Light program and feed restriction during the rearing of out-of-season medium-sized pullets: body weight, bone development, and sexual maturity[1]

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ABSTRACT

An experiment was conducted to determine the most appropriate light program and feeding level for the rearing of out-of-season pullets in the tropics and the effects on growth and sexual maturity. Data were obtained during an 18-wk rearing period from 880 Isa Brown medium-sized pullets. The pullets were randomly distributed between two groups subjected to either a constant light program (CLP) or a decreasing light program (DLP) in open houses. In each case, pullets were subdivided into five groups, which received the following feeding programs: control diet (T-1) with a feeding level suggested by the breeding company; 10% (T-2), and 20% (T-3) over the control diet; and 10% (T-4), and 20% (T-5) under the control diet. The variables studied were mean bird weight (MBW), tarsus-metatarsus length (TML), and age at sexual maturity. Under CLP and DLP, respectively, there were no significant differences in MBW among T-1 (1.46 and 1.5 kg), T-2 (1.51 and 1.49 kg), and T-3 (1.47 and 1.56 kg). However, T-4 (1.35 and 1.41 kg) and T-5 (1.26 and 1.29 kg) showed lower MBW ($P<0.05$). Until 10 wk of age, there were no differences in TML between the two light programs. Under DLP, bone growth at 18 wk was similar for all feed levels: 103, 103, 104, 103, and 101 mm for T-1 through T-5, respectively. However, under CLP, TML of T-5 (101 mm) was less than that of T-1, T-2, and, T-3 (104 mm). Irrespective of light program, overfed pullets demonstrated growth patterns similar to those of the control at 18 wk of age, whereas restriction of feed resulted in less weight than that of control pullets, although bone growth was similar. Feed restriction of 10% (T-4) and 20% (T-5), under both light programs, delayed sexual maturity from three to 14 days compared to that of other treatments.

Key words: medium-sized pullets, body weight, bone development, sexual maturity

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RESUMEN

Programa de iluminación y nivel de alimentación durante la crianza de pollonas de peso mediano: peso corporal, desarrollo óseo y madurez sexual

Con el propósito de determinar el programa de iluminación y el nivel de alimentación más adecuado para la crianza de pollonas fuera de época en el trópico y su efecto sobre el crecimiento y la madurez sexual, se recopilaron datos durante 18 semanas de crianza de 880 pollonas ISA Brown de peso mediano. Las pollonas se distribuyeron aleatoriamente en dos grupos que recibieron un programa de iluminación constante (IC) o decreciente (ID) en galpones abiertos. En cada caso, las pollonas se subdividieron en cinco grupos que recibieron uno de los siguientes programas de alimentación: dieta testigo (T-1) con la cantidad de alimento recomendada por la casa genética; 10% (T-2), y 20% (T-3) sobre dieta testigo; y 10% (T-4) y 20% (T-5) bajo la dieta testigo. Las variables estudiadas fueron peso promedio por ave (PPA), longitud del tarso metatarso (LTM) y edad a la madurez sexual. Bajo ambos programas de iluminación, no se encontraron diferencias en PPA entre T-1 (1.46 y 1.5 kg), T-2 (1.51 y 1.49 kg) y T-3 (1.47 y 1.56 kg). Sin embargo, T-4 (1.35 y 1.41 kg) y T-5 (1.26 y 1.29 kg) exhibieron pesos más bajos. En ambos programas de iluminación, hasta las 10 semanas de edad no se observaron diferencias en LTM. En ID, el desarrollo óseo a las 18 semanas fue similar para todos los niveles de alimentación (103, 103, 104, 103 y 101 mm para T-1 hasta T-5, respectivamente). Sin embargo, en IC, el desarrollo óseo en T-5 (101 mm) fue menor que en T-1 (104 mm), T-2 (104 mm), T-3 (104 mm) y T-4 (102 mm). Irrespectivo del programa de iluminación utilizado, las pollonas sobrealimentadas mostraron patrones de crecimiento similares a las testigos a las 18 semanas, mientras que aquellas alimentadas en forma restringida, a pesar de mostrar diferencias en peso relativo a las aves testigo, tuvieron un desarrollo óseo similar. Las restricciones de alimento de un 10% (T-4) y 20% (T-5), bajo ambos programas de iluminación, retrasaron la madurez sexual entre tres y 14 días al compararse con la de los demás tratamientos.

Palabras Clave: pollonas, desarrollo óseo, madurez sexual

INTRODUCTION

At present, pullet growers in Puerto Rico do not use controlled light programs for the rearing of out-of-season pullets. During the growth of pullets, light and feed are the most important factors that affect their subsequent performance as producers (North and Bell, 1990). The main problem during rearing out-of-season pullets is that day length is increasing during their growth. The increased day length may stimulate the pullet to reach sexual maturity earlier than expected, all of which may result in fewer eggs produced. With an appropriate light program during the rearing period, sexual maturity can be delayed as much as 4 wk, thus obtaining a more desirable egg size.

The developed pullet body weight should be reached no sooner than 18 wk of age, because at this stage the reproductive system usually becomes functional. However, a suitable light program and feed restriction can reduce body weight at that age without affecting bone growth so that a more adult bird can then enter the laying cycle. Lee

(1987) reported that feed restriction during the rearing period was the only treatment that delayed sexual maturity.

The common practice of overfeeding the birds results in overweight pullets starting the laying cycle. This practice increases the cost of producing eggs because the maintenance requirements of these layers cost more. The minimum quantity of feed that the birds need for growth without affecting production should be determined to reduce costs of subsequent egg production. Feed restriction may be used in combination with light programs to delay sexual maturity, thereby improving egg production efficiency. The objective of this study was to evaluate the effects of light programs and feed restriction on body weight, bone development, and sexual maturity during the rearing of out-of-season pullets.

MATERIALS AND METHODS

The experiment was conducted at the Small Animal Research Farm of the Agricultural Experiment Station at Lajas, Puerto Rico. Eight hundred and eighty Isa Brown medium-sized pullets were used during an 18-wk rearing period until reaching sexual maturity or 5% egg production.

Birds were grown in an open house, divided into two sections to avoid light passing through from one side of the house to the other. Each side of the building had a section of Big Dutchman Double Deck Chick Eze cages (Big Dutchman® P.O. Box 1017, Holland, MI 49422)[4], which consisted of 40 colony-type pens, 75 cm wide and 65 cm deep. Cages had nipple-type drinkers distributed every 75 cm (two nipples per pen). Feeders were divided to feed each pen individually. There were 11 birds per pen, providing a stocking density of 0.044 m^2. Table 1 presents the ingredients of the experimental diets used in the study. The starter and grower diets were formulated to contain 21% and 17% crude protein, respectively.

Birds were randomly assigned to two groups or plots which received either a decreasing light program (DLP) or a constant light program (CLP). Under DLP, the growing period day length decreased whereas outside it increased. To establish the DLP we determined the length of the day on which the pullets would reach 20 wk of age. The day length for that date was 14 hours and 15 minutes. Six hours and 35 minutes

[4]Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

TABLE 1. *Percentage composition of experimental diets.*

Ingredient	Starter (0-10 wk)	Grower (11-18 wk)
	(%)	
Corn	61.38	52.11
Soybean meal	14.22	10.17
Wheat middlings	12.00	27.86
Fish meal	9.31	5.81
Limestone	1.19	0.73
Dicalcium phosphate	0.49	1.89
Salt	0.42	0.42
Vitamin and mineral premix[1]	1.00	1.00

[1]Composition of vitamin-mineral premix provided per kg of diet: Fe (45 mg), Cu (7.5 mg), Zn (60 mg), Mn (75 mg), Se (0.1 mg), I (0.75 mg), Vitamin A (10,000 IU), Vitamin D_3 (2,250 IU); Vitamin E (15 IU), Vitamin B_1 (0.05 mg), Vitamin B_2 (5.5 mg), Vitamin B_3 (30 mg), Vitamin B_5 (11 mg), Vitamin B_6 (1 mg), Vitamin B_{12} (0.01 mg), Folic acid (1 mg), Biotin (0.05 mg), Choline Chloride (360 mg), Ethoxyquin (1.67 mg).

was added to day length during the first week of age. Thereafter, a reduction of 20 minutes was made each week, 10 minutes in the morning and 10 minutes in the evening. The total light reduction was six hours and 20 minutes. Table 2 shows this schedule and the daily light hours during rearing.

The CLP consisted of the same day length during the whole experimental period. The constant day length was taken as the number of natural light-hours of the day when pullets would reach 20 wk of age. On this date, sunrise was at 5:30 AM and sunset at 7:45 PM, for a total day length of 14 h and 15 minutes. The electric timer was adjusted to start a daily light period at 5:30 AM and turn the lights off at 7:45 PM, from the first week until 18 wk of age.

The experiment used a split plot in a completely randomized design in which the main plots were the two light programs. Within each main plot there was a section of cages with 40 pens. Each colony-type pen constituted one experimental unit. There were five treatments and eight replications within each plot. Birds were fed ad-libitum until 8 wk of age. Treatments consisted of a control diet (allowances recommended by the breeder company), and diets providing 10% and 20% above and below those quantities. Under each light program, pullets were subdivided into five groups that received the following feed programs: control diet (T-1); 10% (T-2), and 20% (T-3) over control diet; and 10% (T-4), and 20% (T-5) under control diet. Feed was weighed daily for each experimental unit. Table 3 shows the amount of feed that constituted the different treatments, in grams per day.

TABLE 2. *Decreasing light program schedule.*

	Artificial Light				
	Time AM		Time PM		
Wk	On	Off	On	Off	Day length
1	2:20	7:00	6:00	10:55	20 H 35 m
2	2:30	7:00	6:00	10:45	20 H 15 m
3	2:40	7:00	6:00	10:35	19 H 55 m
4	2:50	7:00	6:00	10:25	19 H 35 m
5	3:00	7:00	6:00	10:15	19 H 15 m
6	3:10	7:00	6:00	10:05	18 H 55 m
7	3:20	7:00	6:00	9:55	18 H 35 m
8	3:30	7:00	6:00	9:45	18 H 15 m
9	3:40	7:00	6:00	9:35	17 H 55 m
10	3:50	7:00	6:00	9:25	17 H 35 m
11	4:00	7:00	6:00	9:15	17 H 15 m
12	4:10	7:00	6:00	9:05	16 H 55 m
13	4:20	7:00	6:00	8:55	16 H 35 m
14	4:30	7:00	6:00	8:45	16 H 15 m
15	4:40	7:00	6:00	8:35	15 H 55 m
16	4:50	7:00	6:00	8:25	15 H 35 m
17	5:00	7:00	6:00	8:15	15 H 15 m
18	5:10	7:00	6:00	8:05	14 H 55 m
19	5:20	7:00	6:00	7:55	14 H 35 m
20	5:30	7:00	6:00	7:45	14 H 15 m

In order to measure body weight (BW) and tarsus-metatarsus length (TML), four birds were randomly selected from each pen at 21 d and tagged with a wing band for identification. These birds were taken from each pen every 2 wk from the fourth week onward to record BW and shank length. Length of tarsus-metatarsus was measured with a vernier micrometer.

All data were subjected to analysis of variance using the General Linear Model procedures of SAS® (SAS Institute, 1988). When appropriate, mean differences were separated by Tukey's procedure at the $P < 0.05$ level (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Body weight

Tables 4 and 5 show that during the first eight weeks of rearing there were no significant differences among the mean BWs of the different feeding treatments and light programs. This uniformity in BW was expected since feed restriction was not applied until the ninth

TABLE 3. *Daily offering of five feeding treatments, in grams per bird.*

Wk	T-1	T-2	T-3	T-4	T-5
9	57.00	62.70	68.40	51.80	45.60
10	61.00	67.10	73.20	54.90	48.80
11	64.00	70.40	76.80	57.60	51.20
12	67.00	73.70	80.40	60.30	53.60
13	70.00	77.00	84.00	63.00	56.00
14	73.00	80.30	87.60	65.70	58.40
15	76.00	83.60	91.20	68.40	60.80
16	79.00	86.90	94.80	71.10	63.20
17	82.00	90.20	98.40	73.80	65.60
18	86.00	94.60	103.20	77.40	68.80

week of age, and during this first period birds were fed ad-libitum. Body weight started to change significantly from the tenth week onward, consistent with the feed restriction being applied. Body weight during the rearing phase showed significant differences by feeding treatment under both light programs as illustrated in Tables 4 and 5. Overall, control (T-1) and overfed birds (T-2 and T-3) showed similar but significantly higher BW than that of birds subjected to feed restrictions of 10% (T-4) and 20% (T-5), irrespective of the light program used at 10 wk and later.

The same differences among feeding treatments in BW at 18 wk were found under both light programs (Tables 4 and 5). Regardless of the light program, T-1, T-2, and T-3 showed the same BW at this stage, whereas that of T-5 was the lowest, followed by that of T-4. These results agree with those of Lee (1987), who reported that up to 20 wk of age feed restriction significantly reduced growth, weight gain, and BW,

TABLE 4. *Body weight[1] (g) of birds reared under a decreasing light program.*

	Feeding treatments				
Wk	T-1	T-2	T-3	T-4	T-5
4	258 a[2]	259 a	262 a	249 a	252 a
6	510 a	502 a	513 a	497 a	504 a
8	736 a	728 a	738 a	710 a	712 a
10	867 a	869 a	889 a	812 b	788 b
12	1,056 ab	1,089 a	1,111 a	994 b	919 c
14	1,218 a	1,242 a	1,291 a	1,115 b	1,032 c
16	1,314 a	1,318 a	1,395 a	1,221 b	1,128 c
18	1,499 a	1,496 a	1,563 a	1,408 b	1,299 c

[1]Values represent the mean of 32 birds per treatment.
[2]Means within rows with different letters differ significantly ($P < 0.05$).

TABLE 5. *Body weight[1] (g) of birds reared under a constant light program.*

Wk	Feeding treatments				
	T-1	T-2	T-3	T-4	T-5
4	267 a[2]	257 a	260 a	257 a	265 a
6	506 a	510 a	506 a	512 a	513 a
8	712 a	718 a	715 a	709 a	714 a
10	873 ab	874 ab	890 a	830 bc	802 c
12	1,074 a	1,109 a	1,134 a	1,013 b	965 b
14	1,200 bc	1,258 ab	1,270 a	1,132 cd	1,064 d
16	1,296 ab	1,356 a	1,313 ab	1,235 bc	1,183 c
18	1,466 a	1,514 a	1,466 a	1,347 b	1,264 c

[1]Values represent the mean of 32 birds per treatment.
[2]Means within rows with different letters differ significantly ($P < 0.05$).

depending on the severity of the feed restriction used during rearing, when compared to the control diet. The present results show that birds fed from the ninth week with the control diet, or at levels 10% and 20% above the control, all had similar body weights at 18 wk.

Bone development

Tables 6 and 7 show weekly variations in TML for both light programs and feeding treatments studied. During the first eight weeks TML was uniform and did not show differences among treatments. These data indicate that bone growth followed a linear pattern until 10 wk of age, and then showed a small decline in the curve. This decline can be partially attributed to the application of feed restriction at 9 wk of age. Bone growth normally accelerates during the first 10 wk of life, then decelerate until the age of 18 wk, when it stabilizes at maximum size. The present results confirm the fact that after 10 wk there is indeed a reduction in bone growth, regardless of the light program or feeding level used during rearing. North and Bell (1990) reported that bone growth is rapid and maximum bone size is reached weeks before the increase in BW ceases. Shank length reaches its maximum between 16 and 18 wk of age, but BW continues to develop until 40 to 52 wk.

After feed restriction, transitory differences among treatments were observed on TML in both light programs studied. However, TML was equal for all feeding treatments under DLP by the end of the growing period (Table 6). Bone size of birds reared under CLP did show one significant difference at 18 wk: bone size of T-5 was inferior to that of all other treatments, except for T-4 (Table 7). However, the differences were either the same or only 1 or 2 mm greater than those under DLP.

TABLE 6. *Tarsus-metatarsus length*[1] *(mm) of birds reared under DLP.*

	Feeding treatments				
Wk	T-1	T-2	T-3	T-4	T-5
4	58 a[2]	59 a	59 a	59 a	59 a
6	75 a	72 b	71 b	71 b	71 b
8	83 a	83 a	83 a	82 a	83 a
10	93 a	91 a	93 a	91 a	91 a
12	99 a	99 a	99 a	98 a	97 a
14	102 a	101 a	101 a	101 a	99 b
16	102 a	101 a	103 a	102 a	100 b
18	103 a	103 a	104 a	103 a	101 a

[1]Values represent the mean of 32 birds per treatment.
[2]Means within rows with different letters differ significantly ($P < 0.05$).

These results indicate that the effect of treatments on bone growth was small, whereas BW was significantly affected. We conclude that bone growth cannot be modified in birds reared under DLP, and only slightly so under CLP, regardless of the amount of feed offered.

Sexual maturity

Figure 1 shows the effect of light program and feed restriction on the time to reach 5% egg production (sexual maturity). Under DLP, the number of days required to reach this point increased from 140 to 147 for feed restrictions of 10% (T-4) and 20% (T-5), above the values of 135, 132, and 132 d observed for T-1, T-2, and T-3, respectively. Thus, feed restrictions of 10% and 20% delayed sexual maturity by 7 to 14 d longer than in the other treatments.

TABLE 7. *Tarsus-metatarsus length*[1] *(mm) of birds reared under CLP.*

	Feeding treatments				
Wk	T-1	T-2	T-3	T-4	T-5
4	60 a[2]	60 a	60 a	59 a	60 a
6	72 a	71 a	71 a	72 a	72 a
8	82 a	82 a	82 a	82 a	82 a
10	93 a	93 a	92 ab	91 ab	90 b
12	99 a	100 a	99 a	98 ab	96 b
14	101 ab	102 a	101 ab	99 bc	98 c
16	103 a	104 a	103 a	102 ab	101 b
18	104 a	105 a	104 a	103 ab	101 b

[1]Values represent the mean of 32 birds per treatment.
[2]Means within rows with different letters differ significantly ($P < 0.05$).

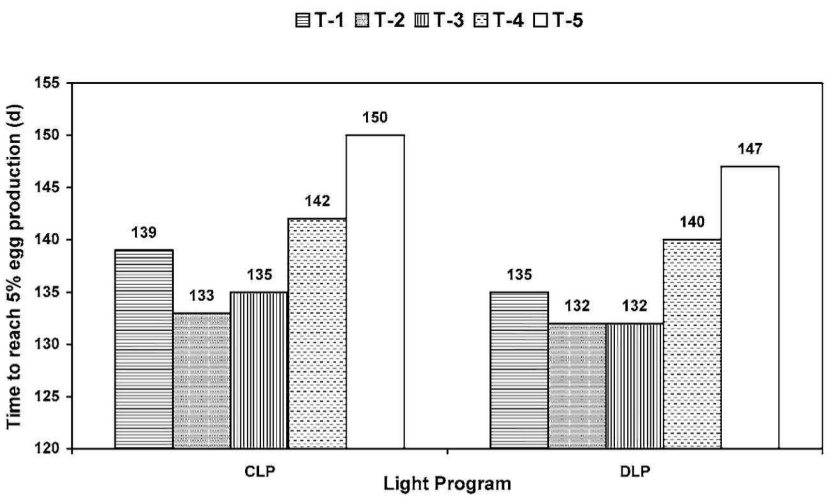

FIGURE 1. Time to reach 5% egg production (d) of pullets reared under a CLP and DLP.

Under CLP, pullets in T-1, T-4, and T-5 reached 5% egg production at 139, 142, and 150 d of age, respectively, whereas those in T-2 and T-3 reached sexual maturity at 133 and 135 d. Feed restriction levels of 10% and 20% delayed sexual maturity by three to 17 days; the length of the delay increased with the severity of restriction.

Brody et al. (1980), Bornstein et al. (1984), and Dunnigton and Siegel (1984) also observed that a reduction in BW due to feed restriction resulted in a delay of the onset of egg production, and suggested that a minimum BW is required to reach sexual maturity. Hurwitz y Plavnik (1989) found that commencement of egg production was delayed by feed restriction directly proportional to the severity of the restriction. Lee (1987) reported that the method of daily feed restriction was more reliable than the alternatives of low energy diets, low protein diets, and skipped feedings to control BW, delay sexual maturity, and save feed during growth.

The results of this study indicate that feed restriction during rearing of out-of-season pullets is more effective than a light program to reduce BW and delay sexual maturity. The use of feed restriction instead of ad-libitum feeding during rearing can significantly reduce BW and delay sexual maturity by up to 14 d without affecting bone development. However, the subsequent effects of feed restriction during growing on layer performance need to be investigated.

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