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BIOLOGICAL AND ECONOMIC PERFORMANCES OF BROILER CHICKENS AS AFFECTED BY DAYLENGTH AND FOOD LOCATION

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SUMMARY

The effects of daylength and food location on biological and economic performances were studied in broiler chickens. Commencing from 14 days of age, equal number of chicks were provided either 12 h of natural lighting (12L) only or 12 h natural lighting and 12 h supplementary lighting (24L). For each lighting regimen the chickens were provided food either at fixed (FF) or alternated (AF) (alternated daily at 1945 h) location. Within the 12L group, FF female chicks were heavier than their AF counterparts on Days 21 and 28. On Day 35 and thereafter, regardless of treatment groups, growth of female chicks was similar. Neither lighting regimen nor food position had significant effect on body weight of males throughout the duration of study. Regardless of daylength and food location, the amount of food consumed (except from Days 14 to 20), feed conversion ratios and incidence of leg deformities were similar. Financial analysis showed a higher net profit for 12L birds.

Keywords: Daylength, food location, growth, economics, broiler chickens

INTRODUCTION.

Lighting may have profound impact on the physiology, behaviour and well being of poultry. In the context of broiler production, one of the primary functions of light is to allow birds to locate food and water. The common husbandry practice is to raise broilers under continuous or near continuous illumination. This is to optimize growth through increased feed intake, digestion and absorption of nutrients (Buyse *et al*., 1996). There are, however, conflicting findings with regard to the influence of daylength on growth of broilers. While Freeman *et al*. (1981), Robbins *et al*. (1984) and Whitley *et al*. (1984) reported that broilers raised under continuous or near continuous photoperiod had improved growth, the findings of Lowe and Heywang (1961) and Skolund *et al*. (1966) suggested negligible benefit from supplementing natural daylength. The little effect of light supplementation on growth could be partly attributed to the ability of chickens to eat in darkness. Cherry and Barwick (1962) suggested that light was not essential for feeding activity, provided the birds have known their way about the pens. In addition, extended photoperiod may increase energy expenditure as a result of excessive locomotor activity, thus, feed efficiency could be impaired (Perry, 1981). There is uncertainty, however, whether 12 h of natural light is adequate to allow maximum food intake and optimum growth of broilers under local conditions.

While most light pattern studies emphasize the influence on growth and feed efficiency, there is a paucity of information on the economics of the practice, particularly under local conditions. With the constant economic pressure on broiler producers to reduce the cost of production, there is a necessity for more studies to evaluate the economic aspects of various lighting programmes. Thus, the present study was undertaken to determine the biological and economic performances of broilers provided either 12 h of natural lighting only or 12 h natural lighting and 12 h supplementary lighting under local conditions. In addition, the effect of food location on food consumption and concomitant growth was also examined.

MATERIALS AND METHODS

Birds and husbandry

One hundred and sixty day-old straight run broiler chicks (Avian) were housed in a conventional open-sided house with cemented flooring and wood shavings as litter. Starter (crumble form; 21% crude protein and 2900 kcal ME/kg) and finisher (pellet form; 19% crude protein and 3050 kcal ME/kg) diets were provided from Days 1 to 20 and Day 21 onwards, respectively. Water and food were available *ad libitum*. Birds were under continuous fluorescent illumination.

Commencing from Day 14, chicks were wingbanded, weighed, and randomly assigned in groups of 8 to 20 battery cages with wire floors. Equal number of chicks were provided either 12 h natural lighting (12L) (of dawn and dusk were about 0600 h and 1920 h, respectively) or 12 h natural lighting and 12 supplementary lighting (fluorescent lighting) (24L). The mean intensities of the supplementary lighting measured at birds' level was 6 lux. The battery cages for each lighting regimen were in two different houses. Both houses were of conventional open-sided type with average annual ambient temperatures ranging from 25°C to 35°C and relative humidity was between 75% to 90%. In order to evaluate the importance of food location and ability to eat in the dark, 12L and 24L chicks were provided food either at fixed (FF) or alternated (AF) position. For the AF group, location of food was changed daily (i.e. either to left or right side of cages) at 1945 h (light intensity in the house at 1945 h was about 1 lux).

Traits measured and statistical analyses

Birds were weighed individually on Days 14, 21, 28, 35 and 42. Food intake was recorded weekly and feed conversion ratios were determined from Days 21 to 27, 28 to 34 and 35 to 41. Mortality and incidence of leg deformities were recorded daily. Leg abnormality was defined as follows; (1) birds that were able to walk upon prompting but with a slight limp, (2) birds with a more distinct limp, or (3) birds which had great difficulty in walking and would likely be culled under commercial practice. Financial assessment was based on the market price of October to December, 1996. Dead chicks were sexed by gonadal examination. At the end of the trial, sex of survivors was determined by the size of comb.

Body weight data on Days 21, 28, 35 and 42 were analysed with ANOVA for each sex, with lighting regimen, position of food and interaction between them as source of variations. Prior to analyses, body weight data were transformed to common logarithm. The same factorial arrangements were used to analyse food consumption and feed conversion ratios. Survivability and incidence of leg abnormalities data were analysed by chi-square. When interactions between main effects were significant, comparisons were made within each experimental variable. Means were considered significantly different at $P \leq 0.05$. All analyses were conducted with the aid of the General Linear Models (GLM) procedure (SAS® Institute, 1982).

RESULTS

Initial mean body weights (Day 14) of birds were similar among treatment groups. There were lighting regimen by food location interactions for body weight (BW) of females on Days 21 and 28 (Table 1). Within the AF group, 24L female chicks were heavier than their 12L counterparts, whereas weights of FF females were similar for both lighting regimens. The interactions disappeared by Day 35 when both AF and FF female broilers, regardless of lighting regimen had similar BW (Table 2). Mean body weights of males did not differ between lighting groups and food locations throughout the period of study (Table 3). Mean feed intakes and feed conversion ratios are depicted in Tables 4 and 5, respectively. Except from Days 14 to 20, where 24L chicks consumed more food than those provided 12L, lighting regimen had no significant influence on amount of food consumed. Food intake was not affected by location of food throughout the period of study. Neither daylength nor position of food had significant effect on feed conversion ratios. Regardless of daylength and position of food, mortality rate (24L-FF, 22.5%; 24L-AF, 22.5%; 12L-FF, 20.0%; 12L-AF, 22.5%) and incidence of leg deformities (24L-FF, 5.0%; 24L-AF, 2.5%; 12L-FF, 2.5%; 12L-AF, 2.5%) were similar. Results of financial assessment are illustrated in Table 6. The net profit per bird was in the order of 12L-FF > 12L-AF > 24L-FF > 24L-AF.

Table 1. Mean (± SEM) body weights (g) of female chicks on Days 21 and 28 where lighting regimen[1] by food location[2] interaction was significant

	Day 21		Day 28	
	12L	24L	12L	24L
Food location				
Fixed	684 ± 12.0	682 ± 23.6	1099 ± 23.4	1062 ± 41.9
	NS	*	NS	*
Alternated	653 ± 13.4[a]	736 ± 13.2[b]	1057 ± 20.7[a]	1157 ± 19.5[b]

Mean within a row-subgroup with no common letters differ significantly ($P \leq 0.05$).

* A significant difference ($P \leq 0.05$) between means within a column.

[1] Commencing from Day 14, birds were provided either 12 h of natural lighting (12L) or 12 h natural lighting and 12 h supplementary lighting (24L).

[2] Commencing from Day 14, birds were fed either at fixed or alternated (alternated daily at 1945 h) position.

Table 2. Mean (± SEM) body weights (g) of female chicks on Days 35 and 42 by lighting regimen[1] and food location[2]

	Day 35	Day 42
Lighting regimen		
12L	1504 ± 20.9	1842 ± 34.0
24L	1477 ± 30.2	1809 ± 35.7
Food location		
Fixed	1471 ± 30.8	1808 ± 40.9
Alternated	1512 ± 17.8	1844 ± 25.5

There was no significant difference (*P>0.05*) between means within a column subgroup
[1] Commencing from Day 14, birds were provided either 12 h of natural lighting (12L) or 12 h natural lighting and 12 h supplementary lighting (24L).
[2] Commencing from Day 14, birds were fed either at fixed or alternated (alternated daily at 1945 h) position.

Table 3. Mean (± SEM) body weights (g) of male chicks on Days 21, 28, 35 and 42 by lighting regimen[1] and food location[2]

	Day 21	Day 28	Day 35	Day 42
Lighting regimen				
12L	691 ± 12.3	1142 ± 21.6	1607 ± 32.2	2019 ± 47.1
24L	691 ± 16.9	1158 ± 24.8	1579 ± 31.4	1930 ± 48.2
Food location				
Fixed	687 ± 12.7	1147 ± 22.3	1599 ± 31.8	1984 ± 47.7
Alternated	695 ± 16.6	1153 ± 24.4	1586 ± 31.9	1961 ± 48.7

There was no significant difference (*P>0.05*) between means within a column subgroup
[1] Commencing from Day 14, birds were provided either 12 h of natural lighting (12L) or 12 h natural lighting and 12 h supplementary lighting (24L).
[2] Commencing from Day 14, birds were fed either at fixed or alternated (alternated daily at 1945 h) position.

Table 4. Mean (± SEM) feed intakes (g) from Days 14 to 20, 21 to 27, 28 to 34, and 35 to 41 by lighting regimen[1] and food location[2]

	Days 14 to 20	Days 21 to 27	Days 28 to 34	Days 35 to 41
Lighting regimen				
12L	456 ± 6.9[a]	721 ± 9.4	860 ± 11.6	970 ± 19.3
24L	508 ± 16.9[b]	746 ± 22.6	892 ± 23.5	950 ± 22.3
Food location				
Fixed	478 ± 10.5	717 ± 12.8	859 ± 15.3	950 ± 17.4
Alternated	485 ± 19.1	751 ± 20.2	890 ± 21.4	970 ± 23.9

Means within a column-subgroup with no common letters differ significantly ($P \leq 0.05$).
[1] Commencing from Day 14, birds were provided either 12 h of natural lighting (12L) or 12 h natural lighting and 12 h supplementary lighting (24L).
[2] Commencing from Day 14, birds were fed either at fixed or alternated (alternated daily at 1945 h) position.

Table 5. Mean (± SEM) weekly feed conversion ratios (feed/gain) from Days 14 to 20, 21 to 27, 28 to 34, and 35 to 41 by lighting regimen[1] and food location[2]

	Days 14 to 20	Days 21 to 27	Days 28 to 34	Days 35 to 41
Lighting regimen				
12L	1.56 ± 0.01	1.66 ± 0.02	1.92 ± 0.04	2.60 ± 0.20
24L	1.56 ± 0.04	1.71 ± 0.07	2.18 ± 0.12	2.78 ± 0.63
Food location				
Fixed	1.54 ± 0.02	1.65 ± 0.02	2.03 ± 0.05	2.64 ± 0.23
Alternated	1.58 ± 0.04	1.72 ± 0.07	2.08 ± 0.13	2.74 ± 0.23

[1] Commencing from Day 14, birds were provided either 12 h of natural lighting (12L) or 12 h natural lighting and 12 h supplementary lighting (24L).
[2] Commencing from Day 14, birds were fed either at fixed or alternated (alternated daily at 1945 h) position.

Table 6. Economic performance[1] (per bird) by lighting regimen and food location subgroup

Item	12L-FF	12L-AF	24L-FF	24L-AF
(a) Cost of day old chick (RM)	0.65	0.65	0.65	0.65
(b) Cost of starter diet (RM)	0.85	0.83	0.87	0.81
(c) Cost of finisher diet (RM)	2.43	2.46	2.42	2.55
(d) Overhead cost* (RM) (8% of a+b+c)	0.31	0.32	0.32	0.32
(e) Cost of supplement lighting (RM)	-	-	0.09	0.09
Total (RM)	4.24	4.26	4.35	4.42
Average final live weight (kg)	1.95	1.92	1.85	1.90
Selling price** (RM 2.90/kg)	5.66	5.57	5.37	5.51
Net profit per bird (RM)	1.42	1.31	1.02	1.09

[1] Mortality was not accounted in the financial analysis because there was no significant (*P*>0.05) differences in the parameter among the various lighting regimen- food location subgroups.
[2] Commencing from Day 14, birds were provided either 12 h of natural lighting (12L) or 12 h natural lighting and 12 h supplementary lighting (24L).
[3] Commencing from Day 14, birds were fed either at fixed (FF) or alternated (AF) (alternated daily at 1945 h) position.
* Overhead include building depreciation, water, electricity, medication and labour. Overheads ranged from 8 to 12% of total cost (Yussof, 1982)
**Selling price of chicken per kg live weight was at RM 2.90, based on the market price of October to December 1996.

DISCUSSION

In the context of broiler production, one of the primary functions of light is to allow birds to locate food and water. According to Savory (1976) and Sykes (1983), broilers consumed food in small quantities at regular intervals throughout the day. Hence, it appears that continuous or near-continuous illumination is required for maximum feed intake and optimal growth.

In the present study, the significant lighting regimen by food location interaction for BW of female chicks on Days 21 and 28 suggests that the amount of light required for maximum feed intake and optimal growth is dependent on the ability of broilers to locate food in darkness. Female chicks subjected to 12L-FF had similar BW to those raised under 24L-FF, suggesting that the former were able to eat considerable proportion of food during the scotoperiod. In contrast, growth of 12L females were retarded when fed AF. This suggests the failure of 12L-AF females to locate food, which was alternated in the dark (1945 h). Thus, it appears that light is not essential for feeding activity, provided the birds have learn the location of the food. Similarly, Cherry and Barwick (1962) compared the growth of chicks in continuous darkness from 7 days of age to those raised under continuous illumination. The authors noted that body weight at 9 weeks of age was similar regardless of lighting pattern. Cherry and Barwick (1962) concluded that after the preliminary training period of one week (adequate light was provided during the training period) during which chicks have known the location of food, they were able to eat in the dark. Hence, the present findings support those of Cherry and Barwick (1962) that light has no direct physiological influence on the growth of birds.

The present findings add to the growing body of evidence (see Fraser and Broom, 1990) that experience, a mental construct which results from some event in the environment, is an important component of learning in farm animals. Albeit the 24L-AF females were heavier than their 12L-AF counterparts on Days 21 and 28, suggesting lower food intake in the latter, both groups had similar body weight by Day 35. These findings suggest that by Day 35, the female chicks have discovered the repeated procedure of alternating the food. Thus, the "experienced" chicks were able to locate the food despite the absence of light.

It is interesting to note that 24L-AF female chicks were heavier than their 24L-FF counterparts on Days 21 and 28. There is a possiblility that the practice of alternating the food location of 24L-AF chicks daily may have "stimulated" their feeding activity and subsequently improved growth. Teeter (1994) indicated that physical shaking of feeders may increase food consumption in broilers. Hence, it appears that physical "manipulation" of feeders may elicit feeding activity in chickens.

Results of this experiment are consistent with earlier findings (Cherry and Barwick, 1962; Perry, 1981) concerning sexual dimorphism for body weight in response to various lighting patterns. Whilst there was significant lighting regimen by food location interactions for BW of females on Days 21 and 28, BW of males was not affected by either factors throughout the experimental period. These discrepancies could be attributed to the larger gizzard-gastrointestinal tract in males (Brake *et al.*, 1993) which enabled them to increase their food intake and store more effectively prior to dark, thus, increasing available energy during the scotoperiod (Gordon, 1994). Buyse (1993) indicated that broilers raised under 14 h light stored food eaten during the late afternoon in the crop, proventriculus and gizzard for utilization in the dark. Hence, our findings strengthen the hypothesis that there are sex differences in responding to environmental fluctuations in broilers (Perry, 1981).

On Day 21, 24L-AF females were apparently heavier than males (regardless of lighting regimen and food location) of the same age. This is not to be expected based on the dimorphism in body weights between female and male broilers. No clear explanation for the phenomenon can be offered at this stage.

In the preceding discussion, the significant lighting regimen by food location interactions for BW of females on Days 21 and 28 were associated with amount of food consumed from Days 14 to 20 and 21 to 27. However, similar interactions were not noted for feed intake data. A possible explanation for the contradictions, is that BW data were recorded individually according to sex, whereas amount of food consumed was measured on cage basis, where both sexes were intermingled. The lack of daylength influence on feed conversion ratios is in agreement with the findings of Cherry and Barwick (1962) and Ngian

There is evidence from several sources (see reviews by Gordon, 1994; Buyse *et al.*, 1996) suggesting that lighting programme may have profound impact on leg health. Broilers raised from hatch to slaughter under a continuous illumination were more susceptible to leg problems. In discussing the important role of daylength in incidence of leg deformities, Gordon (1994) indicated that the slower growth rates of birds provided a shorter daylength may have accounted for some of the improvement in leg health. Our data, however, do not support the notion because albeit 24L-AF females were heavier than their 12L-AF counterparts on Days 21 and 28, there were no differences in incidence of leg deformities between the two groups of birds.

Regardless of lighting regimen and food location subgroup, mortality rate was higher than expected. All deaths occured on a single day and post-mortem lesions of these birds were suggestive of heat prostration.

In the present study, and as noted by Ngian (1980), birds provided 12 h of light gave the highest return. The lack of differences in final BW and feed conversion ratios between 12L and 24L regimens, and added cost of additional lighting at night for 24L birds may have accounted for the lower profit of 24L regimen. In conclusion, data from the 12 h natural lighting regimen strongly suggest that the lighting pattern could be practised to raise broilers under local conditions without impairment of growth, provided the birds have known the location of food, and would be economically superior to those under continous illumination.

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RINGKASAN

Kesan pencahayaan dan lokasi makanan terhadap prestasi biologi dan ekonomi telah dikaji dalam ayam pedaging. Bermula daripada umur hari 14, sebilangan anak ayam sama banyak dibekalkan sama ada dengan 12 j cahaya semula jadi sahaja (12L) atau 12 j cahaya semula jadi dan 12 j cahaya tambahan (24L). Untuk setiap rejim pencahayaan ini, anak ayam dibekalkan sama pada lokasi tetap (FF) atau lokasi terselang (AF) (diselangkan setiap hari pada 1945 j). Dalam kumpulan 12L, ayam betina FF adalah lebih berat daripada ayam AF pada Hari 21 dan 28. Pada Hari 35 dan seterusnya, tidak kira kumpulan perlakuan, pertumbuhan ayam betina adalah serupa. Sepanjang kajian kedua-duanya, rejim pencahayaan dan penempatan makan tidak memberi kesan tererti terhadap berat badan ayam jantan. Jumlah makan yang dimakan (kecuali pada Hari 14 hingga 20), kadar penukaran makanan dan insidens kecacatan kaki adalah serupa, iaitu tidak bergantung kepada kadar pencahayaan atau lokasi makanan. Analisis kewangan menujukkan keuntungan bersih lebih tinggi untuk ayam 12L.