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Effect of Increased Photoperiod on Feed Intake, Egg Production and Egg Size in Japanese Quail (*Coturnix japonica*) Under Zambian Conditions

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Abstract

This study was carried out at Mulungushi University Farm to determine the effect of increased light on feed intake, egg size and egg production in Japanese quail (*Coturnix coturnix japonica*) under Zambian conditions. A completely randomized experimental design consisting of a total of 45 quail, divided into three treatments and three replicates per treatment with five birds in each replicate, was conducted. The treatments were as follows: 12L:12D (Control) - exposure to natural light for a continuous period of 12 hours; 14L:10D - exposure to natural light for a continuous period of 12 hours followed by two hours of artificial light, and 16L:8D - exposure to natural light for a continuous period of 12 hours followed by four hours of artificial light using compact fluorescent lamps. Data were collected on a daily basis for a period of 28 days and analyzed using a One-way ANOVA. The results showed that feed intake was higher ($P < 0.05$) in 16L:8D than in 14L:10D quail which was in turn higher ($P < 0.05$) than in 12L:12D quail. Similarly, quail day egg production was significantly higher ($P < 0.01$) in 16L:8D than in 14L:10D quail which was in turn higher ($P < 0.01$) than in 12L:12D quail. On average, quail day egg production was, respectively, 69.1%, 51.3% and 28.8% for 16L:8D, 14L:10D and 12:12D quail. The mean egg size as measured by weight was also significantly higher ($P < 0.05$) in 16L:8D than in 14L:10D quail which was in turn higher ($P < 0.05$) than in 12L:12D quail. On average, eggs from 14L:10D quail weighed 15.9% more than those from 12L:12D quail while eggs from 16L:8D quail weighed 10.4% more than those from 14L:10D quail. It is concluded that addition of artificial light has economic beneficial effects on quail production under Zambian conditions. It is, however, recommended that more studies of longer period with different permutations of photoperiod be carried out in order to make more concrete conclusions.

Keywords: *Coturnix coturnix japonica; Photoperiod; Feed Intake; Egg Production; Egg Size*

Introduction

Quail production in Zambia has only gained importance in the last decade or so. Prior to the turn of the century, the poultry industry was viewed to include only chickens, ducks, geese, pigeons, guinea fowls, rabbits and turkeys [1]. In the last decade, however, households and many small medium and large poultry firms have also included quail to their lists of poultry species [2]. With increasing need for diversified sources of animal protein, quail rearing is offering one of the most promising cheaper sources of the protein. Quail are being reared for both meat and eggs. Advantages of quail include rapid growth, early sexual maturity, short generation interval, high rate of lay, and less feed and space requirements per bird compared to chickens and other types of poultry. Thus, quail can be produced more efficiently and cheaply.

Unlike chicken, however, production practices for enhanced productivity are not well understood by many households (small-scale farmers) and firms involved in quail production in Zambia. One of the major physiological characteristics of quail is that their performance in terms of feed intake and lay of eggs is greatly influenced by photoperiod. Different workers have shown that light stimulus directly influences the physiological responses of the bird [3-5]. Generally, long day-length has been found to stimulate gonadal growth and increase in plasma sex steroids by stimulating gonadotropin production and release [3]. Thus, long photoperiods are associated with stimulation of sexual maturation whereas short photoperiods inhibit or delay sexual maturation.

Various lighting programs associated with different feeding times have been experimented, but with inconsistent results [6]. The environmental conditions under which feeding is done has also been found to have impact on the reproductive performance of quail. For example, feeding quail under heat stress was found to negatively affect body weight, fertility, hatchability and egg production [7]. Thus, productivity of quail is dependent on a number of factors which must be tested and understood in a particular environment. With the aid of artificial lighting, conditions of either constant or changing photoperiods could be created to investigate the effect on performance of quail.

Zambia is a tropical country but mainly enjoys a sub-tropical climate. It is divided into three agro ecological zones [8], with Zones I, II and III receiving an average annual rainfall of 600 mm, 800 mm and above 1200 mm, respectively. There are three seasons: a cool dry season (April-August), a hot dry season (August-November) and a hot wet season (November-April). Maximum temperatures vary from 15°C to 27°C in the cool season with morning and evening temperatures reaching 6°C to 10°C. During the hot season maximum temperatures range from 27°C to 35°C. However, the mean annual temperature ranges between 18 and 20°C. Poultry production in Zambia is mainly practiced by small-scale farmers who only have basic infrastructure, and limited skill and facilities for increased productivity. No research has ever been conducted in Zambia to investigate the effects of day-length on quail performance. This research was therefore the first of its kind, as a way of building knowledge for enhanced productivity of quail among households and firms involved in quail production.

Objective of the Study

The objective of the study was to investigate the effect of increased day-length on feed intake, egg production and egg size of Japanese quail.

Materials and Methods

Location of the study

The study was conducted at Mulungushi University Farm in Kapiri-Mposhi District, Central Province of Zambia (Latitude, 28.4°E and Longitude, 14.4°S). Mulungushi University is approximately 166 km from Lusaka, the Capital of Zambia, and sits within Agro Ecological Zone II. The farm is equipped with basic facilities, reflecting the environment or conditions under which most small-scale farmers keeping quail in Zambia operate.

Experimental birds and design

Forty-five point-of-lay Japanese quail (*Coturnix coturnix japonica*) (age 50d; weight 125g) were acquired from a commercial farm in Kabwe and assigned to three treatments in a Completely Randomized Design (CRD). Fifteen birds were randomly allocated to each treatment which was replicated three times. The treatments were as follows: 12L:12D (12 hours of natural day light, from 06:00h to 18:00h (Control)); 14L:10D (12 hours of natural day light + 2 hours of artificial light, from 06:00h to 20:00h); and 16L:8D (12 hours of natural day light + 4 hours of artificial light, from 06:00h to 22:00h).

Housing

A 4m x 3m open-sided poultry house was divided into three rooms, with each room being subjected to one treatment only. Between each room was a drop ceiling of black plastic canvas to prevent the passage of light from one room to the other. A wooden cage measuring

1.0m x 0.5m and divided into three compartments, was placed into each room (Figure 1). Each compartment of the cage was equipped with a feeder and a drinker and housed five birds.

Figure 1: *Experimental cages divided into three compartments, each one housing five quail.*

Lighting

Using rechargeable fluorescent lamps, each room received the amount of light according to the treatments. One lamp was placed on top of each cage to provide luminance of 20 lux fluorescent light as required by the laying Japanese quail [4]. Room temperature where cages were placed was 22°C during day time and falling to about 19°C during night time.

Feeding and watering

All the birds were fed on the same commercial feed bought from a commercial feed company. The nutrient content of feed was as follows: Crude protein 18%, Metabolisable Energy 2800 kcal/kg, Calcium 1.0%, Phosphorus 0.8%, Methionine 0.45%, and Cysteine 0.35%. The birds were fed manually. The feed was provided *ad libitum* once per day at 10:00h. Fresh, clean water was provided twice per day, at 10:00h and 22:00h in order to ensure that the commodity was available throughout the day.

Data collection

Feed consumption of birds on a daily basis was determined by subtracting the weight of the left over feed from the initial feed given to the birds. Eggs were collected three times daily at 10:00h, 17:00h, and 22:00h for a period of 28 days. The number of eggs from each treatment was recorded, graded (large, medium and small) and separated as such (Figure 2). The eggs were also weighed using a digital scale. Through a communication error at the end of the experimental period, data of the final body weights of the quail were unusable in terms of correlation between body weight and feed intake.

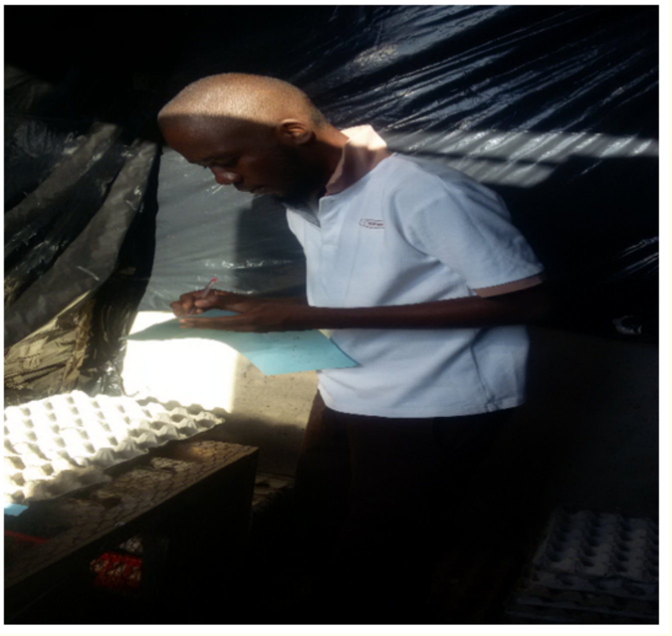

Figure 2: *Grading, recording and separation of quail eggs.*

Statistical analysis

The data for daily feed intake, number of eggs per day and egg size as measured by weight, were recorded in Excel for initial simple computations. The number of eggs per day was computed into percentage in order to determine the reproductive performance of each treatment. The data were then exported to Genstat [9]. The data were pooled and the means generated for each treatment. A One-Way Analysis of Variance (ANOVA) was performed to compare the treatments at a probability level of P = 0.05.

Results

Feed Intake

Except for week 3, average daily feed intake was higher (P < 0.05) in 16L:8D quail than in 14L:10D quail which was in turn higher than in 12L:12D quail (Table 1). In week 3, average daily feed intake in 16L:8D quail was not different from 14L:10D quail but was higher than in 12L:12D quail. Translated into percentage, in week 1, the 14L:10D quail consumed 11.4% more feed than the 12L:12D quail while the 16L:8D quail consumed 3% more feed than the 14L:10D quail. In weeks 2, 3 and 4, the consumption pattern was quite similar to week1, with 14L:10D quail consuming between 10.4% and 11.9% more feed than the 12L:12D quail. Similarly, except for week 3 where there was no statistical difference, the 16L:8D quail consumed just above 3% more feed than the 14:10D quail.

Day length	Feed Intake per day (grams)			
	Week 1	**Week 2**	**Week 3**	**Week 4**
12L:12D	19.71 ± 0.27^a	19.77 ± 0.24^a	19.89 ± 0.27^a	19.89 ± 0.06^a
14L:10D	21.96 ± 0.33^b	22.02 ± 0.21^b	22.05 ± 0.24^b	21.96 ± 0.18^b
16L:8D	22.62 ± 0.15^c	22.77 ± 0.36^c	22.35 ± 0.09^b	22.65 ± 0.06^c
F pr.	0.04	0.01	0.02	0.01

Table 1: *Least square means ± SE of feed intake per day in Japanese quail subjected to different photoperiods of 12 hours, 14 hours and 16 hours.*

^{a,b,c}*: Means with different superscripts within column differ (p < 0.05).*

Quail day egg production

Quail day egg production was higher ($P < 0.01$) in 16L:8D quail than in 14L:10D quail which in turn was higher ($P < 0.01$) than in 12L:12D quail (Table 2). As can be seen from the table, increasing the photoperiod by two hours resulted in huge differences. The quail day egg production in 12L:12D quail ranged between 25.73% and 32.38% during the four-week experimental period compared to 48.09% and 53.34% in 14L:10D quail. Increasing the photoperiod by another two hours (16L:8D) resulted in further significant quail day egg production ranging between 66.67% and 71.43%.

Day length	Quail day egg production (%)			
	Week 1	Week 2	Week 3	Week 4
12L:12D	25.73 ± 5.22^{a}	27.57 ± 4.59^{a}	29.52 ± 3.69^{a}	32.38 ± 3.77^{a}
14L:10D	51.43 ± 3.71^{b}	48.09 ± 4.19^{b}	52.38 ± 3.98^{b}	53.34 ± 4.88^{b}
16L:8D	68.57 ± 4.37^{c}	71.43^{c} ± 5.51^{c}	66.67 ± 4.78^{c}	69.53 ± 5.17^{c}
F pr.	0.003	0.002	0.001	0.002

Table 2: *Least square means ± SE of quail day egg production in Japanese quail subjected to different photoperiods of 12 hours, 14 hours and 16 hours.*

^{a,b,c}: Means with different superscripts within column differ ($p < 0.01$).

Egg size

The mean egg size as measured by weight differed significantly ($P < 0.05$) in quail reared under different light regimens (Table 3). The eggs from quail exposed to the longest day length (16L:8D) had the heaviest weight followed by eggs from 14L:10D quail, with the lightest eggs coming from the control group (12L:12D). As can be seen from the table, the mean egg weight from 16L:8D quail ranged between 9.33g and 9.66g during the experimental period compared to eggs from 14L:10D quail which ranged between 8.57g and 8.66g. The eggs from 12L:12D quail had the smallest weight ranging between 7.24g and 7.57g. In terms of percentage differences, in week 1, the eggs from 14L:10D quail weighed 18.4% more than those from 12L:12D quail while the eggs from 16L:8D quail weighed 10% more than those from 14L:10D quail. In week 2, the eggs from 14L:10D quail weighed 15.5% more than those from 12L:12D quail while the eggs from 16L:8D quail weighed 11.7% more than those from 14L:10D quail. The results in weeks 3 and 4 also exhibited a similar pattern, with eggs from 14L:10D quail weighing between 14.4% and 15.2% more than the eggs from 12L:12D quail. Similarly, the eggs from 16L:8D quail weighed between 8.2% and 11.5% more than those from 14:10D quail.

Day length	Egg weight (grams)			
	Week 1	Week 2	Week 3	Week 4
12L:12D	7.24 ± 0.27^{a}	7.42 ± 0.17^{a}	7.48 ± 0.18^{a}	7.57 ± 0.24^{a}
14L:10D	8.57 ± 0.38^{b}	8.57 ± 0.24^{b}	8.62 ± 0.29^{b}	8.66 ± 0.33^{b}
16L:8D	9.43 ± 0.31^{c}	9.57 ± 0.28^{c}	9.33 ± 0.19^{c}	9.66 ± 0.22^{c}
F pr.	0.03	0.04	0.01	0.01

Table 3: *Least square means ± SE of egg weight in Japanese quail subjected to different photoperiods of 12 hours, 14 hours and 16 hours.*

^{a,b,c}: Means with different superscripts within column differ ($p < 0.05$).

Discussion

Feed intake

While the higher feed intake in 16L:8D quail compared to 14L:10D and 12L:12D quail was expected, what was significant in the present study was the percent increment in the consumption by adding 2 hours of light. Except for week 3 when 16L:8D and 14L:10D quail had similar feed intake, the percent increment in the consumption ranged between 10% and 12%. These results were similar to those of Wagan., *et al*. [10] who studied the effect of light duration on productivity of Japanese quail. In their experiment in which they used 120 birds, they exposed the quail to 12L:12D, 16L:8D and 20L:4D photoperiods. By increasing the day-length by 4 hours, Wagan., *et al*. [10] reported consumption of 882g, 1092g and 1358g per bird, respectively, for the period of two months, representing an increment of about 24% of feed intake for this duration of extended light. In the present study, the percent increment of 10-12% was for the duration of extended light of 2 hours. Thus, for every hour of extended light, the quail ate a specific amount of feed. With increased feed intake, Wagan., *et al*. [10] in their study also reported increased body weights in quail as feed intake increased. The authors reported that the quail that consumed a total of 882g, 1092g and 1358g had average body weights of 133.7g, 136.1g and 143.2g, respectively, in the fifth week of the experiment. While final body weights in the present study were not available, it can be assumed that the 16L:8D quail had an average higher body weight than 14L:10D quail which in turn had a higher average weight than the 12L:12D quail. Other workers Boon., *et al*. [3], Khalil., *et al*. [11] have also reported similar trends in quail.

Increased feed intake has also been observed in chicken layers. Mohammed [12] who investigated the effect of three different periods (13, 16, 19 hours) on 108 birds of Bovans layers found an increase in the behavioural patterns including feeding. Still, other workers have demonstrated that the period of the day influences feed intake per hour. For example, Pizzolante., *et al*. [13] in their experiment with 400 female Japanese quail reported that feed intake was lower during night time (19:00h to 07:00h) and highest from 17:00h to 19:00h, with the period of 07:00h to 17:00 presenting intermediate values.

Increased feed intake under artificial light could be due to reduced stress condition of the birds, and in response to this, the birds' demand for more feed increases [10]. In an earlier study, Ahmed., *et al*. [14] who performed an experiment in broiler chickens found that the light of energy savers enhanced feed intake, thus supporting the analysis put forward by Wagan., *et al* [10]. In the present study, it may be postulated that the extended light at night time (from 18:00h to 20:00h and from 20:00h to 22:00h) had less stressful environmental conditions, thereby resulting in increased feed intake.

Scientific work has also shown that high environmental temperature reduces feed intake. According to Leeson and Summers [15], birds reduce their feed intake during high environmental temperatures in order to decrease heat increment produced by nutrient digestion and metabolism. In the present study, it may be stated that while metabolic rate was reduced during day time when it was hot, the same was enhanced during night time when it was cool and under extended light. Boon., *et al*. [3], in an experiment with two strains of Japanese quail, found that the chicks subjected to shorter light periods (9L:15D or 6L:18D) had decreased nocturnal metabolic rate compared to those subjected to light periods of 12 hours or more. The present study did not have shorter periods of light than 12 hours. However, what was significant was that the light periods that were longer than 12 hours resulted in higher feed intake, most probably due to increased metabolic rate.

Quail day egg production

Increased photoperiod resulted in increased egg production. While this fact is well established, the actual performance may differ depending on the environment where quail production is taking place. For example, the average quail day egg production in the present study (under Zambian conditions) for 12L:12D, 14L:10D and 16L:8D light periods was 28.8%, 51.3% and 69.1%, respectively, while Wagan., *et al*. [10] in Pakistan reported 46.8% for 12L:12D, 62.5% for 16L:8D and 68.7% for 20L:4D. Comparing the like photoperiods, it can be seen that the present study recorded a much lower numerical value of egg production for 12L:12D quail than that reported by Wagan., *et al* [10]. On the other hand, the study by Wagan., *et al*. [10] recorded a lower numerical value of egg production for 16L:8D than the present study. Since these studies were conducted in different environments, environmental factors could play a role. However, what is clear is that overall, the longer the lighting period, the higher the egg production.

Egg production in quail has also been found to be affected by the period of the day. For example, Pizzolante., *et al*. [13] who subjected quail to different lighting periods observed that the lowest egg production was from 21:00h to 01:00h, which increased thereafter, reaching maximum production between 17:00h and 19:00h. It was during this period of maximum production that feed intake was also highest, thus confirming the earlier observations that increased egg production in quail is directly associated with increased feed intake. The authors observed that oviposition peaked at 16:00h in these quail, and therefore the feeding that occurred in the afternoon at the time nutrients were needed for egg production benefitted egg production and also decreased immature eggs. Similar results have been reported in white and brown laying hens [16]. Subjecting these chickens to photoperiods of 8, 10, 13, and 16h of light per day resulted in increased linear effect of photoperiod on egg production and feed intake. The authors concluded that both layer types increased their egg production by 1% for each hour increase in photoperiod. In quail, the present study showed that increase in light by 2 hours had a much greater impact on egg production than in the chickens reported by Lewis., *et al* [16]. This difference between chickens and quail could be due to differences in the sensitivity to photoperiod, with the latter having a highly sophisticated photoperiodic mechanism [17].

Physiologically, the reproductive response to photoperiod in the present study could be supported by the earlier work of Deep., *et al*. [18] who stated that natural or artificial light was one of the environmental or managerial factors that played an important role in the regulation of poultry production, reproduction and welfare by modulating various behavioural and physiological pathways of birds. In fact according to Khalil., *et al*. [11], light stimulates gonadal development, eventually resulting in the onset of lay by stimulating the hypothalamus to release Gonadotropin Releasing Hormone (GnRH) which in turn stimulates the anterior pituitary gland to release gonadotropins, Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LH). Leeson., *et al*. [19] in their experiment with Leghorn pullets also observed that an increase in the photoperiod induced a rise in the plasma concentration of LH. Not only does light stimulate increased production of gonadotropins but also metabolic hormones that play a role in reproduction and other functions [11]. Light stimulates the secretion of metabolic hormones including triiodothyronine (T_3), thyroxine (T_4), insulin, Growth Hormone and Insulin-like-Growth Factor I (IGF-I). All these hormones share in the development and enhancing productive and reproductive functions of quail and other domestic birds [11].

Egg size

The egg weight ranging from 9.43g to 9.66g for average egg size of Japanese quail observed in this study was similar to the size reported by Babangida and Ubosi [20]. The significance of egg size, as measured by egg weight, cannot be overemphasized. Seker., *et al*. [21] who studied the effects of storage period and egg weight of Japanese quail eggs on hatching found that higher egg weight increased fertility rate and hatchability of fertile eggs. Embryonic mortality also decreased with increasing egg weight. Thus, in quail breeding, among the major considerations should be egg weight as this is directly associated with fertility and hatchability.

In the present study, the three photoperiods resulted in variable egg size, with the highest weight recorded under the 16L:8D lighting programme and the lowest egg size recorded under the 12L:12D lighting programme. Similar results were reported by Mohammed [12] in a study with chicken layers. The results in this study showed that egg weight and its surface area were significantly higher in the birds exposed to 16 hours of light compared to those exposed to light for 13 hours. Similarly, external quality traits including egg length, egg width, shell weight, egg shell ratio and shell thickness, followed the same pattern. Accordingly, Lewis., *et al*. [16] also reported increased egg weight for laying hens exposed to longer photoperiods compared to those exposed to short photoperiods. Of course, it is logical that with increased feed consumption, more nutrients would be available for egg formation, thus resulting in bigger eggs.

Since the 12L:12D quail in the present study consumed significantly less feed than quail under longer lighting periods, it can be interpreted that the former had a restriction of consumption of nutrients such as protein compared to the latter. This interpretation is important in the sense that egg weight has been shown to be affected by dietary protein. For example, Grindstaff., *et al*. [22], in their study, found that female Japanese quail that were fed low protein diet weighed less than the control group and also produced fewer eggs that were smaller in size. The authors concluded that maternal dietary protein restriction affected both female body mass and investment in reproduction. The decrease in egg size could have important trans-generational implications for offspring.

Conclusion

Increased photoperiod showed positive effects on feed intake, egg production and egg size in Japanese quail under Zambian conditions. Although this was the first study of its kind under these conditions, these results showed a clear indication of an economic benefit of housing this type of quail at different photoperiods. On average, the natural day-length in Zambia is about 12 hours of light. Quail producers would, however, benefit by artificially increasing the photoperiod by at least 2 hours of light. In fact, the longer the light period, the higher the performance of quail. Further studies, with increased period of experiment and probably trying more permutations of photoperiod, are recommended in order to draw more concrete conclusions.

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