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Faculty of Graduated Studies

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

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Dedication

To Home I Love

Father and Mother

My Wife and Kids

Brothers and Sisters

Relatives and Friends

Acknowledgement

I would like to express my deepest appreciation to every body home helped me to achieve this work, my advisor Dr. Maen Samara for his supervision, guidance, encouragement, and support throughout the course of this study and for reviewing this theses. My appreciation is also extended to Dr. Rateb Aref and Prof. Dr. Adnan Shqueir, for their valuable critique and time in reviewing this theses. I would like to acknowledge and value the efforts of Sinokrot Poultry Farms Co. whom provided all the help and facilities for making this work successful. And I would like to, specially mention Third Uja Farm team, Eng. Alam, Eng. Basel Nazal, Mr. Rajab, Daragma, and Jawabri.

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إقــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

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

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

اقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء مـــا تمــت الإشارة إليه حيثما ورد، وان هذه الرسالة ككل، أو أي جزء منها لم يقدم من قبل لنيل أية درجة علمية أو بحث علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's name: **اسم الطالب:**

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Date: **التاريخ:**

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ABSTRACT

An experiment with broiler breeder pullet's was carried out to determine the effect of pattern of light stimulation and pullets body weight at 20 wk of age on body weight and age at onset of egg laying. Two light stimulation treatments were used: abrupt light stimulation (ALS) in which hours of light were increased to 10 hr at 21 wk, 12 hr at 5% egg production, 14 hr at 35% egg production, and finally to 16 hr at 65% egg production; and step-up light stimulation (SLS) in which hours of light were increased to 12 hr at 21 wk of age, then by half an hour weakly until 16 hrs of light are attained at 29 wk of age. 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 advancing onset of lay, and increasing weight gain at onset of lay

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INTRODUCTION

Introduction

Broiler breeder management protocols are continually being developed to assist in maximizing egg production and hence day old chick production. Almost without exception, the study of the reproductive physiology of the hen has been conducted with commercial egg-type hen (Etches,1990). It has been assumed that broiler breeder hens follow the same pattern. However there are noticeable differences in body weight, feed management, and reproductive capability between egg-type hens and broiler breeders.

Most research on broiler breeder focused on feed allocation (restriction versus *ad lib*) and hatchability. A limited amount of research has been conducted on lighting management of broiler breeder. In practical terms, most basic protocols of lighting management has been arisen from primary breeding companies and integrated broiler companies. Compared to light programs for commercial layers, lighting programs for broiler breeders have been relatively simple. Breeder flocks, grown in closed houses, have traditionally been raised on 8 or 10 hour of light, then 15 hours when moved to the production house. For egg-type hens a complicated step-up lighting program has been used to maximize light stimulation.

Several primary breeders have suggested similar programs for broiler breeders. Broiler breeders do not come into production until exposed to light duration above 13 hours (light threshold). Age and body weight must be at or above critical set points before a response to light stimulation can noticed (Lien and Yuan, 1994). It is believed (assumed) that step-up light program will allow for additional stimulation of under-weight hens within a flock that were not ready to respond when the initial jump to 13 hour was given (Hess and Lien, 1999). Therefore, broiler breeders with sub-optimal uniformity may benefit from step-up lighting programs compared to implementing abrupt light stimulation. It is not known whether light stimulation in a single- step (abrupt) makes any difference compared to a move gradual (step-up) light stimulation.

The objectives of this study were to evaluate the effect of step-up (gradual) lighting stimulation on the performance of 20 wks at age broiler breeder pullets.

LITERATURE REVIEW

Description of Egg Formation

Egg formation and the components of the hen's reproductive system have been will described (Etches, 1993). The ovary contains a hierarchy of ovarian yellow yolk follicles that serve as a source of various steroid hormones. These hormones promote the development of a wide variety of glandular, muscular, and connective tissue components within the reproductive tract. The oviduct consists of five distant segments: Infundibulum (to engulf the ovulated ovum); magnum (the albumen secreting region); isthmus (inner and outer shell membranes forming segment);uterus or shell gland (shell forming segment); and the vagina. The developing egg spends approximately 0.3 h in the infundibulum , 2.9 h in the magnum, 1.2 h in the isthmus and 21.7 h in the shell gland (Warren and Scott, 1935, Romanoff and Romanoff, 1949, Melek *et al*. 1973). Under normal day light conditions (14 L: 10 D) the first ovipositions in a sequence takes place 9-10 h after the onset of darkness (early morning) (Cunningham, 1987) followed (0.4 – 0.5 h) by ovulation of the next egg in this sequence.

Therefore, ovulation dose not occur every 24 h, consequently eggs are laid later each successive day of the sequence. The delay between the oviposition of successive eggs in a sequence is known as the lag period. The sequence is terminated when an egg is laid about 17-18 h after the onset of darkness occurs. The time interval between two successive ovipositions has been reported to range from 24 – 26 h (Warren and Scott, 1935, Melek *et al*, 1973). Hens with longer sequence have shorter resting or pause days (Gilbert, 1967), whereas birds with a shorter sequence have longer interval between eggs (Romanoff and Romanoff, 1949) due to delay in ovulation.

Photo-Periodism and Egg Production

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 the stimulus for increased gonadotrophin secretion. It is also found that after the hen is 12 wks old, extension of the photoperiod (photo-stimulation or light stimulation) from a short day to a long day will induce a 2 to 4 total rise in the plasma concentration of LH. Within a week after photo-stimulation, the secondary sexual characteristic begin to developed (Etches, 1990). Within 3-4 weeks development is completed and the onset of egg production can begin.

The physiological mechanisms controlling the perception of day length are believed to contain a circardian component that measures number of hours that have elapsed since dawn or lights on. This what makes some factors like melatonin, corticosterone and the hypothalamus involved in this circardian system. For instance when the light are on during the photo-inducible (light-sensitive) phase, neural system is stimulated to bring about an increase in the release and amplitude of gonadotrophin releasing hormone -(GnRH from hypothalamus). The response to change in the photoperiod has been implemented to establish photoperiod regimes for the laying hens (Cunningham,1987, Wilson and Cunningham, 1984). For instance, the onset of sexual maturity can be delayed by rearing the pullets (birds) under declining day lengths or short days and initiated by transfer to long days. It is known that the bird's hypothalamus contains a photo-receptor that is tuned to the red portion of the electromagnetic spectrum. Exposure of the hen to a light source during the photosensitive phase will stimulate the hypothalamus to release the GnRH which in turn transported via the portal system to the anterior pituitary. The gonadotrophs in the anterior pituitary release the FSH and LH in response to this hypothalamus stimulation, into the general circulation. The ovarian follicular tissue contain receptors for the FSH and LH and upon binding to these receptor, they trigger a series of actions during which estrogen and androgen are released from the small follicles and progesterone is released from the preovulatory large follicles. The knowledge of all these physiological changes in relation to the light cycle has led to optimize time of onset of egg production, and continuation of egg production. Together with the improved standards of nutrition, light management made the poultry farming more efficient.

Body Weight and Reproductive Performance of Broiler Breeder Hen

The negative relationship between body weight and reproductive efficiency of the broiler breeder hen is well documented (Robinson *el al*. 1993). Under commercial conditions body weight of the broiler breeder pullets is controlled by restricting feed consumption. Limiting body weight of pullets by restricting feed increases production efficiency. This allows pullets to attain sexual maturity at recommended body weight and age. As will it also allows to minimize body weight variation (more uniform) within a particular flock. Bodyweight correction is achieved through adjustment of feed requirement. Feed allocation can either be maintained or increased. Feed allowance must never be decreased during the rearing period, and with good feeders distribution, which allows all the bird to have access to feed at the same time, because birds are fed at less than *ad libitum*. A good uniformity is as important as achieving target bodyweights. One of the first indications of problems during rearing of parent stock is often an increase in variability in body weight of pullets. Another important aspect of uniform growth is good skeletal development. Onset of sexual maturity is dependent on body composition. Flocks with uniform bodyweight, but variable skeletal size will have variable body composition. Birds in such flocks will not respond similarly to changes in lighting pattern and feed allowances.

To control bodyweight all decisions, on feed allowances, should be based on pen average bodyweight in relation to target bodyweight, adequate feeding space must be provided during the rearing period.

The coefficient of variation (CV%) is a mathematical method of expressing the uniformity or evenness of a flock. The precise method of calculation is as follows:

$$CV\% = \frac{\text{Standard Deviation}}{\text{Average Weight}} \times 100$$ (Anonymous, 2001).

A second method of measuring evenness is to express it in terms of percentage of birds within the range of the average weight, plus or minus 10%. Whilst this method gives an accurate indication of the numbers of birds close to the average weight it does not, unlike the CV%, take into account the very light and heavy birds.

A uniform flock will be much easier to manage than a variable one, because the majority of the birds will be in a similar physiological state and will respond to changes in levels of feed or light when necessary.

A uniform flock will react predictably to increases in feed and will produce good results consistently. Flock uniformity can be optimized by applying high standards of management in the first 4 weeks of the pullet life.

At day old, bodyweights of the flock will follow a normal (i.e. bell shaped) distribution, with a low CV%. As the individual birds grow within a flock, their different responses to vaccination, or disease, and their differing competitiveness for feed will tend to increase the CV%. An increasing number of small birds tend to produce a skewed weight distribution. The reasons for this skewed distribution are numerous and can include: chick quality, feed distribution, feed quality, temperature, humidity, vaccination, beak trimming, and disease (Anonymous, 2007).

Flock must be sorted in 2 or 3 sub-populations of different average weight at 28 days (4 wk) of age, at which time the CV% of the flock within the range 10-14%. In most cases, grading will be undertaken when the flock CV% is around 12%. If the CV% is >12, then a 3-way grading will be required and management practices from 0-4 weeks should be examined closely, so that improved CV% can be achieved with subsequent flocks.

Grading is generally not permanently effective if carried out much before 28 days (4 wk). If undertaken later than 35 days (5 wk) the time available in which flock uniformity can be restored up to 63 days (9 wk) becomes too short. It is most important that birds are counted accurately in order that the correct quantities of feed will be allocated to birds. Stocking density per pen, and therefore feed and water space should be routinely adjusted when the moveable partitions between pens are re-positioned.

However, due to the importance of feeding space and speed and uniformity of feed distribution, a confirmatory check of these should be carried out (Anonymous, 2001). Despite all precautions taken to control body weight of the pullet before they are 20 wk of age, significant proportion of pullet tend to have either high or lower than the standard body weights. It is obvious that a flock of poor uniformity is generally more difficult to feed and manage than a uniform flock. With a high 20 wk C.V.%, the under-weight (undeveloped) birds are over fed, given a high stimulation too early and as a result, end up as broilers and hence poor performance later in the production cycle. Under commercial condition light stimulation is usually delayed by one week with such flocks. Instead of considering the delaying light stimulation, it is hypothesized that a step-up (gradual) light stimulation at normal (20 wk) age may provide an opportunity to obtain a better performance.

Effect of Light and Body Weight on Sexual Maturity and Productivity of Broiler Breeder Hens

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 that breeder pullet maturity when light stimulation, changing 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 researchers (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 clearly confirm the relationship between light stimulation and body weight of pullets at the onset of photo stimulation. There is a correlation between mature body weight and age at maturity, with heavier strains maturing later. Since most commercial strains of broiler breeder pullet are similar in mature body weight, this fact is of little practical importance. Of more practical importance, is the decision to light stimulate flocks that do not achieve normal weight – for – age or those having low uniformity at the time of light stimulation. Lien and Yuan (1994) indicated performance of pullets that were either 2.0 kg or 1.8 kg at 20 wk 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 wk, when they were 2.0 kg, and then photostimulated. Their data confirm 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 houses compared to those reared in black-out houses.

Lighting Programs for Broiler Breeder Hens

The growing period is usually regarded as being between 6 and 20 wk of age, whilst pullets are exposed to a lighting program according to type of the rearing house. Management of the lighting program in black-out buildings is usually simple because producers have control over day length. It is 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 wk of age. With open-sided buildings management of the lighting program is complicated because of the seasonal increases or decreases in day length throughout the growing period. Therefore, it is necessary to decide upon a pattern of natural day length and then supplement this with periods of artificial light when needed. As mentioned earlier, it is ideal to give an initial significant increase in day length in order to initiate and synchronize sexual maturity of the pullet. The initial light stimulation can be quite large at +3 or 4 hour for birds which are grown in dark-out houses, these birds will have 14 – 15 hour of light in the breeder house. However, the day length at maturity is dictated by the season of the year for birds grown in open-sided houses. For pullet grown under naturally increasing day length they are exposed to a relatively long day length during rearing to counteract the natural increase in day length. This means that there is less scope for a large increase in day length needed to induce maturity. Therefore an hour increase is often adequate to stimulate maturity. To sustain maturation process there is a need for subsequent weekly or bi-weekly increase in hours of lighting following the initial light stimulation. Eventually, these birds will be provided with 16 – 17 hour light in the breeder house. For a given flock, light stimulation is initiated regardless of body weight of the pullets. It is mentioned earlier that pullet must always be at least 20 wk of age before light stimulation and must also be 2.1 kg in body weight. A limited amount of research has been conducted in the effect of early light stimulation on development and reproduction over-weight and under weight pullets.

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 pullets to a level comparable to that of standard weight pullet 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.

Ciacciariello and Gous (2005) concluded that broiler breeder do not require a lighting stimulus in order to initiate ovarian activity and that, where no lighting stimulus is given, body weight or feeding level plays a critical role in stimulating the birds to attain sexual maturity. These authors reported that when lighting stimulation is given, factors such as body weight and body composition become relatively less important in regulating the age at sexual maturity. 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 and subsequent performance. Age at first egg, egg weight, egg production, egg output, and body weight, were among the performance parameters evaluated. Size and timing of photostimulation did affect these parameters to variable degree. Generally, early stimulation resulted in advanced age at first egg. Egg weight and egg output were greater following an early or late stimulation rather than a mid-term photostimulation.

In a similar study but with Cobb broiler breeder pullets, Lewis and Gous (2006) observed that broiler breeder on 8 – h day-lengths do not need more than a 14 – h photoperiod in the laying period to optimize sexual development or egg production. These authors used Cobb broiler breeder pullets, that were grown to achieve 2.19 kg (normal growth) or 2.41 kg (faster growth) body weight at 20 wk.

It is obvious that a broiler breeder hen respond to light stimulation based on age, body weight and light duration. Its also obvious that too early light stimulation without considering weight and age will be detrimental to early egg size and percentage of egg production. However the relationship between age and weight at sexual maturity relative to pattern of lighting increase (abrupt vs step-up) and relative egg production efficiency of broiler breeder warrants further investigation.

MATERIALS AND METHODS

Birds and Their Management

This study was conducted with 60 Hybro-PG+ broiler breeder pullets, from Uja _ Jericho farm, of Sinokrot Poultry Farms Company. Birds for the study, were selected from a flock of 34-thousand birds that had been reared up to 20 wk of age under uniform condition of lighting, feeding, and management. Prior to 20 wk of age, these birds were vaccinated against Marek's, Salmonella, New castle, Gumboro, Infectious bronchitis, Laryngo tracheitis, Turkey Rhino Tracheitis (TRT), Fowl pox, Reo virus, Avian Encephalomyelitis, Avian Influenza (H9N1), and Coccidiosis. These pullets were also given the same daily allowances of starter, grower and developer rations and were exposed to 8 hr of light and 16 hr of darkness (8L:16D). At 21 wk of age, pullets (60 birds) were moved to individually laying cages (40 × 40 × 30 cm) in two experimental rooms that were partitioned as to allow install 30 cages in each room. 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 arranged and consist of 2 light-stimulation patterns and three groups of pullets exhibiting body weights lower, equal or above the standard for lighting at the recommended age (20wk). Hens were randomly assigned to each treatment. Within treatment, 10 hens (pullets) were randomly assigned to each of two replicate groups. From 20 to 24 wk of age pullets were fed a pre-laying diet, and a layer diet (table 1) thereafter.

Table (1): Nutrient composition of feed[1] according to production stage

Nutrient	Pre- laying feed	Layer feed
Moisture	13%	13%
Protein	15%	15%
Energy	2700 Kcal/Kg (ME)	2700 Kcal/Kg (ME)
Fat	4%	3%
Fiber	4%	4%
Ca ++	3.2%	3.2%
P	0.7%	0.6%
NaCl	0.25%	0.25%
Mn	110 ppm	110 ppm

Feed allotments were similar to that recommended by primary breeders management guide (table 2). Daily allotments were weighed (using an electronic balance)[2] in advance and presented to the pullets at 6:0 am.

Body Weight Treatments

Body weight groups were: group 1, pullets exhibiting low body (1800 ± 20g) than the standard body weight; group 2, pullets exhibiting medium body weights (2200 ± 20 g) to the standard (recommended) body weight; group 3, pullets exhibiting heavy body weights (2600 ± 20g) than the standard body weight for light stimulation at the recommended age (20wk).

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[1] Commercial ration for broiler breeders.
[2] Agrologic – chick scale 102 _2005

Table (2): Feed consumption per hen according to age

Age in week	Feed (gram) / hen
21	110
22	115
23	115
24	120
25	137
26	150
27	160
28	165
29	165
30	165
31	165
32	167
33	167
34	166

Light (Photostimulation) Treatments

Under commercial conditions broiler breeders pullets are raised at 8 hrs of light, and abruptly (with one jump) transferred to 15 or 16 hrs of light at housing (20 wks of age). On the other hand, egg-laying pullets are exposed to step-up lighting stimulation at housing. Therefore, 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 light 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. (Tables 3 and 4) show the patterns of light stimulation programs that were performed on both treatments.

Table (3): Abrupt lighting stimulation (ALS)

Age or percent of production	Light hour	Light intensity
Before age of 21 week	8	5 lux
At age 21 week (threshold)	10	> 60 lux
5%	12	> 60 lux
35%	14	> 60 lux
65%	16	> 60 lux

Table (4): Step-up lighting stimulation (SLS)

Age in week	Light in hour	Light intensity
21	12	> 60 lux
22	12.5	> 60 lux
23	13	> 60 lux
24	13.5	> 60 lux
25	14	> 60 lux
26	14.5	> 60 lux
27	15	> 60 lux
28	15.5	> 60 lux
29	16	> 60 lux
Until the end	16	> 60 lux

Performance Variables

Egg production was recorded daily to 34 wks of age. Eggs were collected 4 times a day. Egg weight, and egg 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. These eggs were marked with the hen number. Egg weight was recorded at the end of the day. An egg scale (Egg scale model: Pk – 11 – 500, cap = 500g, d = 0.1 S/N 800 964136) was used for egg weighing. 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 wk) of the experiment, and body weight change was determined. Body weight change was measured by the difference between initial and final individual weight. Individual body weight was also recorded at the time when 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 sequences, total number of eggs, egg out-put and the production of settable eggs (egg weight >50 g) were calculated on a per hen basis throughout the experimental period.

Statistical Analysis

Data for egg production, egg weight, egg out-put, specific gravity, age at first egg, body weight change, length of the prime sequence, mean sequence length, number of sequences, and number of settable and non-settable eggs were subjected to the analysis of variance (ANOVA) using the General Linear Models Procedure of Statistical Analysis System (SAS)(SAS Institute,2000). The main effects were pattern of light stimulation and body weight group. All data were analyzed for main effects and their interactions. Difference between means were tested by the least square difference method at a statistical significance level of $P < 0.05$.

The effects of light stimulation (LS) and body weight group (BWG) on production variables of broiler breeder pullets were evaluated. All combination of 2 LS (ALS = commercial or conventional, SLS = proposed) and 3 BWG levels were randomly assigned to 10 cages each, resulting in

60 values for each production variable. The model for CRD with a factorial arrangement is:

$$Yijk= u + LSi + BWGj + LS*BWGij + eijk$$

Where LSi is the main effect of the pattern of light stimulation, BWGj is the main effect of the body weight group, LS*BWGij is the interaction and eijk is the error term.

RESULTS

Body weight characteristic

Body weight at first egg and body weight difference for low, medium, and heavy broiler breeder pullets exposed to abrupt (ALS) and step-up (SLS) light stimulation are shown in (Table 5). All the pullets attained almost similar body weight at the time the first egg is laid regardless of the pattern of light stimulation. But there is a trend that pullets exposed SLS had more weight gain compared to their counter pullets. Body weight change (from 20 to 34 wks) was similar (888 and 936 gm) for the heavier pullets regardless 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 gm) regardless of the light stimulation pattern.

Age at First Egg

Age at first egg was affected by body weight at 20 wks but not by the pattern of light stimulation (Table 6). Age at first egg was earlier for the heavy weight pullets than for low weight pullets while age at first egg for medium weight pullets was intermediate. The first eggs were laid at 182.2 day of age by low weight pullets exposed to SLS and at 186.6 day of age by low weight exposed to ALS. It is obvious that SLS had beneficial effects on under weight pullets compared to ALS.

Table (5): Body weight 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 ($p\leq0.05$). n = 20 hens per light-body weight group combination.
[1]Based on difference body weight at 20 wks and body weight at 34 wks.

Table (6): Age at first egg of low, medium 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 ($p\leq0.05$). n = 20 hens per light-body weight group combination

Production Performance

Effects of light stimulation pattern and body weight on egg production, mean egg weight, egg out put, and sequence length are summarized in (Table 7). Production of heavy weight pullets was greater than that of medium or low pullets regardless of the light treatments. Except for medium weight pullets at SLS light, 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 lengths, average sequence length of all treatments differed only slightly throughout the experiment. However, length of the prime sequences was greater for pullets of SLS.

Egg Characteristics

Effects of exposing low, medium, and heavy broiler breeder pullets to ALS and SLS light stimulation on weight of first egg, settable and non settable egg production, and egg specific gravity, are shown in (Table 8). There were significant differences in weight of first egg between low weight hens exposed to ALS and heavy weight pullets exposed to SLS. In general pullets exposed ALS produced heavier egg compared to

Table (7): Performance of low, medium, and heavy weight broiler breeder pullets exposed to Abrupt (ALS) and step-up (SLS) light stimulation at 21 wks of age

Performance characteristics	Pattern of light stimulation	Body weight		
		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.

pullets exposed to SLS. It is clear that the heavy pullets which were exposed to SLS, gave the highest number of settable eggs. Heavy pullets in ALS, gave more settable eggs than other pullets in the same treatment. Under weight pullets in ALS had the lowest number of non settable eggs compared to other in the same treatment. Eggs of these pullets significantly had the lowest specific gravity compared to others in the same treatment. There is no significant differences among pullets of different weight groups in the SLS treatment.

Performance of Experimental Versus Standard Pullets

Body weight change, weekly egg production of the experimental pullets were compared to those recommended in the management guide (figures 1 – 8). It is clear from these figures that SLS treatment had positive influence on low and heavy weight pullets compared to medium weight pullets; but SLS had negative effects on medium weight pullets. It may be noticed that heavy pullets exposed to SLS were more persistent at peak egg production than pullets in ALS.

Its worthy to notice that low weight pullets at 20 wk gained more weight and they were similar to that of the heavy pullets when they reached 34 wk of age. Medium weight pullets maintained similar body gain to that of the standard.

Table (8): Effects of body weight and pattern of light stimulation (ALS and SLS) on egg characteristics 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 ($p \leq 0.05$). n = 20 hens per light-body weight group combination.
[1] Based on number of settable egg through 34 wk of age.

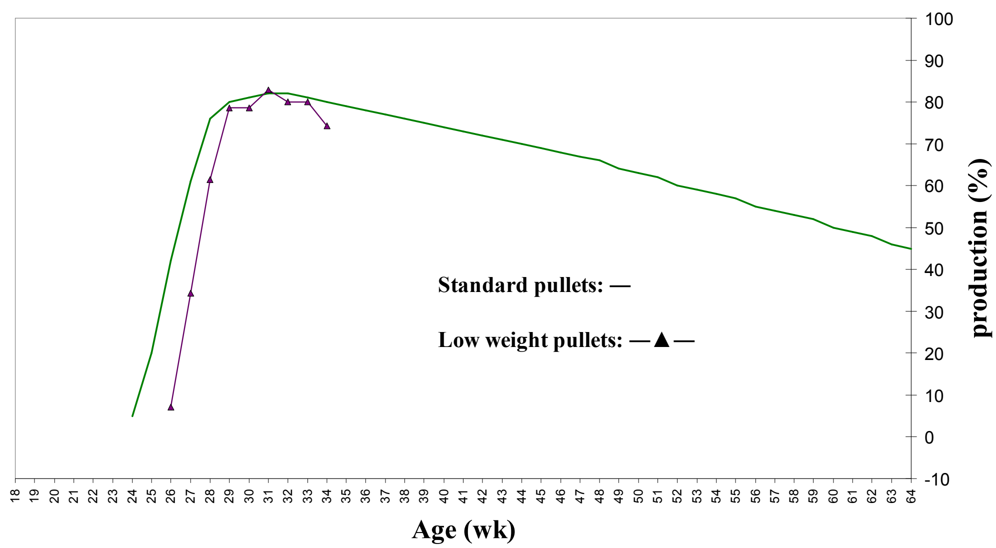

Figure (1): Performance of low weight pullets exposed to (ALS) at 21 wk of age compared to standards pullets as described by the management guide.

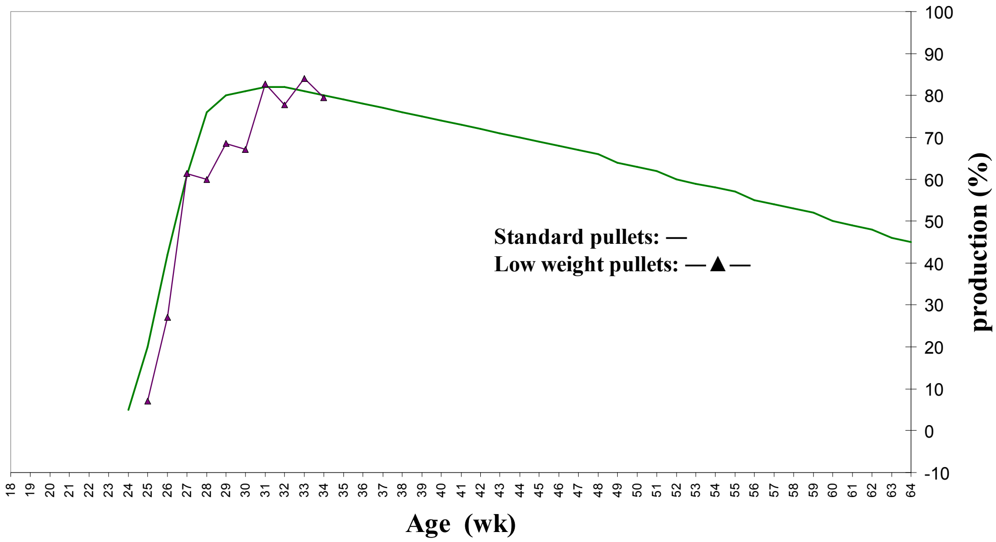

Figure (2): Performance of low weight pullets exposed to (SLS) at 21 wk of age compared to standard pullets described by the management guide.

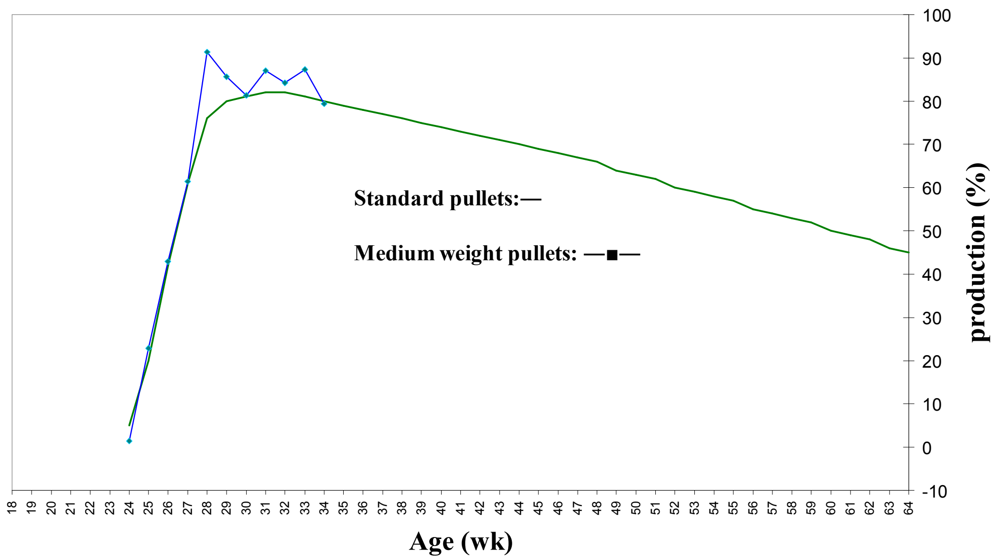

Figure (3): Performance of medium weight pullets exposed to (ALS) at 21 wk of age compared to standards pullets described by the management guide.

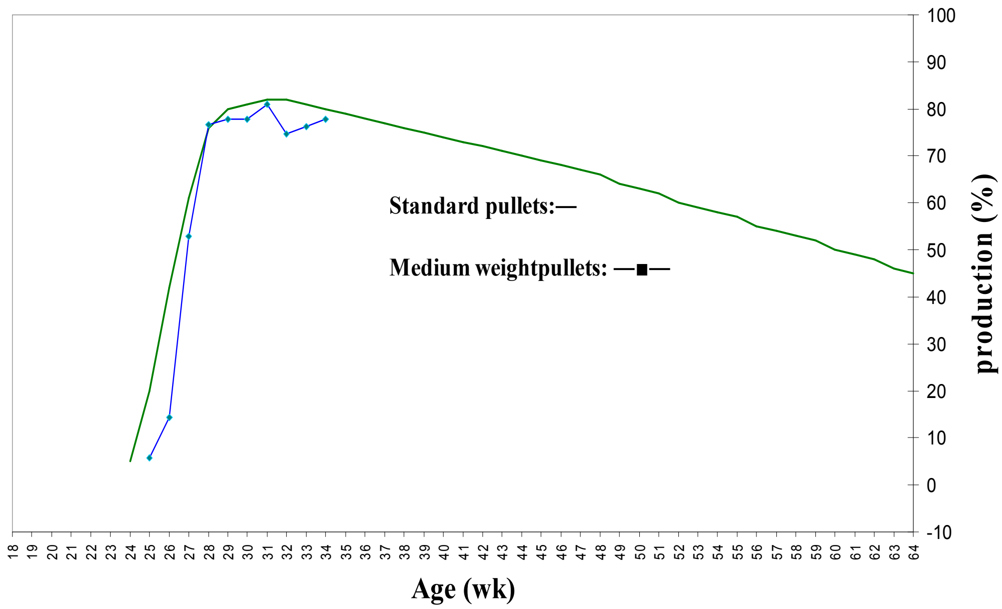

Figure (4): Performance of medium weight pullets exposed to (SLS) at 21 wk of age compared to standards described by the management guide.

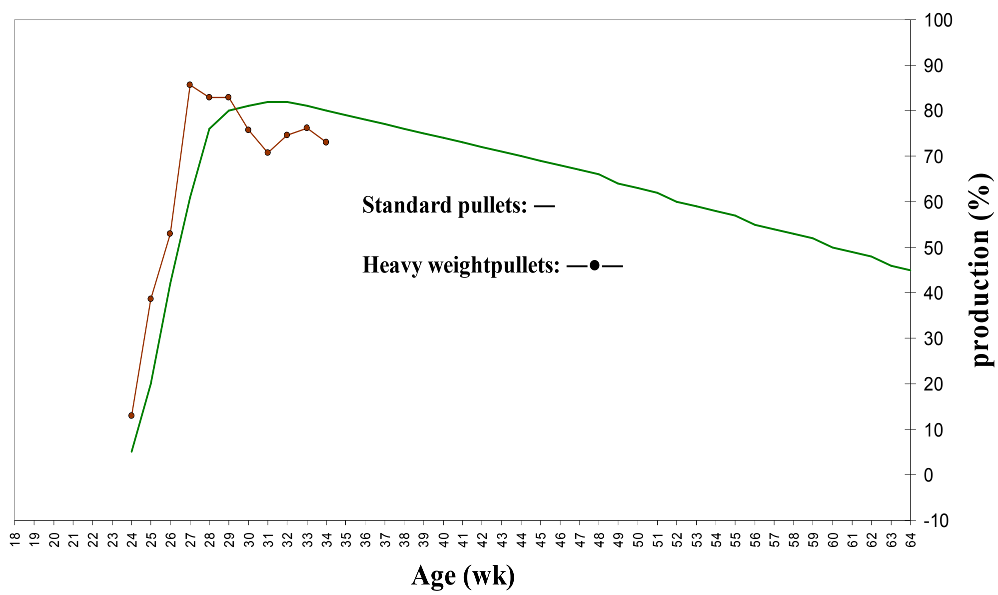

Figure (5): Performance of heavy pullets exposed to (ALS) at 21 wk of age compared to standards described by the management guide .

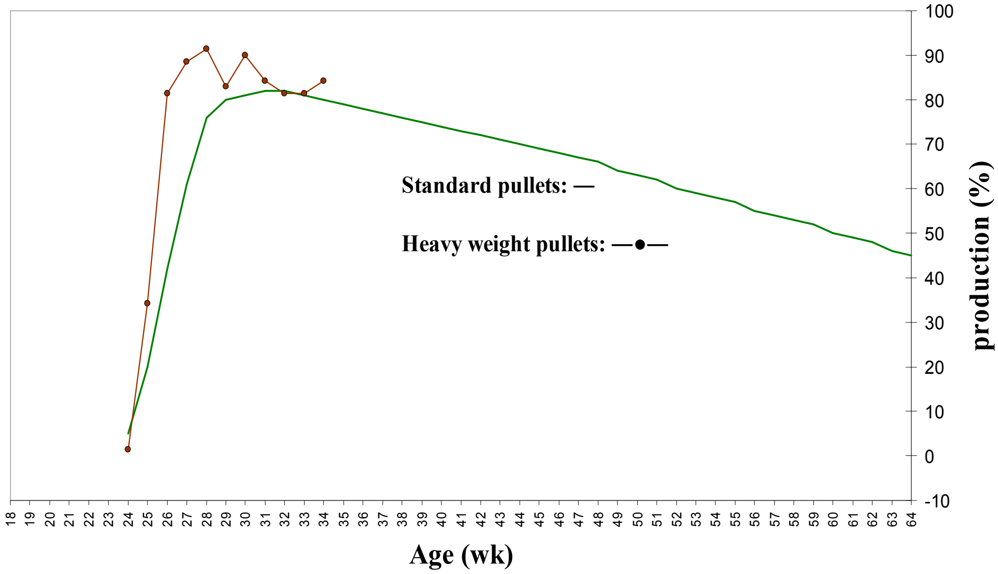

Figure (6): Performance of heavy pullets exposed to (SLS) at 21 wk of age compared to standards pullets described by the management guide.

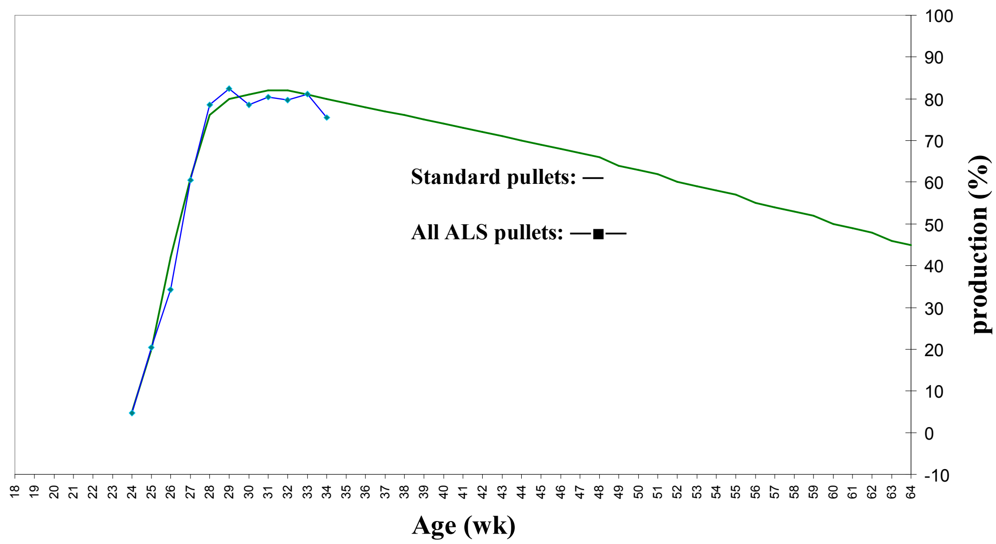

Figure (7): Performance of all pullets exposed to (ALS) at 21 wk of age compared to standards pullets described by the management guide.

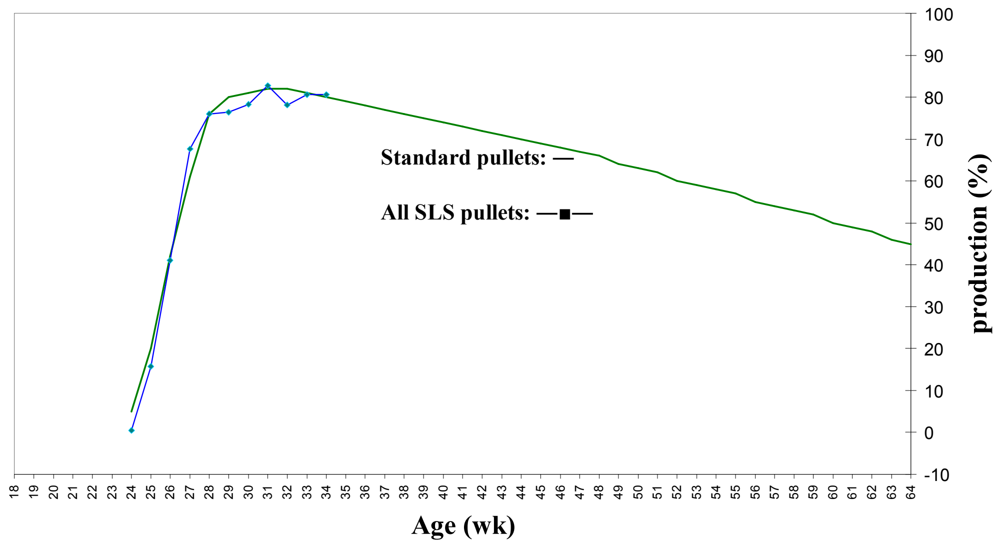

Figure (8): Performance of all pullets exposed to (SLS) at 21 wk of age compared to standards pullets described by the management guide.

DISCUSSION

Discussion

Data on the pattern of light stimulation which can be used to initiate pullet sexual maturity are scanty. It is not known whether an abrupt (fast) light stimulation makes any difference compared to a more gradual (step-up) light stimulation.

Body Weight Characteristic and Age at First Egg

It is unclear whether some hens lay fewer eggs because they are overweight, or alternatively, whether some hens do not become overweight because they are laying well (Robinson *et al*. 1993). It should be noted that in the present study, body weight of low-weight pullets (at 20 wks of age) increased within each pattern of light stimulation in a manner that they were similar to the heavy pullets at sexual maturity. The differences among body weight groups decreased at the onset of egg production (between 3.05 – 3.29 kg) (Table 5). These results seem to concur those found by Abbaker and Robbins (1994), in which pullets reared under short day schedule began to lay when they reached 2.99 kg in body weight. Lewis and Gous (2006) reported that body weight at first egg decreased by 20 g for each 1-d advance in age at first egg for pullets of varying body weights. In our study the heavy pullets had the lowest body weight gain, and low weight pullets had the highest body weight gain at sexual maturity. The results of the present study are in agreement with those reported by Lien and Yuan (1994) who found that weight differences among pullets decreased as egg laying proceeded. At 45 wk, this pullets had similar body weight.

There is a trend that pullets exposed to SLS had more weight gain compared to their counter parts, indicating an improvement in feed efficiency. 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 that when light stimulations is delayed (Table 6). Different studies were conducted to determine age at first egg when pullets were reared under short days. Abbaker and Robbins (1994) and Renden and Oates (1989) found that pullets reared under short day schedule began laying at 173 d with 2.99 kg body weight. Age at first egg of low weight pullets in ALS treatment was significantly delayed by more than 8 days compared to those of medium and heavy weight ones. These results were in agreement with those reported by (Lien and Yuan. 1994) who studied the effect of low body weight and delayed lighting on reproductive performance and feed efficiency of broiler breeder hens from onset of lay to 45 wk of age. These researchers concluded that age at first egg, at 20%, and at 50% hen day egg production (HDP) of low weight pullet were delayed (by six days) compared to that of standard weight pullets lit at 20 wk of age. Our results indicated that low weight pullets laid their first egg as early as pullets of medium weight. In the present study, for each 400 g body weight below standard weight delayed the onset of production by 8.3 d. This means that for each 48 g decrease in body weight production will be delayed by one day. Data from other studies indicated that 43 g (Lien and Yuan, 1994), 48 g (Blair *et al*., 1976), and 73 g (Triyuwanta *et al*., 1992) decrease in body weight will delay the initiation of production for one-day increment. Therefore, it is obvious from the results of our study that SLS had a positive effect on the initiation of egg production by low weight pullets. On the other hand, heavy pullets advanced production significantly compared to standard pullets by 5.3 d in ALS and 9.6 d in SLS. These results are in agreement with those reported by Lewis and Gous, (2006). These authors reported that heavy weight pullets (10 % more than the standard) reached sexual maturity and produced extra egg 4 – d earlier than standard weight pullets. From the present study, we conclude that there is correlation between body weight at 20 wk old and age at first egg, these finding are in agreement with those of Ciacciariello *et al*. (2005) who reported a negative relationship between the pullets weight at 20 wk of age and their sexual maturity. It is clear that SLS may advance sexual maturity of low weight pullet. The current results pointed out the relationship between body weight and age at first egg. The pullets which begin to lay early convert larger amount of feed to production, while diverting less nutrients to growth as explained by (Robinson *et al*. 1990). Therefore, differences among weight groups generally diminished as the pullets approaching 34 wk of age.

Production Performance

Pullets reared under short day produced significantly more eggs (110) through 45 wk compared to those reared under long days (Abbaker and Robbins 1994). In our study, production of heavy weight pullets was greater than that of medium or low weight pullets regardless of the light treatment (table 7). These results support previous observations (Yuan *et al*. 1994), who found that heavy pullets began to lay earlier than medium and low weight at 20 wk age. Similar results were reported by Ciacciariello *et al* (2005). Heavy and medium weight pullets had significantly higher peak rate of lay than those of low weight ones . Heavy pullets coming early in egg production, is due to earlier age at first egg (maturity). Lewis and Gous (2006), reported that egg numbers to 39 wk, though positively linked to photoperiod between 8 and 14 h, were probably a function of the age at first egg induced by these photoperiods, increasing by 0.75 eggs for each 1-d advance in maturity. Primary broiler breeder companies do not prefer to increase body weight more than target weight, because it has a negative effect on postpeak production. This is due to the shortage of nutrients that needed to meet larger body requirements for growth and production. Previous studies reported that the heavy pullets cumulative production did not increase, and their total production did not increase either, because peak and postpeak production levels were 70% of the production of the medium and low weight pullets. Yuan *et al*. (1994) and Ciacciariello *et al* (2005) argued that feed allotment provided during egg production may not be sufficient to support greater production level of the heavy pullets. These pullets fail to meet their nutrient requirements for maintenance and growth. On the other hand, low weight pullets produced less number of eggs (to 56 wk) as reported by Ciacciariello *et al.* (2005). Lien and Yuan (1994) confirmed that pre-peak egg production by the low weight pullets was less than that of the standard pullets. These findings were due to the delay in the initiation of production in low weight pullets, but total egg or final production of low weight pullets was not effected compared to standard weight pullets, when lighting stimulation advanced by a 2 wk in attempt to reach target body weight. Similarly, SLS in the present study resulted in an increase in total egg production of low and heavy pullets. As well SLS had less effect on medium size pullets. It is obvious that SLS exerted similar effects to delaying light stimulation of under weight pullets. But, compared to delaying light stimulation, SLS allowed heavy and medium weight pullets to commence production without delay and allow light pullets to gain more weight before egg laying.

Mean egg weight often does not reflect subtle differences in the weights of eggs produced by broiler breeders of various body weights and ages at lighting. In addition, minimizing the production of small eggs by breeders is particularly desirable (Lien and Yuan, 1994). In the present study heavy pullets produced smaller egg compared to pullets in the other treatments. These results agree with those reported by Yuan *et al*. (1994), but contradict with those of Lewis and Gous, (2006). The later authors reported that accelerating growth to 20 wk did not significantly affect egg weight. Our results indicated that, low weight pullets exposed to ALS produced the heaviest eggs. Similarly, Ciacciariello et al. (2005) reported that mean egg weight of low weight pullets was significantly lower than those of medium and heavy weight pullets. These data are consistent with those of Blair *et al*., (1976) and Triyuwanta *et al*., (1992)who documented that low body weight at lighting caused a decrease in mean egg weight. However, these data are in disagreement with those of Fattori *et al*., (1991) and McDaniel, (1983) who observed no effect on mean weight of eggs produced by low weight pullets lit at 20 wk.

Lewis *et al*., (1997) reported, in an experiment conducted with two types of laying hens ISA brown and shaver 288, that mean egg weight increased linearly with age at first egg at a rate of 1.26 g per 10 d delay in maturity, and increased linearly with body weight at first egg by 1.24 g per 100 g increase in body weight. The current data, indicates that there was a positive relationship between mean egg weight and age at first egg. The heaviest eggs were associated with the latest age at first egg, and the lightest eggs were associated with earliest age at first egg. Although affected to a variable degrees, 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 some previous reports (Wilson *et al*, 1983; Yuan *et al,* 1994).

Pullets exposed to SLS had the highest egg mass compared to their counter-part exposed to ALS. On the other hand, the heavy pullets exposed to ALS laid more egg out-put compared to low and medium weight pullets exposed to ALS. These results agree with the finding of (Lewis and Gous, 2006) who suggested that accelerating growth to 20 wk resulted in a significant 150 g increase in egg output. Lewis *et al*. (1997) reported that age of ISA Brown and Shaver laying hens had a curvelinear relationship with egg out-put. They also concluded that egg out-put of ISA Brown increased by about 200g per 1 h of photoperiod. It clear from the results of the present study that egg out-put is influenced by age at first egg, body weight at 20 wk age, and pattern of light stimulation. Therefore, evaluating the results on egg out-put of the pullets in the present study will lead to similar conclusion as those of egg rate and egg weight.

Prime sequence lengths, average sequence length of all treatments differed only slightly throughout the experiment, all body weight group have significantly the same sequence length and number of sequence regardless of light stimulation program except less sequence number of medium weight in SLS treatment. These data are in agreement with results reported by Robinson *et al.*, (1991), that full-fed and restricted hens lay eggs in a similar number of sequences. In agreement with our data, Robinson *et al*., (1993) reported that, superior hens (upper 50% and upper 25%) laid very long prime sequences compared with the inferior hens and had a low incidence of inter sequence pauses of longer than one day. Ovulation in broiler breeder is more difficult to assess due to irregularities in follicle recruitment and an increased likelihood of erratic ovulations (Yu *et al*., 1992).

Egg Characteristics

There was a significant difference in weight of first egg between under weight pullets exposed to ALS compared to heavy pullets exposed to SLS (Table 8). In general, ALS pullets produced heavier eggs compared to pullets exposed to SLS. Ciacciariello *et al*. (2005) reported that the delay in sexual maturity of low weight pullets would likely to result in a higher initial egg weight, although no significant interaction was found in initial egg weight between body weight at 20 weeks and lighting treatment. These results concur with those of Lewis *et al*. (1997), in which two strains of egg-type hens were used. It is clear that the heavy pullets which were exposed to SLS, gave the highest number of settable eggs (Table 8). Yuan *et al*. (1994) reported that early settable egg production (> 50 g per egg) decreases as body weight increase. However, a significantly higher incidence of double-yolked eggs for heavy birds resulted in all groups producing similar numbers of settable eggs. Ciacciariello *et al*. (2005). Heavy pullets in ALS, gave more settable eggs than other pullets in the same treatment. Under weight pullets in ALS had the lowest number of non settable eggs compared to others in the same treatment. Under weight pullets in ALS had the lowest number of non settable eggs compared to others in the same treatment. It is note worthy to point out that these pullets produced the least amount of eggs. Lein and Yuan (1994) reported that total settable egg production of low weight pullets was less than those of medium weight. they explained their observation by the finding that these pullets produced fewer eggs. Therefore, we conclude that settable and unstable egg production are dependents on several factors: the total egg production, age at first egg and body weight at 20 wk of age. As production increases, the number of settable egg increased. Similarly, when weight of first egg is high, the subsequent eggs will be heavier and thus more settable eggs are produced.

Eggs of pullets which exposed to ALS had the lowest specific gravity compared to others pullets in the same treatment. There is no significant differences among pullets of different weight groups in the SLS treatment. Eggs of low weight pullets significantly had the highest specific gravity compared to others in the same treatment. These differences can be attributed to the findings that similar eggs may have lightest specific gravity compared to larger eggs, since the pullets were kept in controlled environment.

Performance of Experimental Versus Standard Pullets

Body weight change, weekly egg production of the experimental pullets were compared to performance recommended by the management guide (Anonymous, 2007) productions figures (1 – 8). It is clear from these figure that SLS treatment had positively influenced low as well as heavy pullets compared to medium weight pullets. But SLS had negative effects on medium weight pullets. Heavy pullets exposed to SLS were more persistent on peak production than heavier pullets exposed to ALS. Body weight of low and heavy pullets was similar to that of standard pullets at the end of 34 wk. Body of medium weight pullets was similar to that of standard pullets throughout the experiment.

Our results indicate that poorly uniform flock may be divided in to weight categories prior to light stimulation or may be exposed to SLS rather than ALS in order to avoid the negative effects of either low or light body weight on production.

In conclusion, in poorly uniform broiler breeder flocks, low weight pullets can be exposed to step-up light stimulation to increase weight at sexual maturity, advance age at first egg, and to maximize number of total and settable egg production. Performance of heavy weight pullets exposed to step-up light stimulation were not negatively influenced. Step-up light stimulation caused these pullets to attain better body weight and produce more eggs and hence more settable eggs. Abrupt light stimulation can only be used when a broiler breeder flock has achieved high level of uniformities since step- up light stimulation seemed to negatively influence egg production of medium sized pullets.

Recommendations

1. Birds that were exposed to ALS came into lay earlier and had a higher peak egg production than pullets exposed to SLS. However, the latter group had a better egg production at the end of the experiment. A similar trend may persist for the rest of the production cycle.

2. Also heavy pullets came into production early which resulted in production of smaller eggs than pullets exposed to SLS at the same weight.

3. It is recommended that step-up lighting program will allow for additional stimulation of under weight pullets.

4. It is also recommended also that step-up lighting program will allow the underweight pullets to gain more weight by the time maturity is attained.

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APPENDICES

Appendix A: All Experimental Data.

The SAS System

Obs	birdno	littr	wtgrop	bw1	ag1steg	bwt1steg	wt1steg	totleg	setleg	nonsetegg	avgegwt	spgr	primseq	avgseq	noseq	bwf	hatch	bwdif	egoutpt
1	01	1	l	1780	192	3200	52.0	36	34	2	57.0	1.085	1	2.8	12	3460	97.1	1680	2052.0
2	02	1	l	1820	182	2720	47.6	43	41	2	60.2	1.082	2	3.1	13	3120	87.8	1300	2588.6
3	03	1	l	1800	196	3300	52.9	32	32	0	62.7	1.090	1	2.6	11	3240	96.9	1440	2006.4
4	04	1	l	1820	184	3220	52.1	46	45	1	58.6	1.085	3	4.8	9	3360	88.9	1540	2695.6
5	05	1	l	1800	178	2860	45.1	53	52	1	58.8	1.086	3	5.8	9	3400	92.3	1600	3116.4
6	06	1	l	1820	181	2580	50.6	42	40	2	57.3	1.087	1	2.9	13	3260	87.5	1440	2406.6
7	07	1	l	1800	184	3260	51.4	48	48	0	59.3	1.085	2	7.8	6	3520	75.0	1720	2846.4
8	08	1	l	1800	193	3320	53.0	42	42	0	58.2	1.087	1	10.5	4	3140	69.0	1340	2444.4
9	09	1	l	1820	191	3300	51.5	30	30	0	66.8	1.091	1	1.8	17	3660	90.0	1840	2004.0
10	10	1	l	1780	185	2760	43.1	44	40	2	52.6	1.090	2	2.9	14	3200	72.5	1420	2314.4
11	11	1	m	2200	169	2920	45.8	63	61	2	56.8	1.092	2	6.4	10	3200	98.4	1000	3578.4
12	12	1	m	2200	176	3060	47.5	39	37	2	57.9	1.080	1	2.9	13	.	75.7	.	2258.1
13	13	1	m	2180	192	3600	51.0	39	36	3	61.9	1.084	2	3.7	9	3560	94.4	1380	2414.1
14	14	1	m	2200	183	3380	38.5	49	45	4	54.6	1.087	2	4.2	10	3420	68.9	1220	2675.4
15	15	1	m	2180	172	2860	38.3	70	62	8	52.6	1.088	1	12.2	5	3220	95.2	1040	3682.0
16	16	1	m	2220	178	3020	52.0	41	40	1	61.1	1.081	1	3.7	11	3540	95.0	1320	2505.1
17	17	1	m	2180	181	3200	43.3	54	49	5	56.1	1.083	1	5.4	9	3580	87.8	1400	3029.4
18	18	1	m	2220	174	3180	43.0	67	62	5	57.9	1.081	5	15.7	4	3160	95.2	940	3879.3
19	19	1	m	2180	190	3680	47.0	47	42	5	57.2	1.078	3	6.0	7	3660	95.2	1480	2688.4
20	20	1	m	2220	168	2900	36.7	58	35	23	51.1	1.080	3	5.8	10	3000	100.0	780	2963.8
21	21	1	h	2600	177	3020	52.9	37	31	6	56.2	1.077	1	2.8	11	4100	90.3	1500	2079.4
22	22	1	h	2600	182	3000	49.0	51	49	2	53.4	1.081	1	5.4	9	3200	93.9	600	2723.4
23	23	1	h	2620	167	3220	42.0	65	56	9	56.5	1.081	5	3.6	15	3640	94.5	1020	3672.5
24	24	1	h	2580	168	3280	31.0	73	56	17	53.0	1.085	1	3.9	14	4020	73.3	1440	3869.0
25	25	1	h	2620	182	3440	49.2	26	22	4	56.7	1.081	2	3.1	7	3580	18.2	960	1474.2

The SAS System

Obs	birdno	littrt	wtgrop	bw1	ag1steg	bwt1steg	wt1steg	totleeg	setteg	nonseteg	avgegwt	spgr	primseq	avgseq	noseq	bwf	hatch	bwdif	eggoutpt
26	26	1	h	2580	177	3320	46.1	56	50	6	53.4	1.087	1	4.5	11	3420	76.0	840	2990.4
27	27	1	h	2600	164	3200	39.0	85	66	19	54.4	1.080	1	7.8	8	3200	95.5	600	4624.0
28	28	1	h	2580	166	3080	49.0	70	59	11	56.8	1.085	12	4.2	11	3580	98.3	1000	3976.0
29	29	1	h	2600	171	3320	46.1	65	60	5	52.0	1.087	1	6.8	8	3000	95.0	400	3380.0
30	30	1	h	2600	176	3200	75.0	43	41	2	60.1	1.083	1	2.4	16	3120	70.7	520	2584.3
31	31	2	l	1800	182	3040	39.9	37	30	7	52.7	1.086	11	2.4	15	3420	86.7	1620	1949.9
32	32	2	l	1800	175	3460	49.0	60	60	0	57.1	1.089	2	11.8	5	3340	93.3	1540	3426.0
33	33	2	l	1780	201	3300	55.1	33	33	0	54.3	1.086	1	5.3	6	3660	100.0	1880	1791.9
34	34	2	l	1800	175	2900	42.0	62	56	6	55.8	1.090	2	6.2	9	3620	87.5	1820	3459.6
35	35	2	l	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	36	2	l	1820	183	3300	45.8	50	43	7	54.5	1.082	3	3.4	12	3920	88.4	2100	2725.0
37	37	2	l	1800	172	2680	42.2	59	55	4	54.7	1.088	1	3.8	10	3040	76.6	1240	3227.3
38	38	2	l	1800	189	3400	47.0	35	29	6	62.5	1.079	4	2.0	14	4040	65.5	2240	2187.5
39	39	2	l	1820	180	2900	48.0	50	49	1	56.5	1.087	2	3.5	12	3080	89.8	1260	2825.0
40	40	2	l	1820	183	3040	45.8	55	49	6	54.7	1.078	1	7.0	7	3260	93.9	1440	3008.5
41	41	2	m	2220	170	2920	39.0	64	58	6	54.8	1.086	1	7.0	8	3240	69.0	1020	3507.2
42	42	2	m	2200	182	3200	47.0	57	52	5	60.0	1.082	42	13.2	4	3520	90.4	1320	3420.0
43	43	2	m	2180	187	3300	44.7	44	43	1	57.5	1.089	1	4.8	8	3540	90.7	1360	2530.0
44	44	2	m	2180	186	3980	52.8	50	47	3	58.3	1.083	3	7.8	6	3940	100.0	1760	2915.0
45	45	2	m	2200	185	3220	54.5	49	48	1	61.5	1.084	2	7.0	7	3440	81.3	1240	3013.5
46	46	2	m	2220	192	3440	45.5	44	40	4	51.8	1.083	6	5.7	7	3560	87.5	1340	2279.2
47	47	2	m	2200	.	.	.	1	0	0	.	.	1	1.0	1	.	48.0	.	.
48	49	2	m	2220	182	3280	43.9	51	49	2	54.9	1.086	15	7.0	7	3920	87.8	1700	2799.9
49	50	2	m	2200	174	3040	41.0	64	53	11	53.2	1.079	1	4.8	11	3020	88.7	820	3404.8
50	51	2	h	2600	173	2180	47.5	62	56	6	55.6	1.083	1	6.8	8	3300	94.6	700	3447.2
51	52	2	h	2600	168	3020	42.2	70	62	8	56.0	1.082	3	6.4	9	3300	91.9	700	3920.0

The SAS System

Obs	birdno	littrt	wtgrop	bw1	ag1steg	bwt1steg	wt1steg	totleg	setegg	nonseteg	avgegwt	spgr	primseq	avgseq	noseq	bwf	hatch	bwdif	egoutpt
52	53	2	h	2600	177	3500	46.0	51	48	3	54.4	1.084	4	4.2	11	3860	97.9	1260	2774.4
53	54	2	h	2620	174	3400	33.1	64	54	10	57.8	1.078	1	4.8	11	3640	88.9	1020	3699.2
54	55	2	h	2620	170	3400	43.8	70	58	12	52.1	1.083	1	8.2	7	3520	100.0	900	3647.0
55	56	2	h	2600	170	3260	46.7	57	53	4	56.5	1.082	1	3.3	16	3720	88.7	1120	3220.5
56	57	2	h	2580	175	3440	41.3	62	58	4	53.3	1.089	2	8.2	7	3740	94.8	1160	3304.6
57	58	2	h	2580	170	3220	44.5	62	58	4	60.1	1.077	2	5.5	10	3460	96.6	880	3726.2
58	59	2	h	2600	173	3200	44.6	66	60	6	58.7	1.077	16	9.8	6	3040	95.0	440	3874.2
59	60	2	h	2600	176	3400	45.1	64	54	10	55.0	1.087	2	5.4	10	3780	96.0	1180	3520.0

Appendix B: Analysis of Variance, SAS Output.

Class Level Information

Class	Levels	Values
Light Treatment(LS)	**2**	**1 2**
Body Weight Group(BWG)	**3**	h l m

Number of observations **59**

The SAS System
The GLM Procedure

Dependent Variable: Body Weight Difference

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**4864505.873**	**972901.175**	**11.30**	<**.0001**
Error	**50**	**4306115.556**	**86122.311**		
Corrected Total	**55**	**9170621.429**			

R-Square	Coeff Var	Root MSE	BW Difference Mean
0.530445	**23.53781**	**293.4660**	**1246.786**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**139535.860**	**139535.860**	**1.62**	**0.2089**
BWG	**2**	**4692484.336**	**2346242.168**	**27.24**	<**.0001**
LS*BWG	**2**	**32485.676**	**16242.838**	**0.19**	**0.8287**

The SAS System

The GLM Procedure
Least Squares Means

BWG	BW difference LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	912.00000	65.62100	<.0001	1
l	1607.11111	67.41917	<.0001	2
m	1246.66667	71.29943	<.0001	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: BW difference

i/j	1	2	3
1		<.0001	0.0011
2	<.0001		0.0006
3	0.0011	0.0006	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	BW difference LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	1197.77778	54.56251	<.0001	0.1503
2	1312.74074	56.71240	<.0001	

LS	BWG	BW difference LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	888.00000	92.80211	<.0001	1
1	l	1532.00000	92.80211	<.0001	2
1	m	1173.33333	97.82201	<.0001	3
2	h	936.00000	92.80211	<.0001	4
2	l	1682.22222	97.82201	<.0001	5
2	m	1320.00000	103.75591	<.0001	6

The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: BW difference

i/j	1	2	3	4	5	6
1		<.0001	0.0393	0.7161	<.0001	0.0031
2	<.0001		0.0105	<.0001	0.2706	0.1341
3	0.0393	0.0105		0.0845	0.0006	0.3087
4	0.7161	<.0001	0.0845		<.0001	0.0081
5	<.0001	0.2706	0.0006	<.0001		0.0142
6	0.0031	0.1341	0.3087	0.0081	0.0142	

Class Level Information

Class	Levels	Values
LS	**2**	**1 2**
BWG	**3**	h l m

Number of observations **59**

The GLM Procedure

Dependent Variable: age at first egg

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**1530.044444**	**306.008889**	**6.56**	**<.0001**
Error	**51**	**2379.955556**	**46.665795**		
Corrected Total	**56**	**3910.000000**			

R-Square	Coeff Var	Root MSE	age at first egg Mean
0.391316	**3.816333**	**6.831237**	**179.0000**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**5.700000**	**5.700000**	**0.12**	**0.7282**
BWG	**2**	**1365.311753**	**682.655876**	**14.63**	**<.0001**
LS*BWG	**2**	**159.032692**	**79.516346**	**1.70**	**0.1922**

The SAS System

The GLM Procedure
Least Squares Means

wtgrop	age at first egg LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	172.800000	1.527511	<.0001	1
l	184.411111	1.569368	<.0001	2
m	180.275000	1.620170	<.0001	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: ag1steg

i/j	1	2	3
1		<.0001	0.0015
2	<.0001		0.0725
3	0.0015	0.0725	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	age at first egg LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	179.300000	1.247207	<.0001	0.8798
2	179.024074	1.320139	<.0001	

LS	BWG	age at first egg LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	173.000000	2.160227	<.0001	1
1	l	186.600000	2.160227	<.0001	2
1	m	178.300000	2.160227	<.0001	3
2	h	172.600000	2.160227	<.0001	4
2	l	182.222222	2.277079	<.0001	5
2	m	182.250000	2.415207	<.0001	6

The SAS System

The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: age at first egg

i/j	1	2	3	4	5	6
1		<.0001	0.0888	0.8963	0.0049	0.0062
2	<.0001		0.0090	<.0001	0.1691	0.1854
3	0.0888	0.0090		0.0678	0.2171	0.2284
4	0.8963	<.0001	0.0678		0.0035	0.0044
5	0.0049	0.1691	0.2171	0.0035		0.9934
6	0.0062	0.1854	0.2284	0.0044	0.9934	

The GLM Procedure

Class Level Information

Class	Levels	Values
LS	**2**	**1 2**
BWG	**3**	h l m

Number of observations **59**

The SAS System

The GLM Procedure

Dependent Variable: BW at first egg

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**323573.509**	**64714.702**	**0.77**	**0.5768**
Error	**51**	**4294630.000**	**84208.431**		
Corrected Total	**56**	**4618203.509**			

R-Square	Coeff Var	Root MSE	BW at first egg Mean
0.070065	**9.147579**	**290.1869**	**3172.281**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**41551.6569**	**41551.6569**	**0.49**	**0.4856**
BWG	**2**	**245866.2848**	**122933.1424**	**1.46**	**0.2418**
LS*BWG	**2**	**36155.5670**	**18077.7835**	**0.21**	**0.8075**

The SAS System
The GLM Procedure
Least Squares Means

BWG	BW at first egg LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	3205.00000	64.88776	<.0001	1
l	3082.66667	66.66584	<.0001	2
m	3238.75000	68.82386	<.0001	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: BW at first egg

i/j	1	2	3
1		0.1944	0.7227
2	0.1944		0.1095
3	0.7227	0.1095	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	BW at first egg LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	3146.66667	52.98064	<.0001	0.4586
2	3204.27778	56.07870	<.0001	

LS	BWG	BW at first egg LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	3208.00000	91.76515	<.0001	1
1	l	3052.00000	91.76515	<.0001	2
1	m	3180.00000	91.76515	<.0001	3
2	h	3202.00000	91.76515	<.0001	4
2	l	3113.33333	96.72896	<.0001	5
2	m	3297.50000	102.59656	<.0001	6

The SAS System

The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: BW at first egg

i/j	1	2	3	4	5	6
1		0.2349	0.8300	0.9633	0.4809	0.5185
2	0.2349		0.3286	0.2531	0.6475	0.0804
3	0.8300	0.3286		0.8661	0.6192	0.3973
4	0.9633	0.2531	0.8661		0.5090	0.4910
5	0.4809	0.6475	0.6192	0.5090		0.1974
6	0.5185	0.0804	0.3973	0.4910	0.1974	

The SAS System
The GLM Procedure

Class Level Information

Class	Levels	Values
LS	**2**	**1 2**
BWG	**3**	h l m

Number of observations **59**

The SAS System
The GLM Procedure

Dependent Variable: weight of first egg

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**278.357795**	**55.671559**	**1.39**	**0.2450**
Error	**51**	**2047.715889**	**40.151292**		
Corrected Total	**56**	**2326.073684**			

R-Square	Coeff Var	Root MSE	weight of first egg Mean
0.119669	**13.68264**	**6.336505**	**46.31053**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**73.8000175**	**73.8000175**	**1.84**	**0.1812**
BWG	**2**	**97.6553512**	**48.8276756**	**1.22**	**0.3048**
LS*BWG	**2**	**106.9024266**	**53.4512133**	**1.33**	**0.2732**

The SAS System

The GLM Procedure
Least Squares Means

BWG	weight of first egg LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	45.7050000	1.4168855	<.0001	1
l	48.0094444	1.4557115	<.0001	2
m	45.1800000	1.5028340	<.0001	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: weight of first egg

i/j	1	2	3
1		0.2619	0.8004
2	0.2619		0.1822
3	0.8004	0.1822	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	weight of first egg LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	47.3900000	1.1568822	<.0001	0.2007
2	45.2062963	1.2245314	<.0001	

LS	BWG	wt1steg LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	47.9300000	2.0037787	<.0001	1
1	l	49.9300000	2.0037787	<.0001	2
1	m	44.3100000	2.0037787	<.0001	3
2	h	43.4800000	2.0037787	<.0001	4
2	l	46.0888889	2.1121682	<.0001	5
2	m	46.0500000	2.2402927	<.0001	6

The SAS System

The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: weight of first egg

i/j	1	2	3	4	5	6
1		0.4835	0.2072	0.1225	0.5300	0.5344
2	0.4835		0.0527	0.0271	0.1930	0.2026
3	0.2072	0.0527		0.7708	0.5439	0.5652
4	0.1225	0.0271	0.7708		0.3744	0.3965
5	0.5300	0.1930	0.5439	0.3744		0.9900
6	0.5344	0.2026	0.5652	0.3965	0.9900	

The SAS System
The GLM Procedure
Class Level Information

Class	Levels	Values
LS	**2**	**1 2**
BWG	**3**	h l m

Number of observations **59**

The GLM Procedure

Dependent Variable: total egg

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**2807.71456**	**561.54291**	**3.34**	**0.0109**
Error	**52**	**8741.88889**	**168.11325**		
Corrected Total	**57**	**11549.60345**			

R-Square	Coeff Var	Root MSE	total egg Mean
0.243101	**25.00895**	**12.96585**	**51.84483**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**118.029639**	**118.029639**	**0.70**	**0.4059**
BWG	**2**	**2214.876489**	**1107.438244**	**6.59**	**0.0028**
LS*BWG	**2**	**474.808432**	**237.404216**	**1.41**	**0.2528**

The SAS System

The GLM Procedure
Least Squares Means

BWG	total egg LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	59.9500000	2.8992520	<.0001	1
l	45.3000000	2.9786983	<.0001	2
m	49.9055556	2.9786983	<.0001	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: total egg

i/j	1	2	3
1		0.0009	0.0192
2	0.0009		0.2793
3	0.0192	0.2793	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	total egg LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	50.4666667	2.3672294	<.0001	0.4660
2	52.9703704	2.4533384	<.0001	

LS	BWG	total egg LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	57.1000000	4.1001616	<.0001	1
1	l	41.6000000	4.1001616	<.0001	2
1	m	52.7000000	4.1001616	<.0001	3
2	h	62.8000000	4.1001616	<.0001	4
2	l	49.0000000	4.3219498	<.0001	5
2	m	47.1111111	4.3219498	<.0001	6

The SAS System
The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: total egg

i/j	1	2	3	4	5	6
1		0.0100	0.4514	0.3302	0.1798	0.0996
2	0.0100		0.0611	0.0006	0.2198	0.3592
3	0.4514	0.0611		0.0875	0.5373	0.3525
4	0.3302	0.0006	0.0875		0.0245	0.0111
5	0.1798	0.2198	0.5373	0.0245		0.7585
6	0.0996	0.3592	0.3525	0.0111	0.7585	

The SAS System

The GLM Procedure

Class Level Information

Class	Levels	Values
LS	**2**	**1 2**
BWG	**3**	h l m

Number of observations **59**

The SAS System
The GLM Procedure

Dependent Variable: settable egg

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**1463.807663**	**292.761533**	**2.22**	**0.0657**
Error	**52**	**6847.088889**	**131.674786**		
Corrected Total	**57**	**8310.896552**			

R-Square	Coeff Var	Root MSE	settable egg Mean
0.176131	**24.48668**	**11.47496**	**46.86207**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**126.851314**	**126.851314**	**0.96**	**0.3309**
BWG	**2**	**1039.019879**	**519.509940**	**3.95**	**0.0254**
LS*BWG	**2**	**297.936470**	**148.968235**	**1.13**	**0.3304**

The SAS System

The GLM Procedure
Least Squares Means

BWG	settable egg LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	52.5500000	2.5658798	<.0001	1
l	42.6444444	2.6361909	<.0001	2
m	45.1166667	2.6361909	<.0001	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: settable egg

i/j	1	2	3
1		0.0095	0.0485
2	0.0095		0.5102
3	0.0485	0.5102	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	settable egg LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	45.4333333	2.0950321	<.0001	0.3795
2	48.1074074	2.1712398	<.0001	

LS	BWG	settable egg LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	49.0000000	3.6287021	<.0001	1
1	l	40.4000000	3.6287021	<.0001	2
1	m	46.9000000	3.6287021	<.0001	3
2	h	56.1000000	3.6287021	<.0001	4
2	l	44.8888889	3.8249878	<.0001	5
2	m	43.3333333	3.8249878	<.0001	6

The SAS System

The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: settable egg

i/j	1	2	3	4	5	6
1		0.0998	0.6841	0.1724	0.4391	0.2874
2	0.0998		0.2109	0.0035	0.3985	0.5804
3	0.6841	0.2109		0.0788	0.7044	0.5017
4	0.1724	0.0035	0.0788		0.0382	0.0190
5	0.4391	0.3985	0.7044	0.0382		0.7748
6	0.2874	0.5804	0.5017	0.0190	0.7748	

The SAS

The GLM Procedure
Class Level Information

Class	Levels	Values
LS	**2**	**1 2**
BWG	**3**	h l m

Number of observations **59**

The SAS System
The GLM Procedure

Dependent Variable: non settable egg

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**314.235249**	**62.847050**	**3.47**	**0.0088**
Error	**52**	**941.488889**	**18.105556**		
Corrected Total	**57**	**1255.724138**			

R-Square	Coeff Var	Root MSE	non settable egg Mean
0.250242	**86.29147**	**4.255062**	**4.931034**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**0.0788998**	**0.0788998**	**0.00**	**0.9476**
BWG	**2**	**237.3380611**	**118.6690305**	**6.55**	**0.0029**
LS*BWG	**2**	**76.8182881**	**38.4091441**	**2.12**	**0.1301**

The SAS System

The GLM Procedure
Least Squares Means

BWG	non settable egg LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	7.40000000	0.95146087	<.0001	1
l	2.55555556	0.97753311	0.0117	2
m	4.73333333	0.97753311	<.0001	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: non settable egg

i/j	1	2	3
1		0.0008	0.0560
2	0.0008		0.1212
3	0.0560	0.1212	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	non settable egg LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	4.96666667	0.77686454	<.0001	0.9004
2	4.82592593	0.80512334	<.0001	

LS	BWG	non settable egg LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	8.10000000	1.34556886	<.0001	1
1	l	1.00000000	1.34556886	0.4607	2
1	m	5.80000000	1.34556886	<.0001	3
2	h	6.70000000	1.34556886	<.0001	4
2	l	4.11111111	1.41835411	0.0055	5
2	m	3.66666667	1.41835411	0.0126	6

The SAS System

The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: non settable egg

i/j	1	2	3	4	5	6
1		0.0005	0.2323	0.4652	0.0464	0.0275
2	0.0005		0.0148	0.0042	0.1176	0.1784
3	0.2323	0.0148		0.6382	0.3916	0.2802
4	0.4652	0.0042	0.6382		0.1912	0.1268
5	0.0464	0.1176	0.3916	0.1912		0.8255
6	0.0275	0.1784	0.2802	0.1268	0.8255	

The SAS System

The GLM Procedure

Class Level Information

Class	Levels	Values
LS	**2**	**1 2**
BWG	**3**	h l m

Number of observations **59**

The SAS System

The GLM Procedure

Dependent Variable: average egg weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**92.5304035**	**18.5060807**	**1.98**	**0.0979**
Error	**51**	**477.3910000**	**9.3606078**		
Corrected Total	**56**	**569.9214035**			

R-Square	Coeff Var	Root MSE	average egg weight Mean
0.162356	**5.406670**	**3.059511**	**56.58772**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**12.95532943**	**12.95532943**	**1.38**	**0.2449**
BWG	**2**	**37.81842047**	**18.90921023**	**2.02**	**0.1431**
LS*BWG	**2**	**41.75665361**	**20.87832680**	**2.23**	**0.1179**

The SAS System

The GLM Procedure
Least Squares Means

BWG	average egg weight LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	55.6000000	0.6841275	<.0001	1
l	57.5083333	0.7028742	<.0001	2
m	56.6100000	0.7256268	<.0001	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: average egg weight

i/j	1	2	3
1		0.0572	0.3160
2	0.0572		0.3781
3	0.3160	0.3781	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	average egg weight LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	57.0400000	0.5585877	<.0001	0.2560
2	56.1055556	0.5912514	<.0001	

LS	BWG	average egg weight LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	55.2500000	0.9675023	<.0001	1
1	l	59.1500000	0.9675023	<.0001	2
1	m	56.7200000	0.9675023	<.0001	3
2	h	55.9500000	0.9675023	<.0001	4
2	l	55.8666667	1.0198370	<.0001	5
2	m	56.5000000	1.0817005	<.0001	6

The SAS System

The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: average egg weight

i/j	1	2	3	4	5	6
1		0.0063	0.2877	0.6111	0.6627	0.3931
2	0.0063		0.0817	0.0233	0.0235	0.0737
3	0.2877	0.0817		0.5761	0.5465	0.8801
4	0.6111	0.0233	0.5761		0.9530	0.7063
5	0.6627	0.0235	0.5465	0.9530		0.6719
6	0.3931	0.0737	0.8801	0.7063	0.6719	

The SAS System
The GLM Procedure
Class Level Information

Class	Levels	Values
LS	**2**	**1 2**
BWG	**3**	h l m

Number of observations **59**

The SAS System

The GLM Procedure

Dependent Variable: specific gravity

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**0.00014030**	**0.00002806**	**2.05**	**0.0878**
Error	**51**	**0.00069970**	**0.00001372**		
Corrected Total	**56**	**0.00084000**			

R-Square	Coeff Var	Root MSE	specific gravity Mean
0.167024	**0.341697**	**0.003704**	**1.084000**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**0.00000570**	**0.00000570**	**0.42**	**0.5221**
BWG	**2**	**0.00012133**	**0.00006067**	**4.42**	**0.0169**
LS*BWG	**2**	**0.00001327**	**0.00000663**	**0.48**	**0.6194**

The SAS System
The GLM Procedure
Least Squares Means

BWG	specific gravity LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	1.08245000	0.00082824	<.0001	1
l	1.08590000	0.00085094	<.0001	2
m	1.08370000	0.00087848	<.0001	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: specific gravity

i/j	1	2	3
1		0.0054	0.3054
2	0.0054		0.0780
3	0.3054	0.0780	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	specific gravity LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	1.08430000	0.00067625	<.0001	0.5675
2	1.08373333	0.00071580	<.0001	

LS	BWG	specific gravity LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	1.08270000	0.00117131	<.0001	1
1	l	1.08680000	0.00117131	<.0001	2
1	m	1.08340000	0.00117131	<.0001	3
2	h	1.08220000	0.00117131	<.0001	4
2	l	1.08500000	0.00123467	<.0001	5
2	m	1.08400000	0.00130956	<.0001	6

The SAS System

The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: specific gravity

i/j	1	2	3	4	5	6
1		0.0167	0.6744	0.7640	0.1825	0.4627
2	0.0167		0.0453	0.0077	0.2952	0.1172
3	0.6744	0.0453		0.4721	0.3516	0.7341
4	0.7640	0.0077	0.4721		0.1061	0.3104
5	0.1825	0.2952	0.3516	0.1061		0.5809
6	0.4627	0.1172	0.7341	0.3104	0.5809	

The SAS System
The GLM Procedure
Class Level Information

Class	Levels	Values
LS	**2**	**1 2**
BWG	**3**	h l m

Number of observations **59**

The SAS System

The GLM Procedure

Dependent Variable: prime sequence

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**244.155172**	**48.831034**	**1.36**	**0.2547**
Error	**52**	**1867.500000**	**35.913462**		
Corrected Total	**57**	**2111.655172**			

R-Square	Coeff Var	Root MSE	prime sequence Mean
0.115623	**177.3375**	**5.992784**	**3.379310**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**96.47422003**	**96.47422003**	**2.69**	**0.1073**
BWG	**2**	**70.04152654**	**35.02076327**	**0.98**	**0.3839**
LS*BWG	**2**	**77.63942584**	**38.81971292**	**1.08**	**0.3468**

The SAS System

The GLM Procedure
Least Squares Means

BWG	prime sequence LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	2.95000000	1.34002727	0.0322	1
l	2.35000000	1.37674714	0.0938	2
m	5.05000000	1.37674714	0.0006	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: prime sequence

i/j	1	2	3
1		0.7561	0.2794
2	0.7561		0.1714
3	0.2794	0.1714	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	prime sequence LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	2.13333333	1.09412768	0.0566	0.1007
2	4.76666667	1.13392707	0.0001	

LS	BWG	prime sequence LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	2.60000000	1.89508474	0.1760	1
1	l	1.70000000	1.89508474	0.3738	2
1	m	2.10000000	1.89508474	0.2729	3
2	h	3.30000000	1.89508474	0.0875	4
2	l	3.00000000	1.99759471	0.1392	5
2	m	8.00000000	1.99759471	0.0002	6

The SAS System

The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: prime sequence

i/j	1	2	3	4	5	6
1		0.7384	0.8527	0.7950	0.8851	0.0552
2	0.7384		0.8819	0.5531	0.6388	0.0262
3	0.8527	0.8819		0.6562	0.7451	0.0368
4	0.7950	0.5531	0.6562		0.9137	0.0938
5	0.8851	0.6388	0.7451	0.9137		0.0826
6	0.0552	0.0262	0.0368	0.0938	0.0826	

The SAS System
The GLM Procedure
Class Level Information

Class	Levels	Values
LS	**2**	**1 2**
BWG	**3**	h l m

Number of observations **59**

The SAS System

The GLM Procedure

Dependent Variable: average sequence length

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**49.2380498**	**9.8476100**	**1.15**	**0.3453**
Error	**52**	**444.5267778**	**8.5485919**		
Corrected Total	**57**	**493.7648276**			

R-Square	Coeff Var	Root MSE	average sequence length Mean
0.099720	**52.69741**	**2.923798**	**5.548276**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**8.27637521**	**8.27637521**	**0.97**	**0.3297**
BWG	**2**	**31.54249353**	**15.77124676**	**1.84**	**0.1682**
LS*BWG	**2**	**9.41918107**	**4.70959054**	**0.55**	**0.5797**

The SAS System
The GLM Procedure
Least Squares Means

BWG	average sequence length LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	5.35500000	0.65378100	<.0001	1
l	4.77222222	0.67169612	<.0001	2
m	6.53888889	0.67169612	<.0001	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: average sequence length

i/j	1	2	3
1		0.5368	0.2122
2	0.5368		0.0686
3	0.2122	0.0686	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	average sequence length LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	5.18333333	0.53380995	<.0001	0.3376
2	5.92740741	0.55322753	<.0001	

LS	BWG	average sequence length LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	4.45000000	0.92458595	<.0001	1
1	l	4.50000000	0.92458595	<.0001	2
1	m	6.60000000	0.92458595	<.0001	3
2	h	6.26000000	0.92458595	<.0001	4
2	l	5.04444444	0.97459917	<.0001	5
2	m	6.47777778	0.97459917	<.0001	6

The SAS System
The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: average sequence length

i/j	1	2	3	4	5	6
1		0.9696	0.1062	0.1722	0.6600	0.1372
2	0.9696		0.1143	0.1841	0.6869	0.1470
3	0.1062	0.1143		0.7959	0.2522	0.9279
4	0.1722	0.1841	0.7959		0.3697	0.8718
5	0.6600	0.6869	0.2522	0.3697		0.3032
6	0.1372	0.1470	0.9279	0.8718	0.3032	

The SAS System
The GLM Procedure
Class Level Information

Class	Levels	Values
LS	**2**	**1 2**
BWG	**3**	h l m

Number of observations **59**

The SAS System

The GLM Procedure

Dependent Variable: number of sequence

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**124.5605364**	**24.9121073**	**2.45**	**0.0453**
Error	**52**	**527.9222222**	**10.1523504**		
Corrected Total	**57**	**652.4827586**			

R-Square	Coeff Var	Root MSE	number of sequence Mean
0.190902	**33.60072**	**3.186275**	**9.482759**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**31.96847291**	**31.96847291**	**3.15**	**0.0818**
BWG	**2**	**87.64892686**	**43.82446343**	**4.32**	**0.0184**
LS*BWG	**2**	**4.94313663**	**2.47156831**	**0.24**	**0.7848**

The SAS System
The GLM Procedure
Least Squares Means

BWG	number of sequence LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	10.2500000	0.7124728	<.0001	1
l	10.4000000	0.7319962	<.0001	2
m	7.6777778	0.7319962	<.0001	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: number of sequence

i/j	1	2	3
1		0.8838	0.0149
2	0.8838		0.0112
3	0.0149	0.0112	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	number sequence LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	10.2000000	0.5817316	<.0001	0.0764
2	8.6851852	0.6028924	<.0001	

LS	BWG	number of sequence LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	11.0000000	1.0075887	<.0001	1
1	l	10.8000000	1.0075887	<.0001	2
1	m	8.8000000	1.0075887	<.0001	3
2	h	9.5000000	1.0075887	<.0001	4
2	l	10.0000000	1.0620918	<.0001	5
2	m	6.5555556	1.0620918	<.0001	6

The SAS System

The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: number of sequence

i/j	1	2	3	4	5	6
1		0.8889	0.1287	0.2974	0.4976	0.0037
2	0.8889		0.1664	0.3658	0.5871	0.0055
3	0.1287	0.1664		0.6253	0.4161	0.1313
4	0.2974	0.3658	0.6253		0.7341	0.0495
5	0.4976	0.5871	0.4161	0.7341		0.0259
6	0.0037	0.0055	0.1313	0.0495	0.0259	

Class Level Information

Class	Levels	Values
LS	**2**	**1 2**
BWG	**3**	h l m

Number of observations **59**

The SAS System

The GLM Procedure

Dependent Variable: egg output

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	**5**	**6467169.89**	**1293433.98**	**3.68**	**0.0064**
Error	**51**	**17928554.56**	**351540.29**		
Corrected Total	**56**	**24395724.46**			

R-Square	Coeff Var	Root MSE	egg output Mean
0.265094	**19.98265**	**592.9083**	**2967.116**

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LS	**1**	**857842.153**	**857842.153**	**2.44**	**0.1244**
BWG	**2**	**5285091.541**	**2642545.771**	**7.52**	**0.0014**
LS*BWG	**2**	**324236.200**	**162118.100**	**0.46**	**0.6332**

The SAS System
The GLM Procedure
Least Squares Means

BWG	egg output LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
h	3325.32500	132.57833	<.0001	1
l	2590.44556	136.21129	<.0001	2
m	2975.55000	140.62056	<.0001	3

Least Squares Means for effect BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: egg output

i/j	1	2	3
1		0.0003	0.0762
2	0.0003		0.0546
3	0.0762	0.0546	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

LS	egg output LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1= LSMean2 Pr > |t|
1	2850.73333	108.24976	<.0001	0.1576
2	3076.81370	114.57971	<.0001	

LS	BWG	egg output LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	h	3137.32000	187.49408	<.0001	1
1	l	2447.48000	187.49408	<.0001	2
1	m	2967.40000	187.49408	<.0001	3
2	h	3513.33000	187.49408	<.0001	4
2	l	2733.41111	197.63611	<.0001	5
2	m	2983.70000	209.62475	<.0001	6

The SAS System

The GLM Procedure
Least Squares Means

Least Squares Means for effect LS*BWG
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: egg output

i/j	1	2	3	4	5	6
1		0.0121	0.5245	0.1623	0.1443	0.5873
2	0.0121		0.0554	0.0002	0.2989	0.0622
3	0.5245	0.0554		0.0446	0.3944	0.9540
4	0.1623	0.0002	0.0446		0.0061	0.0654
5	0.1443	0.2989	0.3944	0.0061		0.3891
6	0.5873	0.0622	0.9540	0.0654	0.3891	

جامعة النجاح الوطنية
كلية الدراسات العليا

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

إعداد
عثمان هاشم حسن شحادة

إشراف
د. معن سمارة

قدمت هذه الأطروحة استكمالاُ لمتطلبات درجة الماجستير الإنتاج الحيواني بكليـــة الدراســـات العليا في جامعة النجاح الوطنية/ نابلس, فلسطين.

2008م

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الملخص

أجريت تجربة على60 فرحة من أمهات دجاج اللحم لتحديد تأثير نمط الإثارة الضـــوئية ووزن الجسم عند عمر 20 أسبوع على متغيرات الإنتاج. أستخدم نمطين من الإثارة الضـــوئية هما: إثارة ضوئية متسارعة, حيث تم زيادة الإضاءة إلى 10 ساعات بعمر 21 أسبوع, إلى 12 ساعة عند 5 % من الإنتاج, إلى 14 ساعة عند 35 % من الإنتاج, و اخيراً16 ساعة عند 65 % من الإنتاج: والثاني إثارة ضوئية متدرجة, حيث تم زيادة الإضاءة إلى 12 ساعة عند عمـــر 21 أسبوع, ومن ثم زيادة نصف ساعة أسبوعيا حتى الوصول إلى 16 ساعة بعمر 29 أسبوع. وزعت الأفراخ عشوائيا إلى ثلاث مجموعات تبعا لوزن الجسم عند عمر 20 أسبوع على النحو الأتي: 1800 غم و 2200 غم و 2600 غم. دلت النتائج على أن نمط الإثارة الضوئية ووزن الأفراخ لم يؤثرا بشكل ملحوظ على إنتاج الأفراخ, باستثناء إنتاج الأفراخ ثقيلة الـــوزن لبـــيض منخفض الوزن. أدت الإثارة الضوئية المتدرجة إلى تبكير وضع البيض عند الأفراخ منخفضـــة الوزن كما حققت هذه الأفراخ زيادة ملحوظة في وزنها عند بدء الإنتاج.