Effect of Light Stimulation and Body Weight on Reproductive Performance of Broiler Breeder Hens

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ABSTRACT An experiment with broiler breeder pullets was undertaken to determine the effect of pattern of light stimulation and pullets body weight at 20 wk of age on various production parameters, body weight and age at onset of lay. Two light stimulation treatments were used: abrupt (ALS) and step-up (SLS). Pullets were randomly assigned to one of three body weight groups: low weight (1800 g), medium weight (2200 g), or heavy weight (2600 g) at 20 wk of age. The results obtained indicated that pattern of light stimulation and weight at 20 wk did not markedly affect egg production, however, pullets exposed to SLS or ALS produced the lightest eggs. A numerical advancement occurred in age at first egg due to SLS. Significant weight gain occurred in low weight pullets due to SLS. The results of this experiment indicated that SLS of low weight broiler breeder pullets represents a viable means for Increasing weight gain and advancing onset of egg laying.

Key Words: Broiler breeders, pullets, light stimulation, egg production,

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INTRODUCTION

In the non-domesticated bird, the onset of sexual maturity is regulated by day length (Etches,1993). It is believed that increasing day length provides a good stimulus for increased gonadotrophin secretion. It has been reported that after the hen is 12 weeks old, changing of the photoperiod (photo stimulation or light stimulation) from a short day to a long day will induce a 2 to 4 folds rise in the plasma concentration of LH. Within a week after photostimulation, the secondary sexual characteristics begin to developed (Etches, 1990).

Development is complete within 3-4 weeks and egg production can begin. The response to change in the photoperiod has been implemented to establish photoperiod regimes for the laying hens (Wilson and Cunningham, 1984 Cunningham, 1987). For instance, the onset of sexual maturity can be delayed by rearing the birds (pullets) under declining day lengths or short days and initiated by transfer to long days. The negative relationship between body weight and reproduction efficiency of the broiler breeder hen is well documented (Robinson el al. 1993).

It is well documented that the pullet's response to light becomes important only as these birds approach sexual maturity. Lighting programs for birds younger than 16 – 18 weeks of age can influence their development and subsequent reproductive performance. Robinson et al. (1996) observed broiler breeder pullet maturity when changing light stimulation, from 8 L: 16 D up to 14 L: 10 D was initiated at 120 – 160 day of age. These authors reported that very early stimulation (120 – 130 days) does not seem to significantly advance the age at sexual maturity, although later stimulation at 160 day seems to have a definite delaying effect on onset of egg production. However, early light stimulation (120 – 130 days) did have a detrimental effect on production of chicks over the production cycle. Other authors (Yuan et al. 1994; Lewis and Gous 2006) have generally confirmed this work, where light stimulation as 15-17 weeks of age reduced peak egg numbers and / or post peak persistency. The above mentioned studies confirm previous work (Robinson et al. (1993) that there is a negative relationship between light stimulation and body weight of pullets at the onset of photo stimulation.

Decisions to light stimulating flocks that do not achieve normal weight – for – age or have low body weight uniformity are of practical importance. Lien and Yuan (1994) indicated performance of pullets that were either 2.0 kg or 1.8 kg at 20 weeks of age when light stimulation was planned. Because the 1.8 kg birds were below standard, a group of these pullet were grown to 22 weeks, at which time they were 2.0 kg, and where light-stimulated. The data of Lien and Yuan (1994) confirmed that under weight pullets should not be light stimulated until the standard weight (approximately 2.0 kg) is attained, regardless of age. Under practical conditions, this means that broiler breeder pullet must not be light stimulated unless they achieve a minimum threshold of both body weight and age. Given the negative relationship between body weight of the broiler breeder hens and their reproductive efficiency (Robinson et al.1993) the control over sexual development seems complicated especially for pullets reared in open-sided houses, or those reared in black-out houses then transferred to open-sided house compared to those reared in black-out houses.

The growing period is usually regarded as being between 6 and 20 weeks of age, whilst pullets are exposed to a lighting program according to type of the rearing house. It is a common practice that pullets are grown on continuous light for 2-3 days, and then day length is reduced to 8-12 hour of constant light up to 20 weeks of age. Lien and Yuan (1994) observed the effect of light stimulation on broiler breeder flocks exhibiting mean body weight lower than the standard for lighting (2.04 kg). These researchers suggested that delayed lighting increased post-peak, and total settable egg production, and also improved feed efficiency of low weight pullet to a level comparable to that of standard weight pullet lit at recommended age. Yuan et al.(1994) reported that the onset of lay by broiler breeders can be advanced by early photostimulation and that increased body weight facilitates this. Working with commercial egg laying hens, Lewis et al. (1997) observed the effect of size (8 h during rearing to 8, 10, 13, 16 h) and timing (at 42, 63, 84, 105, 126 or 142 day) of photoperiod increase on age at first egg, egg weight, egg production, egg output, and body weight. Size and timing of photostimulation did affect these parameters to variable degree.

Most broiler breeder research focused on feed allocation (restriction versus *ad lib*) and hatchability. A limited amount of research has been conducted in the area of broiler breeders lighting management. In practical terms, most basic protocols of lighting management have been developed primary breeding companies and integrated broiler companies. It is not known whether light stimulation in a single-step (abrupt) makes any difference compared to a more gradual (step-up) light stimulation.

The objectives of this study were to evaluate the effect of step-up (gradual) lighting stimulation on performance of broiler breeder pullets, exhibiting mean body weight, lower, or above the standard for lighting at the recommended age (20 wk).

MATERIALS AND METHODS

This study was conducted with 60 -Hybro-PG+ broiler breeder pullet, obtained from Uja _ Jericho farm, of Sinokrot Poultry Farms Company. Bird were selected for the study from a flock of 34-thousands bird that had been reared up to 20 wks of age under uniform condition of lighting, feeding, and management. At 21 wks of age, pullets (60 birds) were moved to individually laying cage (40 × 40 × 30 cm) in two experimental rooms. Each room was partitioned so as to provide a black-out environment. Feed was served manually, and birds had access to water from cup drinkers connected to municipality water-pipes. Treatments were factorially (2×3) arranged and consisted of 2 light-stimulation patterns and three groups of pullets exhibiting body weights lower, equal or above than the standard for lighting at the recommended age (20wks). Pullets were randomly assigned to each treatment. Within treatment, 10 hens (pullets) were randomly assigned to each of two replicate groups. Each pullet served as an experimental unit. From 20 to wks to the end of the experiment pullets were fed a layer (Table 1). Feed allotments were similar to that recommended by primary breeders (management guide). Daily allotments were weighted in advance and presented to the pullets at 6:0 am. Body weight groups were: group 1, pullets exhibiting body weights lower (low-weight) (1800 ± 20g) than the standard body weight; group 2, pullets exhibiting body weights equal (median-weight) (2200 ± 20 g) to the standard (recommended) body weight; group 3, pullets exhibiting body weights higher (heavy-weight) (2600 ± 20g) than the standard bodyweight for light stimulation at the recommended age (20wks). Two light treatments were imposed: treatment 1, abrupt light stimulation (ALS) in which hours of light were increased to 10 hrs at 21 wks, 12 hrs at 5% egg production, 14 hrs at 35% egg production, and finally to 16 hrs at 65% egg production; treatment 2; step-up stimulation (SLS) in which hours of light were increased to 12 hrs at 21 wks of age, then by half an hour weakly until 16 hrs of light are attained at 29 wks of age.

Egg production was recorded daily to 34 wks of age. Eggs were collected 4 times daily. Egg weight, and specific gravity were obtained from eggs collected during the last two days of every week, except weight of the first egg which was recorded once it was laid. Egg weight was recorded at the end of the day. Egg specific gravity was determined the following morning by using the flotation method (Voisey and Hamilton, 1977), taking measurements of increments of 0.004 (from 1.062 to 1.102). Individual body weight was recorded at the beginning, and at the termination (34 wks) of the experiment. Body weight change was measured by the difference between initial and final individual weight. Individual age and body weight were also recorded at the time the first egg was laid. Abnormal eggs having small sizes, multiple yolks or defective shells were not recorded or included in egg production and weight data.

Individual length of prime sequence, subsequent sequence, total number of eggs, egg out-put (total number of eggs × average egg weight) and the production of settable eggs (egg weight > 50 g) were calculated on a per hen basis throughout the experimental period.

Since obtained data were measured at a single time, a completely randomized desigd (CRD) was used, as follows:

$X_{ij} K = M + L_i + W_j + (LW)_{ij} + e_{ij} K$, where M is the common treatment mean; L_i is the affect of the jth pattern of light stimulation; W_j is the effect the jth body weight group; (LW_{ij}) is the pattern of light stimulation by body weight group; and $e_{ij}K$ is the experimental error. All data were analyzed using the GLM procedure of SAS (SAS Institute, 2000). Difference between means were tested by the least square difference method at a statistical significance level of $P < 0.05$.

Results

Body weight at first egg and body weight differences for low, medium, and heavy broiler breeder pullet exposed to abrupt (ALS) and step-up (SLS) light stimulation are given in (Table 2). All the pullets attained almost similar body weight at the time the first egg was laid regardless of the pattern of light stimulation. However, a trend showed that pullets exposed SLS gained more weight compared to those exposed to ALS. Body weight change (from 20 to 34 wks) was similar (888 and 936 gm) for the heavier pullets irrespective of the pattern of light stimulation. Pullets having low body weight at the beginning of light stimulation gained significantly more weight (1682.2 and 1532 g) across both of the light stimulation patterns.

Age at first egg was affected by body weight at 20 wks but not by the pattern of light stimulation (Table 3). Age at first egg was advanced for the heavy weight pullet compared to that of low weight pullets while that of medium weight pullets was intermediate. First eggs were laid at 182.2 d of age by low weight pullets exposed to SLS treatment and at 186.6 d of age by low weight exposed to ALS treatment. Compared to ALS, SLS had beneficial effects on under weight pullets.

Effects of light stimulation pattern and body weight on egg production, mean egg weight, egg out put, and sequence length are summarized in (Table 4). Production of heavy weight pullets was greater than that of medium or low pullets regardless of the light treatments. Except for medium weight pullets, all pullets exposed to SLS had high production from age at first egg to 34 wks of age. Although egg weight was not affected by light treatment or body weight at 20 wks of age, it tends to be higher for pullets exposed to SLS treatment. Heavy pullets produced smaller eggs compared to pullets in the other treatments. Prime sequence length, and average sequence length of all treatments differed only slightly throughout the experiment. However, length of the prime sequence was greater for pullets reared SLS lighting pattern.

Effects of exposing low, medium, and heavy broiler breeder pullet to ALS and SLS on weight of first egg, settable and non settable egg production, and egg specific gravity, are presented in (Table 5). There are significant differences in weight of first egg for low weight pullets exposed to ALS and that of the heavy weight exposed to

SLS. In general ALS pullets produced heavier egg compared to pullets exposed to SLS. It is obvious that heavy pullets which were exposed to SLS gave the highest number of settable eggs. Under weight pullets exposed to ALS had the lowest number of non settable eggs compared to other weight groups raised under the same lighting pattern and also significantly had lowest specific gravity.

Discussion:

Data on the pattern of light stimulation which can be used to initiate pullet sexual maturity do not exist Lewis et al. (1997). It is not known whether an abrupt (fast) light stimulation makes any difference compared to a more gradual (step-up) light stimulation. In the present study, weight of low-weight pullets (at 20 wks of age) increased within each pattern of light stimulation so that they were similar to the heavy pullets at sexual maturity (table 2). Low-weight pullets subjected to SLS gained significantly more weight compared to the other weight groups with low-weight pullets subjected to ALS were intermediate. Lien and Yuan (1994) suggested that delayed lighting stimulation improved feed efficiency of low weight pullets to a level comparable to that of standard weight pullets lit at recommended age. It is obvious, from the results of our study, that SLS did have similar effects to delaying light stimulation reported by Yuan et al (1994) and Lien and Yuan (1994). Yuan et al (1994) reported that the onset of lay by broiler breeder can be advanced given body weight is above the standard. Working with broiler breeder pullets, Robinson et al. (1996) reported that there was a distinct advantage to delaying light stimulation until after 20 wks of age. These authors also concluded that delaying light stimulation offered a chance to improve flock body composition uniformity and also caused pullets to lay faster and more uniform. Our results (Table 2, 3) indicated that SLS had similar effects to those reported by Robinson et al. (1996). SLS did advance onset of laying by 4 d in low and medium weight pullets. Therefore ALS seems to act in similar a manner to imposing light stimulation too early whereas SLS seems to act as delaying light stimulation. Working with commercial laying hens, Lewis et al. (1997) observed the effect of size (8 h during rearing to 8, 10, 13, 16 h) and timing (at 42, 63, 84, 105, 126 or 142 day) of photoperiod increase on age at first egg, mean egg weight, egg production, egg output, and body weight. These authors concluded that early light stimulation resulted in advanced age at first egg, and that egg weight and egg output were greater following an early or late stimulation rather than a midterm light stimulation. Results or the present study also indicate that pattern of light stimulation (to 34 wk of age) did influence the number of eggs, egg weight, egg out-put, and sequences characteristics) to variable degree (Table 5). Compared to ALS, SLS numerically improved performance of low and medium size pullets. Heavy pullets, at the time 20 wk, were positively affected by SLS. These results are contrary to those reported in previous works (Yuan et al. 1994). These discrepancies may be explained by the finding that heavy weight pullet (at 20 wks) did not gain too much weight at maturity. It should be noted that SLS was effective in increasing production of low-weight pullets compared to ALS. Although affected to a variable degree, weights of eggs laid by low and medium-weight pullets were similar to that of heavy weight pullets regardless of pattern of light stimulation. We observed that increased body weight at light stimulation was associated with decreased egg weight and this is in agreement with several previous reports (Wilson et al, 1983; Yuan et al, 1994). Settable egg numbers were similar for all weight groups, except that of the heavy pullets subjected to SLS which was significantly higher than that of low weight pullets.

In conclusion, the results of this study indicated that the onset of eggs laying can be advanced and weight of underdeveloped pullets can be increased from 20 wk to onset of lay by step-light stimulation (SLS). SLS also improved performance parameters of under-developed pullets (through34 wk) to a level comparable to that of medium and heavy weight pullets subjected to ALS. The noticeable increase in weight of under-developed pullets subjected to SLS provides an opportunity to manipulate the feeding level, from 20 wk to maturity, to advance onset of lay in poorly uniform flocks.

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تأثير نمط الاثارة الضوئية و وزن الجسم على أداء أمهات دجاج اللحم

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الملخص

جريت تجربة على أفـ راخ أمهـ ات دجـ اج اللحـ م لتحديـ د تـ أثير نمـ ط الاثـ ارة الضـ وئية و وزن الجسـ م عنـ د عمـ ر 20 سـ أ بوع على أداء الأمهـ ات الإنتاجي و وزن عمـ ر الأمهـ ات عنـ د بداية أسلا تخدام نمط ين مـ ن الاثـ ارة الضوئية هما الإثـ ارة الضـ وئية السريعة و الإثـ ارة الضـ وئية المتدرجة. و زعت الفرخـ ات بشـ كل عشـ وائي إلـ ى ثلاث مجموعات تبعاً لوزن الجسم عند عمر 20 أسبوع على النحـ و التـ الي: 1800 غـ م و 2200 غـ م و 2600 غم. دلت النتائج على أن استخدام نمط الإثارة الضوئية و وزن الجسم لم يؤثر بشكل ملحوظ على إنتـ اج الأفـ راخ, و مع ذلـ ك فـ ان الأفـ راخ عاليـ ة الـ وزن أنتجـ ت بـ يض مـ نخفض الـ وزن, و أدت الإثـ ارة الضـ وئية المتدرجـ ة إلـ ى تبكير وضع البيض في الأفراخ خفيفـ ة الـ وزن, كما أدت زيـ ادة ملحوظـ ة فـ ي وزنهـ ا باسـ تخدام نمـ ط الإثارة المتدرجة. نستنتج من نتائج التجربة تبين أن تطبيق نمـ ط الإثـ ارة المتدرجـ ة علـ ى الأفـ راخ ذات الـ وزن المـ نخفض يؤدي إلى تقديم وضع البيض و يزيد من وزن الأفراخ عند بداية الإنتاج

Table 1: Composition and calculated analyses of the diet.

Composition of diet	%
Corn	46.65
Wheat	18.00
Wheat middling	8.00
Soya bean meal (44% protein)	16.40
Vegetable oil	0.45
Limestone	6.50
Dicalcium Phosphate	2.25
Salt	0.15
D.L - metheonine	0.10
vitamin – Mineral premix [1]	0.50
Calculated analyses	
ME, Kcal/Kg	2689
Crude protein %	15
Crude fat %	3.6
Calcium %	3.0
Total Phosphate %	0.7
Methionine %	0.34
Cystine %	0.28
Methionine + Cystine %	0.62
Lysine %	0.7

[1] provides per kilogram of diet: Vitamin A, 7000 IU; Vitamin D3, 200 IU; Vitamin E, 10 IU; Vitamin K3, 0.2 mg; Thiamine, 1 mg; Riboflavin, 4 mg; Niacin, 1 mg; Pantothenic acid, 5 mg; Pyridoxine, 7.5 mg; Folic acid, 2.5 mg; Vitamin B12, 0.02 mg; Biotin, 0.04 mg; Choline, 200 mg; Ethoxyquin, 125 mg; Manganese, 80 mg; Zinc, 50 mg; Iodine, 1.2 mg; Cobalt 0.2 mg; Copper, 5 mg; Iron, 20 mg; Selenium, 0.2 mg, NaCl, 2 g.

Table 2: Body weight at first egg and body weight difference of low, medium, and heavy broiler breeder hens exposed to abrupt (ALS) and step-up (SLS) light stimulation.

Body weight characteristics	Pattern of light stimulation	Body weight group		
		Low	Medium	Heavy
Body weight at first egg (g)	ALS	3052.04± 91.76^{a}	3180.0±91.7^{a}	3208.0±91.76^{a}
	SLS	3113.3±96.7^{a}	3297.5±102.6^{a}	3202.0±91.76^{a}
Body weight differences[1](g)	ALS	1532.0±92.8^{ab}	1173.3± 97.8^{bc}	888.0± 92.8^{c}
	SLS	1682.2± 97.8^{a}	1320.0±103.7^{b}	936.0±92.8 ^{c}

^{abc} Means ± SEM with no common superscript within a variable differ significantly ($P<0.05$).
n = 20 hens per light-body weight group combination.
[1] Based on the difference between weight at 20 wk and weight at 34 wk.

Table 3: Age at first egg of low**,** median and heavy broiler breeder hens exposed to abrupt (ALS) and step-up (SLS) light stimulation.

	Pattern of light stimulation	Body weight group		
		Low	Medium	Heavy
Age at first egg (day)	ALS	186.6 ± 2.16 ^{a}	178.3 ± 2.16 ^{bc}	173.0 ± 2.16 ^{c}
	SLS	182.2 ± 2.7 ^{ab}	182.25± 2.41 ^{ab}	172.6 ± 2.16^{c}

^{abc} Means ± SEM with no common superscript within a variable differ significantly ($p<0.05$).
n = 20 hens per light-body weight group combination.

Table 4: Performance of low, medium, and heavyweight broiler breeder pullets exposed to abrupt (ALS) and step-up (SLS) light stimulation at 20 wks of age.

Performance characteristics	Pattern of light stimulation	Body weight group		
		Low	Medium	Heavy
Total egg[1] production (egg/ hen)	ALS	41.6±4.1 [c]	52.7±4.1 [abc]	57.1±4.1 [ab]
	SLS	49.0±4.3 [bc]	47.1±4.3 [bc]	62.8±4.1 [a]
Mean egg weight (g)	ALS	59.15±0.97 [a]	56.72±0.97 [ab]	55.25±0.97 [b]
	SLS	55.87±1.0 [b]	56.5±1.1 [ab]	55.95±0.97 [b]
Egg out-put (g)[2]	ALS	2447.5±187.5 [c]	2967.4±187.5[bc]	3137.32±187.5[ab]
	SLS	2733.4±197.6[bc]	2983.7±209.6[abc]	3513.3±187.5 [a]
Length of prime sequence (day)	ALS	1.7±1.89 [c]	2.1±1.89 [bc]	2.6±1.89 [ab]
	SLS	3.0±1.99 [ab]	8.0±1.99 [a]	3.3±1.89 [ab]
Average sequence length (day)	ALS	4.5±0.92 [a]	6.6±0.92 [a]	4.45±0.92 [a]
	SLS	5.1±0.97 [a]	6.5±0.97 [a]	6.26±0.92 [a]
Number of sequences (day)	ALS	10.8±1.0 [a]	8.0±1.0 [a]	11.0±1.0 [a]
	SLS	10.0±1.1 [a]	6.6±1.1 [b]	9.5±1.0 [a]

[abc] Means ± SEM with no common superscript within a variable differ significantly ($p<0.05$).
n = 20 hens per light-body weight group combination.
[1] Through 34 wks of age.
[2] Egg out-put = Egg weight × Total number of egg, through 34 wks of age.

Table 5: Effects of body weight and pattern of light stimulation (ALS and SLS) on weight of first egg, settable and non settable eggs of broiler breeder pullets.

Egg characteristics	Pattern of light stimulation	Body weight		
		Low	Medium	Heavy
Weight of first egg (g)	ALS	49.93± 2.0 [a]	44.31±2.0[ab]	47.93±2.0[ab]
	SLS	46.1±2.2[ab]	46.1±2.1[ab]	43.48±2.0 [b]
Settable egg production (eggs / hen)[1]	ALS	40.4±3.6 [b]	46.9±3.6[ab]	49.0±3.6[ab]
	SLS	44.9±3.8 [b]	43.33±3.8 [b]	56.1±3.6 [a]
Non settable egg (eggs / hen)	ALS	1.0±1.34 [c]	5.8±1.34[ab]	8.1±1.34 [a]
	SLS	4.11±1.4[bc]	3.66±1.42[bc]	6.7±1.34[ab]
Specific gravity	ALS	1.087±0.001 [a]	1.083±0.001 [b]	1.083±0.001 [b]
	SLS	1.085±0.001[ab]	1.084±0.001[ab]	1.082±0.001 [b]

[abc] Means ± SEM with no common superscript within a variable differ significantly ($p<0.05$).
n = 20 hens per light-body weight group combination.
[1] through 34 wks of age.