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Effects of Photoperiods during the Laying Period on Broiler Breeder Performance

Research Article

T. Mokarami[1], N. Hedayat Evrigh[1*] and B. Navidshad[1]

[1] Department of Animal Science, University of Mohaghegh Ardabili, Ardabil, Iran

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*Correspondence E-mail: nhedayat@uma.ac.ir

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ABSTRACT

The effects of increasing the laying period day-length from 13 to 16 hours were examined in Ross (308) broiler breeders. The birds reared on 8-h photoperiods and then were photo-stimulated at 21 weeks by increasing the photoperiods from 8 h of light, 16 h of darkness (8L:16D) to 11L:13D. Then the birds were given an additional 60 min of light per week cumulatively, such that in different experimental groups the 12L:12D, 13L:11D, 14L:10D, 15L:9D and 16L:8D photoperiods were achieved in 22, 23, 24, 25 and 26 weeks of age, respectively. The photoperiods remained unchanged until the experiment was finished at 50 weeks of age. The 16L:8D group had a poorer feed conversion and less egg production and egg mass than the other 3 groups (P<0.05). The total settable egg percentage was significantly lower for 15L:9D and 16L:8D than for 13L:11D and 14L:10D birds (P<0.05). The 13L:11D and 14L:10D h hens had more double-yolked and broken or abnormal eggs, followed by the 15L:9D h birds, and the 16L h birds (P<0.05). The mean egg weight of 14L:10D birds was significantly more than for 16-L h birds (P<0.05), with 13L:11D and 14L:10D birds were intermediated (P<0.05). The percentage of hatchability was higher in 13L:11D h hens followed by the 15L:9D and the 16L:8D birds (P<0.05), with 14L:10D h hens intermediated between 13L:11D and 15L:9D groups. The findings of this study suggest that 13L:11D was the optimal photoperiods for Ross 308 broiler breeders in the laying period up to 50 weeks of age.

KEY WORDS egg production parameters, hatchability, laying broiler breeders, performance, photoperiods.

INTRODUCTION

The typical female broiler breeder management practice in closed houses is a short day length rearing phase, for instance 8L:16D, followed by an increase in day length, such as 14L:10D at about 20 weeks of age, which broiler breeders reaches an acceptable body weight and frame size (Aviagen, 2016; Cobb, 2016). This photo-stimulation starts a series of physiological alterations, which leads to sexual maturation and reproductive ability. Sharp *et al.* (1992) found that the decrease in egg production in aged hens was to a degree because of the progress of photo-refractoriness. The photo-refractoriness means lack of reaction to the long-day length, the situation similar to the end of the breeding season in nature (Tyler and Gous, 2011). Photo-refractoriness reduce the hypothalamic gonadotropin-releasing hormone (GnRH) concentration in commercial layer hens (Ubuka *et al.* 2013). On the other hand, it has also been recommended that in laying phase, the photoperiods should be to increase just enough to balance the progress of photo-refractoriness (Ubuka *et al.* 2013). Lewis and Gous (2006a) reported that the start of adult photo-refractoriness in broiler breeders exposed to more than 14 h daily light, occurred earlier than in broiler breeders reared under 11-12 h daily light. However, evidences that broiler breeders demonstrate photo-refractoriness (Lewis *et al.*

2003) and the reports that laying performance in broiler breeder reared on 8-h day length and exposed to either 11 or 12 h of light in laying period was better to that of birds kept under 16 h day length (Robinson *et al.* 1998; Ciacciariello and Gous, 2005; Lewis, 2006; Lewis and Gous, 2006b; Lewis *et al.* 2007) have questioned the long photoperiods practice for broiler breeders. Lewis and Gous (2006a) observed a poorer laying performance in broiler breeders reared on 16 h daily light and attributed it to accelerate adult photo-refractoriness because of the stimulatory effect of the photoperiods. The objective of this trial was to find the best photoperiods for photo-stimulated female Ross 308 broiler breeders.

MATERIALS AND METHODS

Birds kept on the floor, on 8-h photoperiods, with illumination from a single 60 W incandescent lamp in each room located 1.8 m above the floor and producing a mean illuminance of 5 lux for female and 7 lux for male broiler breeders.

The stocking densities in rearing period were 7 and 3.5 birds per m^2 for females and males, respectively, and 5.5 mixed sex birds per m^2 in production phase. Table 1 shows the chemical composition of the diets.

The pullets were photo-stimulated at 21 weeks of age by increasing the photoperiods from 8L:16D to 11L:13D. Then the birds were given an additional 60 min of light per week cumulatively, such that in different experimental groups in separated poultry houses the 13L:11D, 14L:10D, 15L:9D and 16L:8D photoperiods were achieved in 23. 24, 25 and 26 weeks of age, respectively. The photoperiods remained unchanged until the experiment was finished at 54 weeks of age.

At 23 weeks of age, 600 male and 6000 female birds were allocated to each 16 experimental poultry house (4 replicates for each experimental group) with 5.5 birds per m^2. The average light intensity at the egg production period was 70 lux for all the experimental groups. Eggs were collected from 26 to 50 weeks of age six times daily and stored in a cooler until set. Egg production was recorded daily and average weekly egg production percent was calculated for each replicate house. The number of settable eggs, double-yolked eggs, abnormal and large eggs, unsettable cracked eggs, were recorded throughout the laying period and was expressed as a percentage of the total number of producing eggs.

The hatchability was determined as the number of chicks hatched per 100 eggs set. The total individual egg production was calculated using the average daily egg production yield in each house multiplied by 175 days egg production period as describe by Lewis *et al.* (2010).

The average weight of 180 eggs per house was used to calculate individual egg weight, weekly and whole experimental period egg mass production. The mortality rate was recorded daily and expressed as the mean mortality percentage per week. The feed consumption per produced egg was calculated from the following formula:

Feed consumption= total feed intake between 26 to 50 weeks of age (g) / total egg produced between 26 to 50 weeks of age

Twenty five birds per pen were randomly selected and weighted at 22, 26, 30, 35, 40, 45 and 50 weeks of age. The body weight gain during egg production period was calculated as the difference in average body weights at 22 and 50 weeks of age. All experimental birds consumed a same diet formulated to meet Ross 308 broiler breeder requirements (Aviagen, 2016) through 50 weeks of age (Table 1). Data were subjected to analysis of variance by GLM procedures of SAS 9.2 (SAS, 1994) using a completely randomized design with 4 photoperiod treatments (13, 14, 15 or 16 h) and 4 replicates poultry house. Significant differences ($P<0.05$) between means were determined using the Duncan multi range test.

RESULTS AND DISCUSSION

Table 2 shows the effects of photoperiod in laying phase on the performance parameters of broiler breeder hens. Photo schedule had a significant effect on egg production parameters. The egg production and egg mass in birds maintained on 16L:8D photoperiods were less than the 13L:11D, 14L:10D or 15L:9D h photoperiod groups ($P<0.05$). Ubuka *et al.* (2013) suggested that a longer photoperiod increase GnRH secretion by stimulating the hypothalamus pathway. This process would result in more gonadotropin serration from the anterior pituitary and consequently an increase in concentration of LH circulation and ovulation.

However, the production of more than 2 eggs for 26-50 week production period of the 13, 14 and 15-h birds, compared with the 16-h hens, agreed with the previous report on broiler breeders transferred directly to 12-h at 20 weeks over hens transferred to 16 h (Ciacciariello and Gous, 2005). This also is agreed with the findings of Lewis *et al.* (2008) who reported that broiler breeders pullets reared on 8 hours and transferred to 13 h stimulator photoperiods, showed an improved sexual maturation for broiler breeder pullets reared on 8 h. The cumulative number of eggs produced in 50 week also supports the report of Lewis and Gous (2006b) who found that broiler breeders reared on 8-h photoperiods do not require more than 14- h in the laying phase to optimize sexual maturity and egg production.

Table 1 The chemical composition of the Ross 308 broiler breeders diets

Ingridients (g/kg)	Starter1	Starter2	Growth	Pre-production	Production1	Production2
	From hatch to 21 d	22 d to 42 d	43 d to 105 d	From 106 d to 5% production	From 5% production	After 245 d
Corn	612.5	651.5	610	685	670	694
Soybean meal	340	262	164.2	207	229	201.8
Wheat bran	0	48	150	54	0	0
Zeolite	0	0	37	10	0	0
Soybean oil	7.2	0	0	0	9.1	7
Dicalcium phosphate	16.5	15.4	14.4	13	14.3	12.9
Calcium carbonate	13	13.6	14.7	21	67.4	74
Mineral premix	2.5	2.5	2.5	2.5	2.5	2.5
Vitamin premix	2.5	2.5	2.5	2.5	2.5	2.5
DL-methionine	2	0.8	1	1.2	1.5	1.5
Salt	2.8	2.7	2.7	2.8	2.7	2.8
Calcium bicarbonate	1	1	1	1	1	1
Chemical composition (%)						
Metabolizable energy (kcal/kg)	2800	2800	2600	2800	2800	2800
Crude protein	19	17	14	15	15	14
Lysine	1.06	0.74	0.58	0.62	0.67	0.62
Methionine	0.46	0.32	0.34	0.37	0.40	0.39
Methionine + cysteine	0.84	0.66	0.53	0.57	0.64	0.62
Threonine	0.72	0.57	0.45	0.48	0.53	0.5
Tryptophan	0.19	0.15	0.14	0.15	0.16	0.15
Calcium	1.00	1.00	0.90	1.20	3.00	3.20
Available phosphorus	0.45	0.45	0.42	0.35	0.35	0.32

Ingridients of mineral and vitamin premix in starter and growth (period): vitamin A: 11000 IU; vitamin D: 3500 IU; vitamin E: 100 IU; vitamin B_1: 3 mg; vitamin B_2: 6 mg; Nicotinic acid: 30 mg; Pantonic acid: 13 mg; vitamin B_6: 4 mg; Biotin: 0.2 mg; Folic acid: 1.5 mg; vitamin B_{12}: 0.02 mg; Colin: 1300 mg; K: 3 mg; Cu: 16 mg; Zn: 110 mg; Mn: 120 mg; Se: 0.3 mg and I: 1.25 mg.

Ingridients of mineral and vitamin premix in production (period): vitamin A: 11000 IU; vitamin D: 3500 IU; vitamin E: 100 IU; vitamin B_1: 3 mg; vitamin B_2: 12 mg; Nicotinic acid: 55 mg; Pantonic acid: 15 mg; vitamin B_6: 4 mg; Biotin: 0.25 mg; Folic acid: 2 mg; vitamin B_{12}: 0.03 mg; Colin: 1050 mg; K: 5 mg; Cu: 10 mg; Zn: 110 mg; Mn: 120 mg; Se: 0.3 mg and I: 2 mg.

Table 2 Effects of photoperiod on the performance of broiler Ross-308 breeder

Photoperiod (h)	Egg production parameters						
	TEP	MEP (g)	TEMP (kg)	Hatching egg (%)	Double-yolked (%)	Broken or abnormal eggs (%)	Hatchability (%)
13	135.09^a	63.10^{ab}	8.56^a	97.00^a	0.72^c	2.28^c	81.64^a
14	134.52^a	63.27^a	8.53^a	96.75^a	0.85^c	2.51^c	81.28^{ab}
15	134.45^a	62.66^{ab}	8.43^a	96.11^b	1.01^b	2.87^b	81.06^b
16	132.31^b	62.11^b	8.24^b	95.43^c	1.27^a	3.31^a	80.42^c
SEM	0.525	0.310	0.051	0.098	0.047	0.079	0.140
P-value	0.0135	0.018	0.0031	0.0001	0.0001	0.0001	0.0004

TEP: total egg production for 175 d experimental period; MEP: mean egg weight (g) and TEMP: total egg mass production (kg).
The means within the same column with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

The more earlier decrease in egg production by the hens exposed to more than 13 h daily light is indicative of a more rapid start of adult photo-refractoriness, as explained by Lewis *et al.* (2003) and Lewis (2006). Confirmation of the photo-refractoriness occurrence in broiler breeders has also been reported by Robinson *et al.* (1998) and Lewis *et al.* (2007) for hens transferred to 15-h and 16-h day lengths, respectively.

Dawson (2001) suggested that it is the preliminary increase in photoperiod that activates the sexual maturation and also the adult photo-refractoriness and the faster transfer to stimulatory photoperiod, the more rapid sexual maturation and adult photo-refractoriness. In this regard, Lewis *et al.* (2010) found a positive relationship for the hinged regression between the egg numbers and photoperiod.

The total hatching egg percentage was significantly lower for 15L:9D and 16L:8D h than for 13L:11D and 14L:10D h birds (P<0.05).

The 13L:11D and 14L:10D h hens had significantly less double-yolked and broken or abnormal eggs, followed by the 15L:9D h birds, and the 16L:8D h birds (P<0.05). This was a surprising observation as previous study has revealed that the number of eggs laid out-side the nest box and abnormal eggs, reduced with increased day lengths (Lewis and Gous, 2006a; Lewis *et al.* 2007).

The effect of more rapid sexual maturation and body weight on double-yolked egg production was formerly reported in egg type hens by Lewis *et al.* (1997). However, Lewis and Backhouse (2004) suggested that these unflavored effects are a result of the advance in average oviposition time and higher number of eggs laid before lights-on when hens are exposed to day lengths shorter than 12.25 h, which is out of the photoperiod treatments of current study. In another study, Ciacciariello and Gous (2005) found that each 100 g higher body weight in hens resulted in about two more double-yolked egg production. The relationship between birds body weight and abnormal and double-yolked eggs is also clear in the present study.

The mean egg weight 14-L hens were significantly more than for 16-L h birds *(*P<*0.05)*, with 13 h and 14 h birds were intermediated (P<0.05). The lower average egg weight of broiler breeders shifted to 16 h photoperiods was probably a consequence of their earlier age of sexual maturity and lower body weight at maturity.

The negative effect of daily light duration on average egg weight has been reported by other authors who shifted broiler breeders from short to extended day lengths at about 20 weeks (Ciacciariello and Gous, 2005; Lewis *et al*. 2005; Lewis and Gous, 2006a; Lewis and Gous, 2006b; Lewis *et al*. 2010) and suggest the positive age effect of sexual maturity on egg weight (Lewis *et al*. 1994).

The percentage of hatchability was higher in 13L:11D h hens followed by the 15L:9D birds, and the 16Lh birds (P<0.05), with 14L:10D h hens intermediated between 13L:11D h and 15L:9D h. The mortality rate for 15L:9D and 16L h birds was significantly more than for 13L:11D h birds (P<0.05), with 14 h intermediate between 13 h and 15 h (P<0.05) (Table 3).

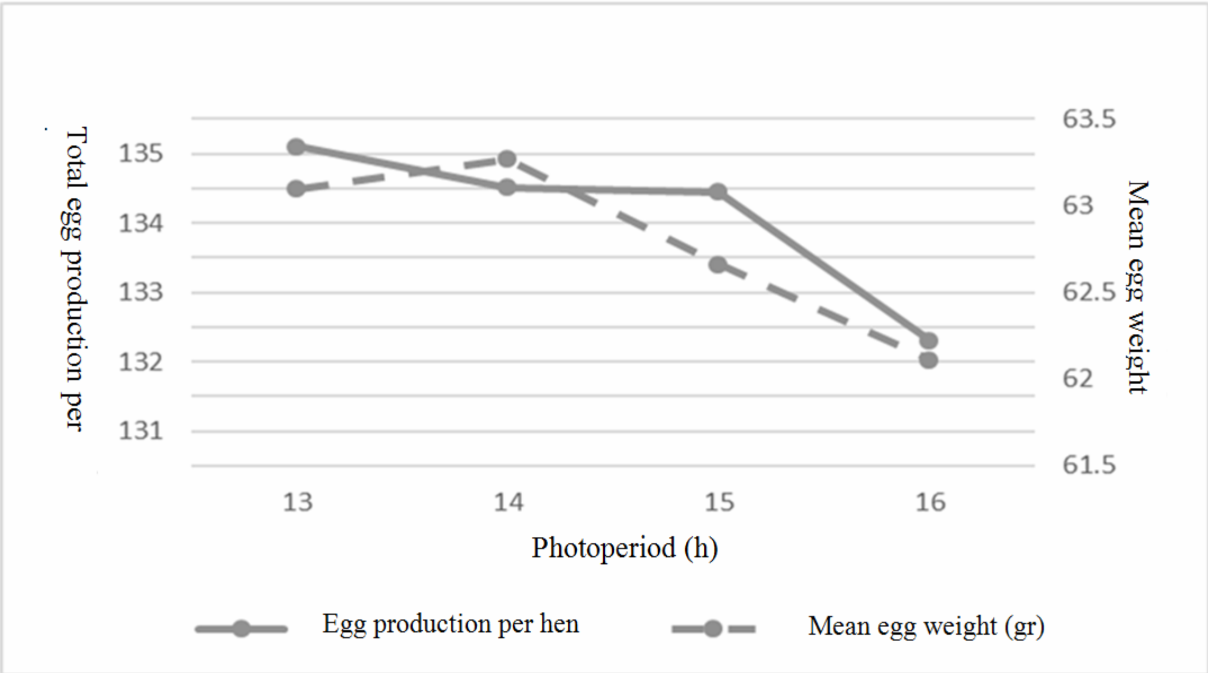

Figure 1 Effect of photoperiod on total egg production and mean egg weight of Ross 308 broiler breeder hens

Table 3 Effects of photoperiod in laying phase on the mortality rate and body weight of broiler breeder hens

Photoperiod (h)	Mortality	FIPPE (g)[1]	Body weight (kg) at different ages (week)							
			22	26	30	35	40	45	50	22-50
13	2.64^{c}	205.81^{b}	2.66	3.30^{a}	3.68^{a}	3.98^{a}	4.04^{a}	4.07	4.09	1.43
14	3.75^{b}	206.70^{b}	2.61	3.29^{a}	3.60^{b}	3.80^{b}	3.96^{b}	4.11	4.11	1.50
15	5.23^{a}	206.81^{b}	2.63	3.20^{b}	3.60^{b}	3.79^{b}	3.90^{b}	4.01	4.02	1.39
16	5.84^{a}	210.17^{a}	2.59	3.24^{b}	3.64^{ab}	3.82^{b}	3.95^{b}	3.99	4.02	1.42
SEM	0.345	0.831	0.023	0.015	0.023	0.033	0.023	0.051	0.029	0.041
P-value	0.0001	0.0130	0.273	0.001	0.071	0.006	0.012	0.466	0.108	0.299

FIPPE: feed intake per produced egg (g).
The means within the same column with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

This appears contradictory to the lack of the photoperiodic effect on the incidence of mortality in laying period, which previously reported for broiler breeders (Ciacciariello and Gous, 2005; Lewis *et al*. 2005; Lewis and Gous, 2006a; Lewis *et al*. 2007; Lewis *et al*. 2010). In the current study, there were no significant differences in the mean body weight of birds at 22 wk of age.

However, At 26 weeks, birds given the final photoperiod of 13-L and 14-L h had significantly heavier mean body weight than groups transferred to 15L:9D or 16L h (P<0.05) (Table 3). At 30 weeks, groups given the final photoperiod of 13L:11D h had a significantly heavier mean body weight than groups transferred to 14L:10D or 15L:9D h (P<0.05); and 16L h birds were intermediate. At 35 and 40 weeks, the group given a final photoperiod of 13L:11D h had a significantly heavier mean body weight than groups transferred to 14L:10D or 16L h (P<0.05). The final photoperiod did not affect the weight gain of birds between 22 to 50 weeks of age.

These results support the previous reports that hen's body weight is an important factor of double-yolked egg production (Hocking, 1993). The heavier body weights for broiler breeders exposed to shorter photoperiod during laying phase is in agreement with previous reports of Lewis and Gous (2006a) and Lewis *et al*. (2010) and to a lesser extent the results of Joseph *et al*. (2002), who observed heavier body weights between 41 to 48 weeks for broiler breeders kept for 14 h day length than whose given an increased day length up to 18 h. This higher body weight can be explained, in part, by the MacLeod *et al*. (1988) theory that the maintenance energy requirement of hens is decreased by about 1% for each 1 h decrease in photoperiod, and consequently, with the same daily feed provision and almost comparable egg production, the saved maintenance energy at shorter photoperiods results in increasingly heavier body weight as birds age (Lewis *et al*. 2010). Figure 1 shows the reducing effect of long photoperiod on total egg production and mean egg weight, with a linear trend being followed over all treatments in 35 to 50 weeks of age.

The 16L h birds had significantly poorer feed conversion ratio (FCR) than any of the other groups (P<0.05) (Table 3). There is a probable explanation for this observation. All experimental birds were given the equal daily amount of feed; consequently, hens exposed to longer day lengths would be estimated to have a poorer FCR, because the extra daily illumination enhanced birds maintenance need and in the same way decreased the quantity of energy accessible for egg production (MacLeod *et al*. 1988). This finding does not support the result of Lewis *et al*. (2010), who found that the FCR was improved with longer photoperiods.

CONCLUSION

The findings of this study suggest that the optimal photoperiod for Ross 308 broiler breeders in the laying period up to 50 wk of age was about 13 h, and the birds reared in this pattern had consistently better egg production, hatchability and FCR, especially in comparison with birds reared on 16 h photoperiod.

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