processes that facilitate feeding and digestion in birds [10, 11]. Looking at the physiological prospective of the bird, adequate light stimulates secretory glands of several hormones that control growth, maturation, and egg production [11]. Lien *et al.* [9] further reported that typically poor egg production during summer is a consequence of insufficient lighting and reduce photoperiodic drive and in Guinea fowls, this can be improved by increasing day length through artificial means. Different lighting regime in poultry production is a topic of increasing importance's and concern among Guinea fowl breeders and local farmers. In view of the limited information on the influence of different lighting regime in Guinea fowl production, there is the need to undertake investigations aiming to determine the effect of different lighting regime on growth and reproductive performance of the Guinea fowl (*Numida meleagris*).

The ultimate aim of this experiment was to investigate the influence of different lighting regime on growth and reproductive performance of the Guinea fowl (*Numida meleagris*).

2. Material and methods

2.1. Study location and duration

The study was carried out at the Poultry Unit of the Animal farm of the Department of Animal Science Education, University of Education, Winneba, Mampong-Ashanti campus, Ghana. Mampong-Ashanti lies in the transitional zone between the Guinea savanna zone of the north and the tropical rain forest of the south of Ghana along the Kumasi-Ejura road. Mampong lies on latitude 07° 03' N and longitude 01° 24'W, on an altitude of 289.7 m above sea level. The rainfall pattern is bimodal, with the major rainfall season occurring from April to July with 1000mm of rainfall while the minor season occurs from August to November with 350 mm of rainfall. The average daily temperature was between 25 °C and 30 °C and the average relative humidity of the area is 70 %. The experiment lasted for twenty-four (24) weeks.

2.2. Experimental birds, design and treatment

The pearl variety of Guinea fowl was used for the study. A total of five hundred eggs were collected from an ongoing photoperiod experiment which were hatched and used for the study. Out of the over three hundred keets hatched, a total of 240 day old keets were randomly selected and used for the experiment. Each treatment had sixty (60) birds. The birds were brooded for four weeks and subjected to natural daylight and darkness before being transferred to a deep litter floored house. Each group was randomly assigned to a lighting programme of 12 hours of light: 12 hours of darkness as treatment one (T1), 14 hours of light: 10 hours of darkness (T2), 16 hours of light: 8 hours of darkness (T3) and 18 hours of light: 6 hours of darkness (T4) using bright energy saving bulbs of 50 watts and a supplemented rechargeable lamp incase of light out situation which also contain 40 watts with an average light intensity of 5.60 lux. The birds were divided into four treatment groups and each was replicated three times in a Completely Randomize Design (CRD).

2.3. Housing, Feeding and Medication

A total of twelve (12) experimental cages were used for rearing the birds, each measuring 1.4 m × 1.34 m and housed twenty (20) birds. The floor was concreted, and wood shavings were used as litter for the birds. Removable wooden feeding troughs measuring 0.8 m × 0.04 m × 0.03 m were used for feeding the growers. A 4.5 liter watering trough was used for supplying water *ad libitum* for the growers in each cage. The experimental diets were supplied to the birds *ad libitum* throughout the experimental period. Vaccination and other routine poultry practices were also carried out.

2.4. Parameters Measured

Parameters measured included: egg weight, hen-day egg production, fertility, hatchability, dead in shell and piped eggs, body weight, body weight gain, feed intake, feed conversion ratio,.

2.4.1. Egg weight

Egg weight was determined by weighing individual eggs collected daily with the use of A&D Weighing EK-6000i electronic balance.

2.4.2. Hen day egg production

Hen day egg production was therefore calculated as the percentage of the number of eggs laid to the number of hen days. $HDEP = \frac{\text{Number of eggs laid}}{\text{Number of hen days}} \times 100 \%$

2.4.3. Percentage fertility

Percentage fertility was calculated by expressing the total number of fertile eggs as a percentage of the total number of eggs set. Arithmetically, $\% \text{ Fertility} = \frac{\text{Total number of fertile eggs}}{\text{Total number of eggs set}} \times 100$

2.4.4. Percentage hatchability

Percentage hatchability was determined as the total number of eggs hatched as a percentage of total number of fertile eggs. $\% \text{ Hatchability} = \frac{\text{Total number of Guinea keets hatched}}{\text{Total number of fertile eggs}} \times 100$

2.4.5. Dead in shell and piped eggs

Number of dead in shell was determined by breaking the un-hatched eggs. Number of piped was determined by checking for those eggs that cracked but the keets did not emerge.

2.4.6. Body weight and body weight gain

Body weight: Birds were weighed at the start of the experiment and also at weekly intervals using A&D Weighing EK-6000i electronic balance (A&D Co. Ltd, USA). Body weight gain (g/bird) was calculated by subtracting the initial weight from their final weights.

2.4.7. Feed intake and feed conversion ratio

Feed intake was calculated as the difference between the initial feed offered to birds and the feed left over. Feed conversion ratio (FCR) was computed as the feed intake divided by the total weight gain. Arithmetically, $FCR = \frac{\text{Total feed intake (g)}}{\text{Total weight gain (g)}}$

2.5. Data Analysis

The data collected were analyzed using the one-way analysis of variance (ANOVA) according to the procedure of Steel and Torrie [12] and the treatment means were separated by the least significant difference (LSD) to determine which of the treatments has significance difference or not at 5 % probability level.

3. Results

3.1. Effect of different lighting regime on reproductive performance

The different lighting regime affected reproductive performance (Table 1). Percentage fertility, hatchability and hen-day egg production of Guinea fowls subjected to 16L: 8D photoperiodic lighting schedule significantly ($P < 0.05$) increased as compared to all other photoperiodic lighting schedule. Egg weight, dead in shell and piped eggs were observed to be highest ($P < 0.05$) among Guinea fowls subjected to 12L: 12D photoperiodic lighting schedule and lowest ($P < 0.05$) among Guinea fowls subjected to 16L: 8D photoperiodic lighting schedule.

Table 1 Effect of different lighting regime on reproductive performance.

Treatment/ Parameters	T1 (12 L: 12 D)	T2 (14 L: 10 D)	T3 (16 L: 8 D)	T4 (18 L: 6 D)	S.E.M	P-value
Fertility (%)	52.84 ^d	54.68 ^c	60.56 ^a	56.72 ^b	2.324	0.001
Hatchability (%)	45.89 ^b	53.12 ^c	58.92 ^a	52.35 ^c	2.891	0.001
Dead in shell	20.35 ^a	16.89 ^b	13.68 ^c	15.48 ^b	2.481	0.001
Piped eggs	13.58 ^a	13.12 ^a	6.981 ^c	8.391 ^b	1.982	0.001
Egg weight (g)	43.25 ^a	41.58 ^b	39.25 ^c	39.45 ^c	2.011	0.001
Hen-day egg production (%)	65.42 ^b	63.81 ^c	68.25 ^a	66.45 ^b	1.561	0.002

Means bearing different superscripts in the same row are significantly different ($P < 0.05$), 12 L: 12 D = 12 hours of light: 12 hours of darkness, 14 L: 10 D = 14 hours of light: 10 hours of darkness, 16 L: 8 D = 16 hours of light: 8 hours of darkness, 18 L: 6 D = 18 hours of light: 6 hours of darkness.

3.2. Effect of different lighting regime on body weight

Different lighting regime significantly ($P < 0.05$) affected body weight of pearl Guinea fowls from four weeks up to sixteen weeks of age. However, after sixteen weeks of age no significant ($P > 0.05$) differences were observed among the treatment groups (Table 2). Body weight of pearl Guinea fowls subjected to 18L: 6D lighting schedule significantly ($P < 0.05$) increased from four weeks up to sixteen weeks of age followed by Guinea fowls subjected to 16L: 8D and 14L: 10D lighting schedule respectively. While birds subjected to 12L: 12D lighting schedule had the lowest body weight.

Table 2 Effect of different lighting regime on body weight

Treatment/ Parameters	T1 (12 L: 12 D)	T2 (14 L: 10 D)	T3 (16 L: 8 D)	T4 (18 L: 6 D)	S.E.M	P-value
Day old (g)	26.23	26.25	26.29	26.51	0.301	0.121
4 Weeks (g)	188.11 ^b	189.74 ^b	190.02 ^{ab}	196.14 ^a	6.532	0.015
8 Weeks (g)	328.81 ^c	335.31 ^b	337.43 ^b	348.01 ^a	5.74	0.018
12 Weeks (g)	523.29 ^c	542.11 ^b	543.77 ^b	585.22 ^a	15.48	0.013
16 Weeks (g)	743.29 ^c	812.11 ^b	813.77 ^b	825.22 ^a	15.48	0.013
20 Weeks (kg)	1.052	1.019	1.076	1.068	0.421	0.498
24 Weeks (kg)	1.235	1.218	1.295	1.291	0.488	0.458

Means bearing different superscripts in the same row are significantly different ($P < 0.05$), 12 L: 12 D = 12 hours of light: 12 hours of darkness, 14 L: 10 D = 14 hours of light: 10 hours of darkness, 16 L: 8 D = 16 hours of light: 8 hours of darkness, 18 L: 6 D = 18 hours of light: 6 hours of darkness.

3.3. Effect of different lighting regime on body weight gain

Different lighting regime had significantly ($P < 0.05$) effect on body weight gain throughout the period of study except the first eight weeks of age (Table 3). Body weight gain of the pearl Guinea fowl increased with increasing day length up to 18L: 6D lighting schedule except at 17 to 20 weeks. Birds subjected to 18L: 6D lighting schedule gain the highest ($P < 0.05$) weight followed by Guinea fowls subjected to 16L: 8D and 14L: 10D lighting schedule respectively. Birds subjected to 12L: 12D lighting schedule had the lowest body weight gain. However, at 17 to 20 weeks of age, birds subjected to 12L: 12D lighting schedule gain the highest ($P < 0.05$) weight followed by Guinea fowls subjected to 14L: 10D, 16L: 8D and 14L: 10D lighting schedule respectively.

Table 3 Effect of different lighting regime on body weight gain

Treatment/ Parameters	T1 (12 L: 12 D)	T2 (14 L: 10 D)	T3 (16 L: 8 D)	T4 (18 L: 6 D)	S.E.M	P-value
0-4 Weeks (g)	162.28	163.49	163.73	164.03	2.871	0.098
5-8 Weeks (g)	140.70	145.57	147.41	151.87	2.182	0.121
9-12 Weeks (g)	194.48 ^c	206.80 ^b	206.34 ^b	237.21 ^a	2.485	0.001
13-16 Weeks (g)	220.00 ^c	270.00 ^a	270.00 ^a	259.00 ^b	1.084	0.001
17-20 Weeks (g)	308.71 ^a	206.89 ^d	262.23 ^b	242.78 ^c	0.874	0.001
21-24 Weeks (g)	183.00	219.00 ^b	219.00 ^b	223.00 ^a	2.341	0.001

Means bearing different superscripts in the same row are significantly different ($P < 0.05$), 12L: 12D=12 hours of light: 12 hours of darkness, 14L: 10D=14 hours of light: 10 hours of darkness, 16L: 8D=16 hours of light: 8 hours of darkness, 18L: 6D = 18 hours of light: 6 hours of darkness.

3.4. Effect of different lighting regime on feed intake

Table 4 presents the feed intake across the period of study. Feed intake was observed to be significant ($P < 0.05$) across the period of study except ($P > 0.05$) at 0-4 and 13-16 weeks of age. Feed intake increased with increasing day length. Guinea fowls subjected to 18L: 6D photoperiodic lighting schedule significantly ($P < 0.05$) recorded the highest feed intake followed by 16L: 8D, 14L: 10D and lowest among birds on the 12L: 12D photoperiodic lighting schedule.

Table 4 Effect of different lighting regime on feed intake

Treatment/ Parameters	T1 (12 L: 12 D)	T2 (14 L: 10 D)	T3 (16 L: 8 D)	T4 (18 L: 6 D)	S.E.M	P-value
0-4 Weeks (g)	315.51	320.44	321.22	329.56	3.561	0.114
5-8 Weeks (g)	409.80 ^c	407.61 ^c	413.89 ^b	416.72 ^a	2.832	0.002
9-12 Weeks (g)	526.70 ^c	542.78 ^c	549.20 ^b	558.21 ^a	4.981	0.001
13-16 Weeks (g)	670.90	669.51	670.85	670.32	2.821	0.231
17-20 Weeks (g)	720.50 ^b	710.11 ^c	681.21 ^d	735.00 ^a	8.791	0.002
21-24 Weeks (g)	735.22 ^b	729.81 ^b	785.31 ^a	793.24 ^a	11.83	0.006

Means bearing different superscripts in the same row are significantly different ($P < 0.05$), 12L: 12D = 12 hours of light: 12 hours of darkness, 14L: 10D = 14 hours of light: 10 hours of darkness, 16L: 8D = 16 hours of light: 8 hours of darkness, 18L: 6D = 18 hours of light: 6 hours of darkness.

3.5. Effect of different lighting regime on feed conversion ratio

Table 5 shows the feed conversion ratio across the period of study. Different lighting regime had significantly ($P < 0.05$) effect on feed conversion ratio at 5-8, 9-12 and 13-16 weeks of age (Table 5).

Table 5 Effect of different lighting regime on feed conversion ratio

Treatment/ Parameters	T1 (12 L : 12 D)	T2 (14 L : 10 D)	T3 (16 L : 8 D)	T4 (18 L : 6 D)	S.E.M	P-value
0-4 Weeks	1.944	1.960	1.962	1.949	0.681	0.116
5-8 Weeks	2.913 ^a	2.800 ^b	2.808 ^b	2.744 ^c	0.072	0.002
9-12 Weeks	2.708 ^a	2.624 ^c	2.662 ^b	2.353 ^d	0.286	0.001
13-16 Weeks	3.333 ^c	2.479 ^b	2.485 ^b	2.587 ^a	0.089	0.003
17-20 Weeks	3.937	3.432	2.590	3.027	1.087	0.349
21-24 Weeks	3.598	3.332	3.586	3.557	0.152	0.112

Means bearing different superscripts in the same row are significantly different ($P < 0.05$), 12L: 12D=12 hours of light: 12 hours of darkness, 14L: 10D=14 hours of light: 10 hours of darkness, 16L: 8D=16 hours of light: 8 hours of darkness, 18L: 6D = 18 hours of light: 6 hours of darkness.

Feed conversion ratio at 5-8 and 9-12 weeks of age was observed to be better ($P < 0.05$) followed by 16L: 8D and 14L: 10D. However, Guinea fowls subjected to 12L: 12D photoperiodic lighting schedule had the poorest feed conversion ratio. At 13-16 weeks of age, the trend of feed conversion ratio changed. Guinea fowls subjected to 12L: 12D photoperiodic lighting schedule had the best feed conversion ratio as compared to the other photoperiodic lighting schedule.

4. Discussion

4.1. Effect of different lighting regime on reproductive performance

The significant increase in percentage fertility and hatchability of Guinea fowl eggs subjected to 16L: 8D photoperiodic lighting schedule could be explained that light is a fertility all-star, playing a make-it-or-break-it role in the functioning of the reproductive systems of Guinea fowl hens. This means that 16L: 8D photoperiodic lighting schedule is adequate enough to keep the circadian pacemaker (the body's master clock) in synch which stimulates higher production of Luteinizing Hormone (LH) and Follicle-stimulating hormone (FSH). These hormones are among some other hormones responsible for egg fertility. Also, this can be explained that 16L: 8D photoperiodic lighting schedule stimulate increase secretion of metabolic hormones (T_3 , T_4 , insulin, GH and IGF-1). All these hormones shared in development and enhancing productive and reproductive functions of domestic birds [13]. This study confirms earlier reports from the study of Shafey [14] who observed differences in fertility and hatchability among various layer strains, and attributed this to physical dimensions of the eggs allowing different light levels through. The study is also in agreement with studies conducted by Schwean *et al.* [15]. Additionally, egg weight decreased with increasing day length, and this result is similar to the findings of Lewis *et al.* [16]

The significant increase in hen-day egg production among Guinea fowls subjected to 16L: 8D photoperiodic lighting schedule could be explained that, 16L: 8D photoperiodic lighting schedule stimulate gonadal development, eventually resulting in onset of lay by stimulate the hypothalamus area via eyes or by pineal gland to release GnRH, which stimulate anterior pituitary to release FSH and LH [17]. These hormones are responsible for production of the major sex steroid hormone such as testosterone, estrogen and progesterone which helps the birds to lay more eggs. Again the increased in egg weight could be attributed to the higher estrogen levels among Guinea fowls subjected to 16L: 8D photoperiodic lighting schedule. Estrogen is necessary for yolk precursor lipoprotein secretion by the liver and oviduct and follicle development [18] leading to the production of large size eggs, reduce dead keets in the shells and piped eggs. This is comparable to earlier studies by Hassanzadeh *et al.* [19] who reported that when birds are given 16 hours of light it increased the level of estrogen in the blood which influenced globulin levels to increase egg size and yolk height. Egg size, yolk weight and height are positively correlated with globulin levels [19]. However, this result does not corroborate earlier report by Schaper *et al.* [19] who observed that light had no significant ($P > 0.05$) effect on egg weight.

4.2. Effect of different lighting regime on body weight and body weight gain

Results regarding the effect of different lighting regime on body weight were consistent with substantial scientific evidence that longer day length during the growth period results in heavier body weights and body weight gain, because appetite was stimulated by photoperiod, which led to rapid early growth and enhanced skeletal development [21, 22]. However, results obtained in this study on body weight and body weight gain were not consistent with the results of Banks and Koen [23] who did not find a significant effect of lighting system during the growth phase on the average live body weight of birds during the production stage. Similarly, Shunshun *et al.* [11] also reported no significant effect of three lighting regimes during ten weeks growth phase of Pengxian yellow pullets. The variation in this study and the findings from literature may be because a day length of 6 hours provided enough light for normal feed and water access, which meets the requirement for growth development, and the longer day length possibly, may increase the feed intake. According to Shunshun *et al.* [11] there is a strong negative relationship between body weight and reproductive efficiency; therefore, the body weight of grower Guinea fowls should be controlled within reason.

4.3. Effect of different lighting regime on feed intake and feed conversion ratio

In this study it was observed that feed intake increased with increasing day length with better feed conversion ratio. This trend could be due to the fact that increasing day length allowed maximum feeding time, with birds consuming more feed. Physiologically, increases in day length inhibit the secretion of the hormone leptin (leptin is often referred as the satiety hormone) from the adipose cell and ensures that the birds will feed throughout the lightning period. This result is similar to what Mendes *et al.* [24] reported in turkeys subjected to three different lightening programmes on live weight and feed intake. Lewis *et al.* [10] reported that feed intake is highly influenced when birds are supplemented with artificial light more than 16L: 8D. Leeson *et al.* [21] also reported that longer day length during the growth period results in higher feed intakes and heavier body weights, because appetite was stimulated by photoperiod, which led to

rapid early growth and enhanced skeletal development. Results on feed conversion ratio is in line with the findings of Classen *et al.* [25] who reported that early light restriction improved feed conversion ratio during the early phases of the grower stage in broiler chickens.

5. Conclusion

This study concludes that 16L: 8D photoperiodic lighting schedule increased percentage fertility, hatchability of Guinea fowl eggs and hen-day egg production. Guinea fowls subjected to 12L: 12D photoperiodic lighting schedule lay heavier eggs, recorded the highest dead in shell and piped eggs. Guinea fowls subjected to 18L: 6D lighting schedule had the highest body weight, body weight gain, feed intake with better feed conversion ratio.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors have declared that, no conflict of interests exist.

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Author's short biography

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