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Effect of Photoperiod on Production of Ring-Necked Pheasants (*Phasianus colchicus*)

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Abstract: This study assessed the effect of photoperiod duration on production parameters (amount of eggs and weight) in ring-necked pheasants (*Phasianus Colchicus*). Forty-five birds were caged, distributed in groups of one male and four females (total 9 cages). Three photoperiod treatments were applied (18, 16 and 14 h of light) with three repetitions per treatment. Males and females were randomly assigned to the different groups. An ANDEVA test was used to compare means between treatments, with a multiple comparison Tukey's test in a GLM with SAS V.8.0. software package. Production parameters were recorded during 18 production weeks: egg weight (EW), egg mass (EM), eggs per female (EF) and laying percentage (LP). Significant differences were found in all variables between weeks ($p<0.01$), although the interaction of photoperiod with week was not significant ($p>0.05$). Photoperiod treatment had a significant effect on LP, EF and EM ($p<0.05$) during the study period (18 weeks); EW showed a 0.65% difference between the 18 h-light and 14 h-light treatments, although not statistically significant ($p>0.05$). All productive variables improved with the highest light-hours treatment (18 h) with the exception of EW.

Key words: Pheasants, photoperiod, light hours, egg production, laying cycle

INTRODUCTION

Pheasants belong to the *Galliformes* order, *Phasianidae* family and are of Asian origin. Their presence has been known for several decades now, with the Mongol pheasant or ring-necked pheasant (*Phasianus colchicus*) being the most common one (Manetti, 1996). There are other varieties such as the silver pheasant (*Lophura nycthemera*), Chinese golden pheasant (*Chrisolophus pictus*), melanistic mutant pheasant (*Melanistis mutantis*), lady pheasant (*Chrisolophus amherstiae*) and Reeve's pheasant (*Syrmaticus reevesi*). There are forty species with more than 100 subspecies and mutations (Wambier, 1991). The ring-necked pheasant is the most disseminated variety in our country, well liked for its precociousness, rusticity, good body development and use as game fowl (Wambier, 1991).

From an economical perspective, focus has been on meat production since it is tender, with exquisite flavor and excellent lean (Patino *et al*., 2005) and is considered to be elite as it is sold in high class restaurants and hotels (Manetti, 1996). There is also demand for their feathers for making costumes used in carnival troupes (Sell Randy, 1997). Furthermore, due to their beauty, birds are displayed in parks, zoos, residences, hotels, etc., (Patino *et al*., 2005). As such, production and commercial exploitation of animal species with these characteristics has flourished, due to the low cholesterol content of their eggs (Manetti, 1996) since they contain approximately 180 mg/egg and 14.1 mg/g in egg yolk (Craig and William, 1978). These levels are similar to those in chicken eggs that have approximately 220 mg (Simopoulos, 2000) to 243.5 mg/egg and 14.0 mg/g in egg yolk (Craig and William, 1978). Pheasants are an excellent food alternative due to their low cholesterol content (Manetti, 1996).

These birds have marked sexual dimorphism. Females are beige with black or reddish brown spots, while males have their head and neck iridescent green or blue. The remaining plumage is copper brown with black and beige markings (Gomez de Silva *et al*., 2005). Females weigh between 545 and 1453 g, while males weight between 770 and 1990 g (McGowan, in Del Hoyo *et al*., 1994).

Physiologically, male pheasants reach sexual maturity later than females and the laying season ranges from March/April until July (Gorrachategui, 1996). Molting occurs in the months of December and January. Sexual dimorphism is evident at 45 days of age and they reach adult manifestations around one year of age (Manetti, 1996). The mating season is in spring and individuals

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can live between 1 to 3 years (Gomez de Silva *et al*., 2005). Clutch size is generally between 10 and 12 eggs, although records have ranged between 1 and 28 eggs (Ehrlich *et al*., 1988). Eggs are olive brown (Gomez de Silva *et al*., 2005) to brownish gray (Manetti, 1996), although they can be occasionally light blue without any marks (up to 42 mm in length). Each egg can weigh between 33 to 35 g (Manetti, 1996; Gorrachategui, 1996). Eggs must be kept in a cool humid environment (13-18°C and 70% humidity) until they are taken to the incubator (Tesky, 1995). When in the incubator, eggs must be kept at 37.5 to 37.8°C with 60% relative humidity for 23 to 25 days (Hulet *et al*., 2004; Gomez de Silva *et al*., 2005). Pheasants normally eat daily 50 to 70 g of feed, although Gorrachategui (1996) reported that pheasants eat between 100 and 190 g of feed and drink between 120 and 290 ml of water. In captivity, they are fed the same feed that is used for chickens with minor variations (Manetti, 1996).

Traditional laying systems, which use natural lighting, limit the number of eggs obtained to between 40 and 60 per pheasant. Using a complementing lighting system that increases light hours, eggs laid can increase to between 70 and 80 eggs, but normally they lay 40 to 50 eggs per season (Tesky, 1995) up to 70 eggs per year with a 24-25 day incubation period (Manetti, 1996).

Photoperiod is defined as the amount of hours of light (natural and artificial) that are received by birds within a 24 hour period (Quintana, 2011). Programs are variable in regards to light restriction depending on the time of year and latitude in which the facilities are (Leonard *et al*., 2003; Ruiz, 1992). Among lighting programs, there are the intermittent and ahemeral lighting programs. Intermittent lighting programs are those that have more than one darkness and one light periods within 24 h, while ahemeral lighting programs use darkness and light periods that add to more than 24 h (Hevia and Quiles, 2005). Domestic fowl are seasonal species that depend on photoperiod to improve their performance. Thus, lighting regimes provide economic advantage in birds in terms of sexual maturity and high laying numbers. The reason behind this effect is that light waves pass through photoreceptors in the retina and from there on to the optic nerve stimulating the pituitary gland, which in turn produces follicle-stimulating (FSH) and ovulation (LH) hormones. Together, these hormones control ovary and ovule development that later are part of eggs so increasing light hours helps anticipate egg-laying (Manetti, 1996).

There are many reports on the use of supplementary lighting to stimulate the reproductive performance of domestic poultry. Photoperiod has been reported to influence the start of sexual activity helping start the egg-laying process and its synchronization, as well as egg size, shell quality and food efficiency (Robinson and Renema, 1999; Morris, 1964; Kirby and Froman, 2000), improved body and genital development (Robinson and Renema, 2003), playing an important role in the various phases of the laying-hen life cycle (Lera, 2005). Many studies have looked at improvement of performance parameters in pheasants, demonstrating that lighting programs improve egg production (Blake *et al*., 1987; Jacovak and Mrsic, 1992; Mantovani *et al*., 1993; Mashaly *et al*., 1983; Slaugh *et al*., 1988).

In regards to duration of the egg-laying cycle, Woodard and Snyder (1978) obtained the first egg at 12 to 13 days after implementing a lighting program (8L: 16D) and Yang and Kim (1993b) reported that the egg-laying cycle lasted nearly 12 weeks. When measuring the number of eggs laid per female, Yang and Kim (1993a) reported 73.4, 70.2 and 69.6 eggs per pheasant. Mantovani *et al*. (1993) using 37-week-old pheasants in a lighting regime that started at 11L:14D increasing 1 h every week until reaching 16L:8D, obtained on average 72 eggs per pheasant. In contrast, Marshall *et al*. (1998) used a lighting program of 16L:8D and 8L:16D at 27 and 21 weeks of age, reported that the average number of eggs per pheasant reached 65 and 39 eggs, respectively. Also, Yannakopoulus (1992) determined that the average number of eggs laid per pheasant exposed only to natural lighting reached 65.34 eggs.

A photoperiod of 16L:8D has been recommended in order to improve the reproductive efficiency of pheasants, as it is the lighting program that increases production, while keeping costs low, which is vital in order to have a cost efficient industry, as stated in various studies (Woodard and Snyder, 1978; Mashaly and Keene, 1979; Mashaly *et al*., 1983).

Currently there has been an increase in the demand of pheasants for various uses including food, feather art and for ornamental and display birds, as well as game birds. Alternative poultry production, with the purpose of producing eggs and meat different from what is generally found in the market, is important to provide high quality products that come from a cottage industry and are more “natural” due to improvements perceived by the consumers, in contrast with intensive poultry production in terms of animal welfare and “sustainable” agriculture (Cepero, 2009).

Studies published on the effects of photoperiod on pheasant productivity are scarce and many are not recent. As such, it is important to determine the parameters required for the correct productive management of this species in captivity.

The purpose of this study was to determine if the increase in artificial lighting (photoperiod), during the productive cycle of pheasants, improved productive performance in terms of the number of eggs obtained and their weight. It was expected that an increase in photoperiod (light hours) would improve productive parameters per female (egg production), egg mass, egg-laying percentage and egg weight in collared pheasants, similar to what happens in chickens.

Study site: The study was carried out in the Ecological Park of the State of Puebla Mexico within "Centro Reproductor de Vida Silvestre SMRN Flor del Bosque, Semarnat". The main objectives of this Center are the reproduction of these birds, provide donations and give environmental education opportunities to the public.

This park encompasses a 664.03 ha surface with altitudes ranging between 2200 to 2470 momsl. Geographically it is located within 19°00'00" and 19°01'50" latitude north and 98°20'35" and 98°20'53" longitude west (Martinez, 2008). The climate is temperate with the rainy season in summer and an average annual rainfall of 750-950 mm. The annual temperature average is 16-18°C with a monthly maximum temperature of 22°C (Martinez, 2008).

The breeding center or reproduction house measures 45 m^2, has 30 individual pens divided by a central hall and has a gabled roof. Each pen measures 3 m long by 2 m wide and 2 m high, with brick and wire divisions; the floor is gravel. Each pen has hopper-type food and water supplies and a nest area delimited by bricks. Nine pens are used for pheasant production and nine for partridges. The breeding house stands at 2225 momsl and houses common pheasants (*Phasianus colchicus*) the subjects of this study, as well as Lady Amherst's pheasants (*Chrisolophus amherstiae*) golden pheasants (*Chrisolophus pictus*), Silver pheasants (*Lophura nycthemera*) and melanistic mutant pheasant (*Melanistis mutantis*), as well as Chukar partridges (*Alectoris chukar*). Furthermore the breeding house has 3 areas, breeder house, rearing house and incubation area, as well as a flight area.

MATERIALS AND METHODS

A total of 45 ring-necked pheasants, between 1 and 2 years of age, weighing approximately 1.3 and 1.6 kg, respectively, were used (36 females and 9 males) in the study during 18 weeks. Birds were kept in the breeder area and divided into three groups before the start of the lighting program, which was carried out between March 2nd and July 5th, 2009. Three lighting regimes were used, with individual sections separated by black curtains. The lighting regime took into account the latitude and season. The control group was subjected to 18L: 6D (18 h light with artificial lighting from 6 to 12 pm: 6 h darkness); the second group was subjected to 16L: 8D (with artificial lighting from 6 to 10 pm) and the third group to 14L: 10D (with artificial lighting from 6 to 8 pm). Light bulbs used in the light fixtures were 75-watt white light.

Each treatment had three repetitions. Birds were kept in groups of one male and 4 females in 9 pens. Commercial balanced feed was provided in pellets or meal form containing 18% raw protein and selected grains (such as corn) and green alfalfa were provided every other day. Eggs were collected daily, three times a day every a 4-h time frame and placed in trays for storage.

Eggs were collected daily, three times a day, every 4 h and placed on plastic trays, vertically, thin side down, disinfected using a 1:10 antibenzil water solution and kept for one week in the incubation room. Later they were incubated for 23-24 days. Eggs obtained from each group were marked and weighed once a week using an electronic scale. Daily counts were recorded.

Production parameters of the birds were evaluated using weekly measurements of average egg weight (EW, g), egg mass (EM, g), number of eggs per female (EF, eggs) and laying percentage (LP, %); the total accumulated at 18 weeks was also recorded. Egg mass was obtained by multiplying the number of eggs by egg weight and divided by the number of females. The laying percentage was obtained by dividing the total production by 21 (number of females time 7 days) multiplied by 100.

A fully random experimental design, regarding bird distribution among treatments or photoperiods, was used. Data were analyzed using a fully random statistical model described as $Y_{ijk} = \mu_{ij}+S_i+T_j+S_i*T_j+E_{ijk}$ in which Y_{ijk} are the response variables evaluated, μ_{ij} is the mean of the I experimental weeks and j treatments, S_i are the I experimental weeks, T_j are the j treatments or photoperiods, $S_i * T_j$ is the interaction of treatment j with week I and E_{ijk} is the experimental error of week I in treatment j within repetition k. Furthermore, an ANDEVA with Tukey's multiple comparisons test was carried out. Both tests were carried out using the SAS V.8.0 statistical software package using the general linear models (GLM) procedure.

RESULTS

Implementation of the photoperiods was carried out during the week between February 13 and 20th, 2009. Records of egg parameters were kept between March 2nd and July 5th, 2009 (18 weeks). Nevertheless, production started on February 28th and ended on August 12th with a total egg laying cycle of 22 weeks.

Weekly response of the various egg production variables, in ring-necked pheasants, subjected to the three photoperiods, in the 18 weeks of this study, can be seen in Table 1. The photoperiod had an effect ($p<0.05$) on EF, LP and EM, but not on EW ($p>0.05$). As light-hours increased (h-l) in the study period the aforementioned parameters increased. It is noteworthy that an increase from 14 to 18 h-l caused a 0.65% increase in EW, although it was not statistically significant ($p>0.05$).

Experimental weeks, representing time throughout the egg-laying cycle, had an effect on all variables studied ($p<0.01$). Furthermore, the effect of the photoperiod on the variables studied (LP, EF, EM and EW) was different depending on the experimental week ($p<0.01$). In other words, the effects were not equal throughout the egg-laying cycle.

DISCUSSION

Regarding egg weight, Manetti (1996) and Gorrachategui (1996) established that eggs should weigh between 30 and 35 g each, while Blake *et al.* (1987) using 14L:8D reported 33 g, Romboli *et al.* (1996) using 15L:9D obtained 30.14 g and Slaugh *et al.* (1988) using 16 h-l obtained 31.9 g egg weight. The results in this study do not agree with those of the aforementioned authors, as lower average weights were obtained (28.48, 29,11 and 29.30, using treatments 16, 18 and 14 h-l, respectively). Nevertheless, Slaugh *et al.* (1988) stated that egg weight decreased in the 16 h-l treatment in their study, although egg weights, among the treatments in their study, were similar. This is similar to the results in this study as there were no significant differences between the three photoperiods. This can be due to excessive light hours provided, as the eggs in the 16 and 18 h-l treatments had lower weight than those in the 14 h-l treatment. Furthermore, age of the breeders could have an effect on egg weight since as birds are older the oviduct becomes longer resulting in heavier eggs (Shanawany, 1982) and breeders in this study were 1 and 2 years old.

Madero (2003) stated that egg-laying started in spring ended around December, but in this study the egg-laying cycle ended in August. Nevertheless, Gorrachategui (1996) found the egg-laying cycle very similar to the results in this study with a start of cycle in March/April ending around July. This most probably has to do with the latitude and region in which the experiment is carried out.

Egg production, in this study, reached 35.55, 39.88 and 44.16 eggs in photoperiods 14, 16 and 18 h-l respectively, which agrees with the results obtained by Manetti (1996) and Tesky (1995), who found that females lay between 40 and 50 eggs per season. Manetti (1996) also showed that females laid up to 90 eggs per year, in contrast with this study, at 18 weeks, females had laid 65.42 eggs in the 18 h-l photoperiod, 59.83 eggs in the 16 h-l photoperiod and 53.42 eggs in the 14 h-l photoperiod. This could be due to differences, in the amount of females used, treatments or photoperiods, or the length of time, handling and environmental conditions, amongst others.

Considering studies that have used 16 h-l treatments, Slaugh *et al.* (1988) reported a production of 58 eggs that is less when compared to the 59.83 eggs in this study. On the other hand, Tepeli *et al.* (2002) reported a production of 138 days that is much less than the 154 days in this experiment.

Regarding the number of eggs per female in photoperiods of 14 h-l, Blake *et al.* (1987) reported 55.6 eggs, which is similar to the result in this experiment of 53.42 eggs.

In studies that used 16 h-l photoperiods, Woodard and Snyder (1978) stated that egg-laying lasted 12 weeks,

Table 1: Response of several egg production variables (weekly averages) in ring-necked pheasants subjected to 3 different photoperiods during 18 production weeks

		Photoperiod[1]			Significance[3]	
Variable[2]	18 h-l	16 h-l	14 h-l		Photo	Week
EW (g)	29.11[a]	28.48[a]	29.30[a]		NS	**
	SE	0.30	0.21		0.42	
	Total	29.16	27.70		29.31	
EF (eggs)	3.68[a]	3.32[ab]	3.08[b]		*	**
	SE	0.22	0.20		0.18	
	Total	65.42	59.83		53.42	
LP (%)	52.57[a]	47.48[ab]	44.02[b]		*	**
	SE	3.22	2.93		2.64	
	Total	51.92	47.49		42.39	
EM (g)	112.33[a]	98.24[ab]	94.04[b]		*	**
	SE	6.60	6.19		5.73	
	Total	1909.6	1670.2		1567.5	

[a,b]Values with different letter are statistically different ($p<0.05$). (Tukey's multiple comparison)

[1]Photoperiods: Control: 18 h-l (hours light), experimental 16 h-l and experimental 14 h-l

[2]EW: Egg weight, EF: Eggs per female, LP: Egg-laying percentage, EM: Egg mass, SE: Standard error

Total: Total accumulated per female during the 18 weeks of study

[3]Significance: *$p<0.05$, **$p<0.01$, NS (Not significant) $p>0.05$

females laid between 8 and 9 eggs and the maximum peak was at weeks 4 and 5 of production. Results in this study were markedly different as egg-laying lasted 18 weeks and maximum peak was at the third week. Notwithstanding, females laid 9.97 eggs which is similar to their results, albeit the 14 h-l and 18 h-l treatments obtained 8.87 and 11.04 eggs, respectively. Slaugh *et al.* (1988) reported a production of 58 eggs per female, which is similar to the results obtained by Ensminger (1980) who reported 40 to 60 eggs per female. Results in this study agree with these results as females produced 59.83 eggs. Furthermore, Slaugh *et al.* (1988) stated that the best production parameters were obtained with the 16 h-l photoperiod, but that the egg-laying cycle shortened. In itself, this confirms that egg-laying decreases, but when compared to the 18 h-l treatment the effect is unnoticeable and better performance is actually obtained with this photoperiod when compared to the 16 h-l photoperiod.

Furthermore, Mantovani *et al.* (1993) reported a production of 72 eggs per pheasant, while Tepeli *et al.* (2002) reported 56.57 eggs and Mashaly and Keena, (1979; Mashaly *et al.*, 1983) reported 65 eggs. In perspective, even though at 59.83 eggs per female production is higher than what was obtained by Slaugh *et al.*, the results in this study only coincide with the results obtained by Tepeli *et al.* (2002). In addition, Yannakopoulus (1992) reported production levels of 65.34 eggs in females with natural lighting, up to 5.51 eggs less than in this study.

Yang and Kim (1993b) reported that the egg-laying cycle lasted almost 12 weeks in the three groups they established, during less time than the 18 weeks in this study. In addition, these same authors state that using an intermittent lighting program egg production reached 73.4, 70.2 and 69.6 eggs per pheasant, different to the results obtained in this study. It is possible that the differences between the studies are due to uncontrolled environmental conditions such as light periods, feeding and handling of pheasants used in the experiment.

In terms of egg-laying or production percentage, Tepeli *et al.* (2002) reported a 50% production in the fourth and fifth week in the 16 h-l group. In contrast, this study obtained an average of 47.49% with the peak during week three of production.

Slaugh *et al.* (1988) have suggested that the ideal photoperiod to extend production is between 11 and 12 h light. Nevertheless, Woodard and Snyder (1978) and Cain (1979) suggested that in order to obtain the best performance, birds must be previously conditioned with non-stimulating light (less than 14 h-l) during 6 weeks before the start of the cycle and that stimulation must be provided at 27 weeks, but optimum light-time has not been studied.

It is known that after exposure to long photoperiods many birds enter a photorefraction state and egg production ceases. Nevertheless, even though a maximum of 18 h-l was applied to birds in this study, it seems that the species was not photo-refracted, which can be noted by their better reproductive performance and best productive results in this study. It is important to note that egg weight did not show variation among the three photoperiods and remained constant throughout the 18 weeks of the productive cycle. Blake *et al.* (1987) found that birds occasionally would lay 2 eggs in the L:D cycle. This phenomenon is typical of this species as it was apparent in the three treatments. In this study, it occurred 5, 5 and 11 times, in the 14, 16 and 18 h-l treatments, respectively, with peaks in April and May.

Conclusion: In conclusion, the longest photoperiod (18 hours-light) had the best reproductive performance and greater egg production, similar to domestic poultry, while the 14 h-l program does not have a stimulating effect and at 16 h-l the EW is lighter, although not statistically significant. The 18 h-l period increased EF, LP and EM and as such, pheasants are similar to domestic poultry in that they respond unequally to light stimulation and the latitude at which they are housed. Productive performance and efficiency improve depending on the h-l amount to which they are subjected to, during the productive cycle and the age at which they are photo-stimulated.

Notwithstanding, there is a dearth of research using the 18 h-l photoperiod, therefore few comparisons can be made with the variables measured in this experiment in order to better understand the effects of photoperiod and achieve an improved reproductive management.

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