Effect of Light and Feed Restriction During Rearing on Production Performance of Egg Strain Layers

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ABSTRACT : 432 Babcock ISA white leghorn pullets reared for 8 weeks on a standard managemental conditions were exposed to feed/nutrient and light restrictions from 9 to 20 weeks of age. Four feeding regimes i. e. 100, 85 or 70 percent of the recommended allowance and low energy (2,500 Kcal/kg) low protein (13% CP) ration were fed each in the three light regimes i. e. (A) Natural day light starting from 13.24 hr/day at 8 weeks of age and ending 10.41 hr/day at the end of 20 weeks; (B) Constant 11 hr/day light and (C) starting with 13 hr/day at 8 weeks and decreasing @ 20 min/week till 20 weeks of age. At the age of 20 weeks all the birds were shifted to separate cages under uniform lighting feeding and management. During the 21st week light was increased to 12 hr a day and thereafter with an increase of 30 min per week, increased to 16 hr a day at the age of 29 weeks. From 20 weeks onward till 72 week age, all the birds were offered commercial layer rations *ad libitum*, prepared according to climatic conditions. The results of the study revealed that birds reared under natural and constant light had higher weights than decreasing light, yet they could not out perform during production period. The effect of feed and nutrient restriction, on the other hand, was found significant during rearing as well as production period. The birds exposed to higher level of feed and those exposed to nutrient restriction were lighter in weight. The 100% fed birds laid their first egg at an early age. However, those reared on 85% of the recommendation excelled all other groups in terms of produced number of eggs, egg mass, hen housed and hen day production and net returns.
(Key Words : Pullet Rearing, Photoperiod, Feed Restriction)

INTRODUCTION

In commercial poultry a number of methods have been tried to optimize the performance and efficiency of production. *Ad libitum* feeding during growing stage result in early maturity and higher abdominal/carcass fat in the body, generally associated with reduced egg production, livibility and reproductive performance (Fuller et al., 1973; McDaniel et al., 1981; Robbins et al., 1986; Prasad et al., 1991). Quantitative feed restriction has been found to reduce body weights (Fattori et al., 1993), delay sexual maturity and improve egg size at the start of production (Fattori, et al., 1991a; Sodhi and Sharma, 1992 ; Krishnappa et al., 1992), with higher rate of lay and economy of feeding during laying cycle (Nasheim et al., 1979; Wilson et al., 1989). A number of reports (Lilburn et al., 1992; Sunde, 1992), indicated that rearing and laying period light hours could also affect the productive performance of birds. However, feed or nutrient restriction without or with photoperiod manipulation are now becoming common practice to rear pullets on less feed, more uniformity in body size and maximum efficiency of production. This study was conducted to determine the effect of feed or nutrient and light restrictions during rearing period on performance of commercial layers.

MATERIALS AND METHODS

Five hundred day old chicks of Babcock ISA white egg layer strain were reared up to 8 weeks of age under uniform conditions of lighting, feeding and management. At the age of 7 weeks, 432 uniform pullets were selected, wing banded and randomly distributed into 36 experimental units of 12 pullets each. Three experimental rooms of equal size 7.6 × 7.0 meter were partitioned so as to prepare 12 pens of same size (9,230 × 120 cm) in each room, with saw dust as litter on floor.

Four rations namely starter, grower, developer and layer mash were prepared to feed during 0 to 6 weeks, 6 to 12 weeks, 12 to 20 weeks and 20-72 weeks of age,

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respectively. In addition, to this a low protein (13%) and low energy (2,500 kcal/kg) ration was also prepared which was used from 8-20 weeks for one treatment group only. The composition of these rations is shown in table 1.

Table 1. Composition of the rations fed at various ages

Ingredients (percent)	WEEKS OF AGE					
	0 – 6	6 – 12	12 – 20	8 – 20	20 – 45	45 – 56
		standard		low protein low energy	Cool *	hot**
					weather	
Maize	10	10	08	07	20	22
Rice Broken	19	22	30	42	12	08
Wheat	20	20	21	16	25	27
Wheat Bran	–	–	–	10	–	–
Gluten feed 30%	07	07.5	08	09	–	–
Gluten feed 60%	02	01	–	–	06	04
Rice Polish	08	08	08	–	08	10
Cotton Seed Meal	07	07	05	–	06	06
Guar Meal	04	04	–	–	–	–
Sun Flower Meal	04	04	04	02	–	–
Rape Seed Meal	03	03	04	03	–	–
Fish Meal	08	07.5	06	04	08	08
Blood Meal	02	–	–	–	–	–
Bone Meal	01	01	01	01	02	02
Soybean Meal	–	–	–	–	02	02
Lime Stone	01	01	01	01	07	07
Molasses	03	03	03	04	03	03
Premix	01	01	01	01	01	01
Crude protein (%)	21	19	16	13	17.1	16.3
ME (Kcal/kg)	2,750	2,750	2,691	2,500	2,750	2,750
Calcium (%)	1	1	1	1	4	4
Available Phosphorus (%)	0.5	0.5	0.5	0.5	0.5	0.5

* Cool weather means when poultry house temperature was 15-28℃.
** Hot weather means when poultry house temperature was 29-40℃.

At the age of 8 weeks, 12 experimental units were randomly allotted to any one of the following three lighting regimes, in separate windowless rooms, and kept there on floor till 20 weeks of age.

(A) Natural day light supplemented with some artificial light so as to provide approx. 0.5 ft. candle intensity that started from 13.24 hr/day at 8 weeks of age and ended by 10.41 hr/day at the end of the 20th week. (This provided a total of 1,015 light hours in 12 weeks).

(B) Constant 11 hr/day light, provided by using artificial source equal to 0.5 ft. candle from 8-20 weeks of age, (thus providing a total of 924 light hours in 12 weeks).

(C) Decreasing light of 0.5 ft. candle starting with 13 hr/day at 8 weeks and decreasing at the rate of 20 minutes per week till 20 weeks of age, (thus providing 938 hours of total light during the same period).

Commercial grower (8-12 weeks) and developer (12-20 weeks) rations (table 1) were offered at 100 (D), 85 (E) or 70 percent (F) of recommended allowance, prescribed in technical bulletin of Babcock white egg layers, to 3 experimental units under each of the three light regimes. While rest of the 3 experimental units under each light regime were offered (8-20 weeks) on low protein (13%) and low energy (2,500 Kcal/kg) ration (G).

At the age of 20 weeks, all the groups of pullets reared under various lighting and feeding regimes were shifted to cages under uniform lighting, feeding and management, for 32 weeks production period. During 21st week light was increased to 12 hr a day and thereafter, with an increase at the rate of 30 min per week, to 16 hr a day at the age of 29 weeks. From 20 weeks onward till 72 weeks age, all the pullets were offered commercial layer rations *ad libitum*, prepared according to the climatic condition (table 1).

The body weight and feed consumption of individual birds were recorded weekly from 8-20 weeks of age and at 4 weeks interval, thereafter. The record of the first egg and later production of each bird, reared under different light and feed restriction, were maintained and used to calculate hen housed production, hen day production, age at peak production, percentage peak production and total mean egg production for 32 weeks. All the eggs were weighed weekly to determine average egg weight and egg mass of each experimental unit.

The data collected on various parameters during the experimental period were processed for statistical analysis using MSTAT package (Nissen, 1986).

RESULTS AND DISCUSSION

Average weight gain, feed consumption and feed efficiency of birds, during the 12 weeks experimental period of 9 to 20 weeks age, on the three light and four feeding regimes have been summarized in table 2 and 3, respectively.

Table 2. Effect of lighting regimes on body weight, weight gain, feed consumption and feed efficiency of birds

Lighting regimes	Av. body weight (gm)		weight gain (gm)	Av. feed consumption (gm)	Feed efficiency (feed/gain)
	8 weeks	20 weeks			
A) Natural light	450.91	1,248.68	797.77^a	4,041^b	5.17^b
B) Constant light	453.24	1,227.23	773.99^a	4,190^a	5.50^a
C) Decreasing light	472.38	1,220.92	748.54^b	4,210^a	5.70^a

$^{a-b}$ Same superscripts on means in various columns show non-significant ($p < 0.05$) differences.

Table 3. Effect of feeding regimes on body weight, weight gain, feed consumption and feed efficiency of birds

Feeding regimes	Av. body weight (gm)		Weight gain (gm)	Av. feed consumption (gm)	Feed efficiency (feed/gain)
	8 week	20 week			
D) *Ad libitum* feeding	461.87	1,279.29^a	817.42^a	3,908^b	4.80^b
E) 85% of requirement	466.09	1,274.96^a	808.87^a	3,687^c	4.56^b
F) 70% of requirement	458.52	1,224.82^b	766.30^b	3,175^d	4.14^c
G) Low protein, low energy	448.88	1,150.00^c	701.12^c	5,817^a	8.30^a

$^{a-d}$ Same superscripts on means in various columns show non-significant ($p < 0.05$) differences.

The pullets reared on natural day light (A) had the highest weight gain with non-significant difference from those on 11 hours continuous light (B). However, the birds reared on decreasing light (C) had significantly ($p < 0.05$) lower weight gain compared with former two groups. It may be recalled that natural day light during the experimental period, was also decreasing but at a lower (about one half) rate compared with the group C, exposed to 20 minutes per week decreasing light period. The birds on natural day light not only consumed significantly ($p < 0.05$) less feed but also had the best feed conversion efficiency. The birds on the other two light periods consumed similar amounts of feeds but those on decreasing light had the poorest ($p < 0.05$) feed efficiency.

The earlier work of Leeson and Summers (1985) also revealed higher weight gain of birds reared on longer photoperiod but in another experiment the same workers were unable to find such improvement. Similarly the work of Petersen et al. (1986a) led to the inference that less light period resulted in lower body weight. The lower body weight on decreasing light regime have been attributed (Noles and Smith, 1964) to reduced growth rate associated with rapid decrease in daily light period. Andrews et al. (1990) also reported that birds reared under constant light from 4 to 18 weeks consume more feed and gain more compared with those on decreasing light. Improvement in feed efficiency with less light and restricted feeding had been reported by Goldrosen and Buckland (1976) but the work of Petersen et al. (1986a) revealed reduced feed consumption on less light.

Auckland (1978) however, could not find any difference in final body weight and feed efficiency of birds reared on 23, 14 or 8 hr/day light.

The results of feed restriction indicated a linear decrease in weight gain through increasing feed restriction and feeding pullets on ration containing lower levels of protein and energy. Simultaneously the efficiency of feed conversion was improved significantly but those fed ration containing lower protein and low energy consumed more feed and performed poorly ($p < 0.01$). It has been reported (Plavnik et al., 1986; Krishnappa et al., 1992) that limiting nutrient intake at an early age resulted in lower weight gain with better feed efficiency. The work of Hagos and Devegowda (1989) on broiler breeder pullets exposed to similar restriction had shown similar reduction in body weight on respective diets. Feed restriction improve the biological efficiency of feed conversion (Belyavin, 1986).

Decrease in body weight with protein restriction in diet has also been reported by Reddy et al. (1988). Dietary energy restriction by 15 or 30 percent significantly decreased live weight gain (Pliavink et al., 1986) and feed utilizing efficiency of hens during growing period (Prased et al., 1991; Lee, 1987). However, the restriction imposed by controlled feeding (Belyavin, 1986) and by giving high fiber diet (Sodhi and Sharma, 1992) although reduced growth but recovery of growth occurred immediately after the end of such restriction due to compensatory growth. The birds fed 70 percent of *ad libitum* feed consumed significantly less feed than others (Reddy and Eswaraiah, 1988) while *ad libitum* fed birds had significantly greater body weight (Sharma and Sharda, 1987b) and feed intake than restricted daily (Savory et al., 1993). However, the extent of weight reduction in high line was more than crosses (Barbato et al., 1983). Severely restricted birds showed a reduction in body growth due to cessation of muscle fiber growth in pectoralis muscles of chickens (Gille et al., 1992).

Table 4. Effects of lighting regimes on mean age at first egg, egg weight and body weight of birds at sexual maturity

Lighting regimes	Age at first egg (days)	Egg weight (gm)	Body weight (gm)
A) Natural light	151.8	39.08	1,405.2
B) Constant light	151.8	40.25	1,385.1
C) Decreasing light	150.2	40.98	1,391.1

The difference in age of the birds, reared under different light regimes, at the first egg, egg weights and the weights of birds first egg were non-significant (table 4). However, the effect of feeding regime was significant on all these parameters, except body weight. The birds reared on *ad libitum* feeeding showed early ($p < 0.05$) sexual maturity, but it was delayed by 5, 8 and 11 days in case of group E. F and G, respectively. (table 5). The *ad libitum* fed group layed their first egg earlier but with less weight. The body weight of brids at their first egg were non-significantly ($p < 0.05$) affected by rearing period feed restrictions.

Table 5. Effect of feeding regimes on mean age at first egg, egg weight and body weight of birds at sexual maturity

Feeding regimes	Age at first egg (days)	Egg weight (gm)	Body weight (gm)
D) *Ad libitum* feeding	146.0[d]	36.15[b]	1,394.9
E) 85% of requirement	149.9[c]	40.22[a]	1,377.6
F) 70% of requirement	153.2[b]	40.83[a]	1,370.4
G) Low protein low energy	155.9[a]	43.22[a]	1,363.2

[a-d] Same superscripts on means in a columns show non-significant ($p < 0.05$) differences.

The age at sexual maturity is although genetically determined, yet some manipulation can be done by photoperiod (Hawes et al. 1991). For example the exposure of newly hatched chicks to long days for several weeks with subsequent transfer to short days delays the onset of sexual maturity (Sharp, 1992). But in order to undergo the process leading to lay, female chicken must reach a minimum threshold age and body weight which require some minimum amount of light stimulation (Eitan and Soller, 1991). In our study the birds exposed to different light treatments were similar in body weight, at the onset of maturity indicating that light provided to them was sufficient to stimulate the onset of maturity. Similar to our results, Woodard et al. (1986) also reported that neither light conditioning nor duration had any appreciable effect on lay of first egg. But different lines of birds may behave differently under different lighting systems (Eitan and Soller, 1991).

The occurrence and nature of production responses of hens during laying period caused by restriction during rearing are important because of the wide spread use of this practice in poultry industry. Recent increase in feed cost has boosted interest in quantitative feed restriction (Reddy and Eswaraiah, 1988), which is also preferred because of its advantageous effect on egg mass, rate of lay and economy of feeding (Lee et al. 1971; Gous, 1978; Nasheim et al. 1979). However, the extent of restriction response may vary from breed to breed (Mbugua and Cunningham, 1983; Najib and Al-Noor, 1987). In our study feed restriction significanlty delayed the onset of first egg with corresponding increase in egg weight and decrease in body weight. It has been reported (Hurwitz and Plavnik, 1989) that body weight was positively correlated with age at onset of egg producion and egg weight was a function of both age and body weight at the onset of production. Feed restriction delay the onset of egg production leading to some influence on egg weight. Summers and Leeson (1983) however, held responsible the body weight to be the main factor directly affecting early egg size. Most of the workers (Johnson et al., 1984; Kwakkel et al., 1991; Fattori et al., 1991b; Sodhi and Sharma, 1992; Krishnappa et al., 1992) agree that restricted feeding delay the sexual maturity by decreasing body weight and improve egg size at the start of production. Restricting nutrient content (Lillie and Denton, 1966) of the feed, particularly energy (Kirkland and Fuller, 1971) and protein (Wright et al., 1968; Voitle et al., 1970) have been used to delay the sexual maturity satisfactory.

The results of our study are supported with much of the earlier work on the subject and it can be inferred that feed and nutrient restriction during rearing period can be used to delay the sexual maturity which not only save the costly feed but also improve the egg size at the start of production.

During the production period the effect of previous light restriction on productive performance was found non-significant (table 6), but the effect of feed restrictions on productive performance was found significant ($p < 0.01$), The birds reared on 85% of the requirement, produced maximum ($p < 0.01$) eggs, with non-significant differences among the other three groups. Since the average weights during production cycle did not vary significantly among group, the birds of this group also produced more egg mass per bird. Hen housed and hen day calculations followed a similar pattern (table 7). The effect of rearing period light and feed restrictions on the attainment of peak egg production were found non-significant. All the birds reared under different photoperiods attained their peak production at 29 weeks of age, however, it was maintained for only a week. But the birds reared on *ad libitum*, 85 or 70 percent feeding attained peak at 27 weeks age and those reared on low energy-low protein ration attained peak at 29 weeks age. All the groups however, maintained it for one week only. Similarly the effect of rearing period light on subsequent feed intake or feed efficiency was non-significant (table 8). The birds previously restricted in respect of feed intake took comparable feed during production cycle (table 9), however, those reared on 85 percent of the requirement, utilized it more effeciently due to higher egg production.

Table 6. Effect of different lighting regimes on egg production and egg mass

Lighting regimes	Egg number/hen	Hen housed production (%)	Hen day production (%)	Egg weight (gm)	Egg mass (kg/hen)
A) Natural light	193.4	77.30	77.55	54.20	10.50
B) Constant light	195.0	78.06	78.32	54.02	10.55
C) Decreasing light	194.5	77.87	78.22	53.72	10.46

Table 7. Effect of different feeding regimes on egg production and egg mass

Feeding regimes	Egg number/hen	Hen housed production (%)	Hen day production (%)	Egg weight (gm)	Egg mass (kg/hen)
D) *Ad libitum* feeding	191.7^{b}	76.67^{b}	77.26^{b}	53.77	10.33^{b}
E) 85% of requirement	204.7^{a}	81.95^{a}	81.95^{a}	54.34	11.12^{a}
F) 70% of requirement	189.0^{b}	75.79^{b}	76.16^{b}	54.29	10.27^{b}
G) Low protein low energy	191.9^{b}	76.54^{b}	76.74^{b}	53.53	10.28^{b}

$^{a\text{-}b}$ Same superscripts on means in various columns show non-significant ($p < 0.05$) differences.

The results of variable light treatment during growth period of the pullets, on the whole, did not show any influence on subsequent production performance to layers. The reason might be that the light restriction was not so pronounced that could affect the growth rate of pullets to any significant extent, and the birds under three light regimes consumed similar amounts of feed and matured at about the same time. The reports of some workers

Table 8. Effect of different lighting regimes on average feed consumption and feed efficiency

Lighting regimes	Feed consumption per hen (kg)	Feed intake (kg)/dozen eggs	Feed intake (kg)/kg egg mass
A) Natural light	26.12	1.62	2.49
B) Constant light	25.94	1.60	2.46
C) Decreasing light	25.82	1.59	2.47

Table 9. Effect of different feeding regimes on average feed consumption and feed efficiency

Feeding regimes	Feed consumption per hen (kg)	Feed intake (kg)/dozen eggs	Feed intake (kg)/kg egg mass
D) *Ad libitum* feeding	26.30	1.64[a]	2.55[a]
E) 85% of requirement	26.04	1.53[a]	2.34[c]
F) 70% of requirement	25.31	1.61[a]	2.47[b]
G) Low protein low energy	26.19	1.64[a]	2.55[a]

[a-c] Same superscripts on means in various columns show non-significant ($p < 0.05$) differences.

(Petersen et al., 1986b; Erch and Rose, 1987; Andrews et al., 1990; Curtis et al., 1992) favouring the idea of higher egg production by light restricted birds are based on much wider differences in light periods provided to the growing birds under study. Actually the egg number, weight and mass increased with advancing age of pullets and is more affected by the feeding pattern than light regimes (Ei Aggoury et al., 1989).

Keeping in view the previous work on feed restriction, there is little doubt that restricting birds to 85 percent of recommended, is not severe restriction program to adversely affect the performance (Pepper et al., 1961; Berg and Bearse, 1961). Mild feed restriction during rearing result in no effect (Velasco, 1987; Kwakkel et al., 1991; Fattori et al., 1991a) to increase number of egg and size (Robinson et al., 1989; Hurwitz and Plavnik, 1989; Hocking, 1990; Bunan, 1990; Krishnappa et al., 1992) but when the differences in production become wider the size of the egg may reduce slightly (Kashiwagi et al., 1981).

In our study the feed restriction in rearing period upto 70 percent of recommended had comparable performance to that of control, while low level feed restriction resulted in improved performance of birds. There are some reports (Sharma and Sharda, 1987a; Reddy, 1987) where feeding at 80 and 70 percent of feed intake significantly increased egg weight and egg production. These variations may be attributed to the period of restriction and age of birds at the time of its imposition which varied in experiments of different workers.

The dietary protein restriction decreased total egg production of pullets but egg size was not affected (Lilburn et al., 1987; El-Dokroury et al., 1987). However, it is the extent of restriction which matter. A level of 13.5 percent protein in diet may not affect production (Lilburn et al., 1987; Reddy et al., 1989) but reduction beyond this level may result in reduced egg weight (Reddy et al., 1988; Kavous and Mark, 1992) and hen day percentage egg yield (Prasad et al., 1991).

The birds fed *ad libitum* and exposed to feed restrictions consumed similar amounts of feed during the production period (21-56 weeks age). But, since the birds exposed to low level feed restriction produced more number of eggs with no effect on egg weight and thus produced more egg mass during the laying period, their efficiency of feed utilization was much better ($p < 0.05$) compared with other groups. Such improvement in feed conversion has earlier been reported by many workers including Reddy (1987) and Krishnappa et al. (1992) but not by Plavnik (1987) and Reddy (1992). Some workers (Johnson et al., 1984) have also observed higher feed intake by birds following the feed restriction but in our and many other studies (Tomhave, 1962; Macintyre and Gardiner, 1964; Gous, 1978) this was not the case and there was no carry over effect of previous feed restriction on subsequent feed intake.

The economic appraisal of the project led to the inference that the effect of light period within the tested limits was minimum. The birds reared on 85 percent of the requirement, however, excelled all other groups, followed by those fed on 70 percent of the requirement, *ad libitum* feeding of a standard ration and protein energy deficient ration.

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