Ahemeral Light Cycles and Protein Levels for Older Laying Hens[1]

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ABSTRACT Variations in light: dark ratios and timing schedules of 26- and 28-hr ahemeral cycles were examined for their effects on shell quality and egg weight. In two experiments utilizing 2578 White Leghorn Laying hens, 16-week long ahemeral treatments were instituted abruptly late in the pullet laying season and again following a forced-molt production cycle.

Ahemeral light-dark cycles of 28-hr length resulted in significantly heavier shell and egg weights as compared to 26-hr ahemeral cycles or the control 24-hr cycle. Ahemeral 26-hr cycles did not significantly increase egg weight compared to the 24-hr controls but did increase shell weight. Varying total light in 28-hr cycles from 20 to 10 hr with the light given in either one continuous period or interrupted by two intermediate dark periods and as either 18 or 16 hr of continuous light in the 26-hr cycles did not result in significant differences in shell or egg weight compared to the other treatments of the same cycle length. Rate of lay was lower for the hens given only 10 hr of interrupted light in a 28-hr cycle but was not otherwise affected by light treatment.

Dietary protein levels of 15% (as compared to 17%) and 14% (as compared to 16 and 18%) consistently reduced egg weights ($P<.10$ or $<.05$) and tended to improve shell quality.

These experiments further demonstrated the effectiveness of 26- and 28-hr ahemeral light-dark cycles in increasing shell weight as a method of extending the economic laying period of either older pullets or force-molted hens without a sacrifice in the number of eggs produced.

(*Key words:* laying hens, ahemeral light cycles, egg weight, shell quality protein level, forced molt)

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INTRODUCTION

Ahemeral light-dark cycles longer than 24 hr have been shown to increase the weight of shell and the average weight of eggs produced by older hens without any detrimental effects on the number of eggs laid provided that rate of lay is below about 70% (Bieller and Ostmann, 1960; Rosales *et al*, 1968; Foster, 1968, 1969; Fox *et al.*, 1971; Fox and Shaffner, 1972; Morris, 1973; Cooper and Barnett, 1976; Leeson *et al.*, 1979; Yannokopoulos and Morris, 1979; Nordstrom, 1982). Increasing the light-dark cycle to a length longer than the hen's normal ovulatory cycle allows the egg to reside longer in the oviduct and shell gland. This results in an increased deposition of both shell and egg contents (Melek *et al.*, 1973). Although there is a net increase in shell strength under these longer light cycles, improvement is not as great as it might be if the increase in egg weight could be controlled.

The use of 28-hr light cycles is convenient in that it results in six complete cycles per week, allowing easier time switch adjustments and regular work schedules as compared to other ahemeral light schedules. It has been reported that the daily light period given laying hens can be interrupted by one or more dark periods without affecting egg production (van Tienhoven and Ostrander, 1973, 1976; Skoglund and Whittaker, 1980). Because the use of ahemeral light cycles requires additional artificial lighting, the interruption of the light period with intermittent dark periods could reduce electrical energy required.

Dietary protein levels also affect egg weight (Scott *et al.*, 1976). Feeding protein above the level required for optimum egg production results in increased egg weight. No data are available on the protein requirement of hens on ahemeral light cycles.

These trials were designed to compare the overall practicability of the use of 26- and 28-hr ahemeral light cycles for the improvement of shell quality with older hens. If proven practical, such ahemeral light cycles would allow a longer egg production period before forced molting and could extend the period of economic production following a forced molt. Various combinations of light and darkness

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were compared along with the interruption of the light period by periods of darkness. In addition, the effect of protein level on the performance parameters of the hens exposed to ahemeral light cycles was evaluated.

MATERIALS AND METHODS

White Leghorn hens from earlier nutritional experiments were utilized in two experiments. They were moved into a facility consisting of 18 separate, light-controlled, fan ventilated rooms. Each room had four lots of 8 cages, each 30 × 41 cm in size. Three rooms were assigned to each light treatment. Two to three hens, depending upon the number of birds available, were placed in each cage. Lot size ranged between 16 to 20 hens at the beginning of each experiment and between 13 to 19 by its finish. After an acclimitization period of about 3 weeks, experimental treatments were begun.

Eggs were gathered daily and those considered marketable were recorded. Egg production was calculated on a hen-day basis of 24 hr per day for consistency. One day each week eggs were group weighed and the weekly mean egg weights were averaged per 28-day period. For 2 days near the end of each 28-day period, eggs were group weighed, broken out, and washed to remove albumen. The shells, with adhered membranes, were dried overnight at 100 C and then cooled and weighed. Shell weight per unit area (SWUSA) was then calculated as milligrams per square centimeter using the formula of Carter (1975), 3.9782 × the egg weight (g)$^{.7056}$, to calculate egg surface area. Feed consumed was determined for each lot of hens for each 28-day period and used to calculate the feed required per egg.

Experiment 1. A total of 1296 Hubbard Leghorn hens were moved at 62 weeks of age and randomly distributed into 70 lots and assigned to six light treatments (Table 1). Treatment double-molt was designed to resemble the double-molt production method quite common in this area and was included for an overall comparison of production efficiency. The other treatments included two 16-week ahemeral light cycle periods and a 24-hr cycle control group. A molt and a normal 24-hr light cycle production period followed the initial ahemeral period and preceded the second ahemeral period. The hens were molted by imposition of a light cycle of 8L:16D for 4 weeks and the withholding of all feed for 7 days until production had ceased and mean body weights had declined about 25%. Limited amounts of ground corn were fed for 3 weeks. They were then fed the appropriate laying ration and exposed to 16L:8D to regain egg production. Control treatment 16L:8D was given a 24-hr light cycle throughout and compared to the ahemeral cycles. Ahemeral treatments 18L:8D and 20L:8D used the same length of dark period (8 hr per cycle) as the control treatment 16L:8D while treatments 16L:10D and 16L:12D used the same length of light period (16 hr per cycle) as the control treatment 16L:8D. Due to the limited number of hens available, treatments 18L:8D and 20L:8D were assigned only 11 lots of hens whereas 12 lots were assigned to the other treatments.

Two of the four lots in each room were fed a 15% protein laying ration and the other two lots were fed a 17% ration (Table 2) throughout the experiment. Data were analyzed by analysis

TABLE 1. *Design of light treatments (Experiment 1)*

Treatment	Weeks of age			
	67-82	83-90	91-106	107-122
16L:8D	16L:8D	molt-8L:16D	16L:8D	16L:8D
18L:8D	18L:8D	molt-8L:16D	16L:8D	18L:8D
16L:10D	16L:10D	molt-8L:16D	16L:8D	16L:10D
20L:8D	20L:8D	molt-8L:16D	16L:8D	20L:8D
16L:12D	16L:12D	molt-8L:16D	16L:8D	16L:12D
	Weeks of age			
	67-74	75-94	95-102	103-122
Double molted	molt-8L:16D	16L:8D	molt-8L:16D	16L:8D

TABLE 2. *Composition of experimental rations*

	Rations fed				
	Experiment 1		Experiment 2		
	15	17	14	16	18
	(%)				
Ingredient					
Corn	69.95	67.7	73.85	68.85	63.85
Wheat millrun	5.5	2	2.5	2.5	2.5
Soybean meal (48.5%)	7.75	13.5	8.0	13.0	18.0
Meat and bone meal	5.7	5.7	5.5	5.5	5.5
Dehydrated alfalfa (17%)	3.0	3.0	2.0	2.0	2.0
Limestone	7.5	7.5	7.55	7.55	7.55
Salt	.25	.25	.25	.25	.25
DL-Methionine	.10	.10	.10	.10	.10
Premix[1]	.25	.25	.25	.25	.25
	100.0	100.0	100.0	100.0	100.0
Calculated analyses:					
Crude protein (%)	15.0	17.0	14.25	16.0	17.95
Calcium (%)	3.5	3.5	3.4	3.4	3.4
Available phosphorus	.34	.34	.33	.34	.34
Metabolizable energy (kcal/kg)	2845	2845	2875	2825	2775

[1] Premix supplies (per kg diet): 7900 IU vitamin A, 2000 ICU vitamin D_3, 2.25 IU vitamin E, 2.3 mg menadione sodium bisulfite complex, 5 mg riboflavin, 7.5 mg calcium d-pantothenate, 29 mg niacin, 280 mg choline chloride, .01 mg vitamin B_{12}, 125 mg butylated hydroxytoluene, 60 mg manganese (oxide), 27 mg zinc (oxide), 20 mg iron (carbonate), 2 mg copper (oxide), 1.2 mg iodine (iodate), and .2 mg cobalt (carbonate).

of variance. The effect of room was not significant, and the room squares were pooled with those of the replicates to estimate the error mean squares for evaluation of the main effects and for calculation of significant differences by Duncan's multiple range test (Steel and Torrie, 1960).

Experiment 2. A total of 1282 hens of four commercial strains (H & N Petite 1, H & N Petite 2, H & N p.g.-1, and Babcock) were moved at 75 weeks of age, and the six experimental treatments (Table 3) were begun at 78 weeks of age. One lot of each strain were assigned to each room. Two treatments were 28-hr ahemeral cycles with the light given in one continuous period whereas three treatments had the daily light period interrupted by dark periods. Light duration was 20, 16, 14, 12, and 10 hr per light/dark cycle of 28 hr for these treatments and 16 hr per 24-hr cycle for control treatment 16L:8D. The light period of the hens given 14, 12, and 10 hr was interrupted by two extra dark periods of 3, 4, or 5 hr, respectively.

Light treatments were continued for four 28-day periods until the hens were 93 weeks of

TABLE 3. *Design of light treatments (Experiment 2)*

Treatment	Weeks of age: 78-93	94-99	100-113	114-129
20L:8D	20L:8D	molt-8L:16D	16L:8D	20L:8D
16L:12D	16L:12D	molt-8L:16D	16L:8D	16L:12D
14L:14D	4L:8D:5L:3D:5L:3D	molt-8L:16D	16L:8D	4L:8D:5L:3D:5L:3D
12L:16D	4L:8D:4L:4D:4L:4D	molt-8L:16D	16L:8D	4L:8D:4L:4D:4L:4D
10L:18D	4L:8D:3L:5D:3L:5D	molt-8L:16D	16L:8D	4L:8D:3L:5D:3L:5D
16L:8D	16L:8D	molt-8L:16D	16L:8D	16L:8D

age. The hens were then force-molted by the same treatment as in Experiment 1 and brought back into production. At 114 weeks of age, they were exposed to the same ahemeral light cycles as used earlier for another four 28-day periods until the hens were 129 weeks of age and the experiment terminated.

The three laying rations (Table 2) were assigned so that two rations were fed the hens in each room, but so that an equal number of lots of each strain and each light treatment received each ration.

Data were evaluated by analysis of variance using mean squares of the 3-way interactions (light × strain × feed) as the initial estimate for error mean square. Because none of the mean squares for the primary interactions were significant, the mean squares of all interactions were pooled and used as the error mean square for the evaluation of the main effects and for calculation of significant differences by Duncan's multiple range test (Steel and Torrie, 1960).

RESULTS

Results for Experiment 1 are tabulated in Tables 4 and 5. There were no significant differences in rate of lay, although the hens exposed to ahemeral treatments 16L:10D and 16L:12D, with the lowest dark: light ratios, were numerically superior to the hens on the other treatments. There were no significant differences in feed efficiency over the course of the experiment.

All 28-hr ahemeral treatments resulted in significantly greater egg weights, shell weights, and SWUSA's during the ahemeral treatment periods as compared to the 24-hr cycle controls. Shell weights and SWUSA's from the hens exposed to the 26-hr cycles tended to fall in between those exposed to 24- or 28-hr cycles.

Overall rate of lay (Table 4) was nonsignificantly higher for the single-molt treatments than for the double-molt treatment. Feed required per egg was almost identical for the various light treatments and for the two protein levels.

The laying hen performance data during the two ahemeral cycle periods for the hens in Experiment 2 are summarized in Table 6. There were significant differences due to the strain of hen in each parameter measured. There were no significant interactions between any combination of strain, feed, and light. All ahemeral light cycles consistently resulted in heavier shell weights, egg weights, and SWUSA's than the 24-hr light cycle during the ahemeral treatment periods. Feed per egg tended to be less for the ahemeral cycles than for the 24 hr cycle with treatment 12L:16D being significantly less than control treatment 16L:8D during the first cycle. Rate of lay varied among the light treatments. It was significantly higher for treatments 20L:8D, 16L:12D, and 12L:16D as compared to treatment 10L:18D during the first cycle.

Protein level and egg weight in both trials were positively associated, although the effects were significant ($P<.05$) only during the nonahemeral period in Experiment 1 and for ration 14 as compared to rations 16 and 18 diets during the second ahemeral period in Experiment 2. During the other periods of both experiments, the effects were significant at the 10% probability level. The lighter egg weight coupled with an essentially identical shell weight resulted in a significantly higher SWUSA for hens fed the ration 14 during the second ahemeral period of Experiment 2.

DISCUSSION

Consistent with the reports cited earlier, exposure to ahemeral light cycles of 26 and 28 hr in the later stages of the production cycles increases shell weight without reducing egg

TABLE 4. *Overall rate of lay and feed efficiency for hens exposed to 26- and 28-hr ahemeral light treatment (Experiment 1)*[1]

Treatment	Rate of lay (hen day)[2] Mean	Feed/egg
	(%)	(g)
16L:8D	55.6	198
18L:8D	56.3	200
16L:10D	57.6	198
20L:8D	55.9	198
16L:12D	56.8	199
Double molted	53.0	199
Mean	55.9	199
Ration 15	55.4	199
Ration 17	56.5	199

[1]No significant differences in overall means. The first 5 treatments were molted between 83 and 90 weeks of age. The last treatment was molted between 67 and 74 weeks, and again between 95 and 102 weeks.

[2]Rate of lay during ahemeral periods calculated on the basis of 24-hr periods.

TABLE 5. *Laying hen performance for the single molted treatment - Experiment 1*

	Rate of lay (hen day)[1]			Egg weight			Shell weight			SWUSA[2]		
	Age in weeks			Age in weeks			Age in weeks			Age in weeks		
Treatment	67-82	91-106	107-122	67-82	91-106	107-122	67-82	91-106	107-122	67-82	91-106	107-122
	(%)			(g)						(mg/cm²)		
Light												
16L:8D	64.1	65.5	57.6	64.4^{a}	66.2	65.9^{a}	5.33^{a}	5.81	5.42^{a}	70.8^{a}	75.8	70.8^{a}
18L:8D	65.0	67.8	56.5	64.6^{a}	66.7	66.3^{a}	5.29^{a}	5.76	5.48^{ab}	71.5^{a}	74.8	71.4^{ab}
16L:10D	65.6	68.7	60.2	64.9^{a}	66.8	66.0^{a}	5.45^{a}	5.84	5.55^{b}	72.0^{ab}	75.7	72.4^{bc}
20L:8D	66.1	66.6	56.7	66.0^{b}	65.9	68.0^{b}	5.64^{b}	5.78	5.72^{c}	73.6^{c}	75.6	73.2^{c}
16L:12D	65.9	66.7	59.0	66.6^{b}	66.5	68.4^{b}	5.66^{b}	5.79	5.74^{c}	73.3^{bc}	74.3	73.2^{c}
Mean	65.3	67.1	58.0	65.3	66.4	66.9	5.49	5.80	5.58	72.2	75.4	72.2
Rations												
15	66.0	67.4	58.6	65.0^{x}	66.1^{a}	66.6^{x}	5.48	5.80	5.58	72.3	75.6	72.4
17	64.7	66.7	67.4	65.6^{y}	66.8^{b}	67.2^{y}	5.50	5.80	5.58	72.2	75.2	72.0

a,b,c,x,y Means within groups followed by different superscript a,b,c are significantly different at $P<.05$ and for those followed by superscript x,y at $P<.10$.

[1] Rate of lay during ahemeral periods calculated on the basis of 24-hr periods.

[2] Shell weight per unit of egg surface area.

TABLE 6. *Laying hen performance during ahemeral 28-hr cycle periods (Experiment 2)*

	Rate of lay (hen day)[1]		Feed/egg		Egg weight		Shell weight		SWUSA[2]	
	Age in weeks		Age in weeks		Age in weeks		Age in weeks		Age in weeks	
Treatment	78-93	114-129	78-93	114-129	78-93	114-129	78-93	114-129	78-93	114-129
	(%)		(g)						(mg/cm²)	
Light										
20L:8D	53.1^{a}	56.0	197^{ab}	185	64.9^{a}	65.2^{a}	5.67^{a}	5.65^{a}	74.9^{a}	74.6^{a}
16L:12D	52.9^{a}	58.7	199^{ab}	178	65.0^{a}	65.4^{a}	5.63^{a}	5.65^{a}	74.4^{a}	74.3^{a}
14L:14D	50.0^{ab}	57.7	199^{ab}	171	64.8^{a}	65.0^{a}	5.72^{a}	5.75^{a}	74.7^{a}	76.0^{a}
12L:16D	52.6^{a}	55.2	183^{a}	175	65.3^{a}	65.6^{a}	5.70^{a}	5.77^{a}	75.0^{a}	75.8^{a}
10L:18D	48.0^{b}	53.1	199^{ab}	182	64.8^{a}	65.2^{a}	5.65^{a}	5.77^{a}	74.7^{a}	75.9^{a}
16L:8D	50.8^{ab}	56.5	203^{b}	184	63.1^{b}	63.2^{b}	5.37^{b}	5.33^{b}	72.3^{b}	71.7^{b}
Strain										
1 - Shaver	49.3^{b}	52.8^{b}	217^{c}	200^{c}	65.8^{a}	67.3^{a}	5.52^{b}	5.66^{ab}	72.1^{a}	73.0^{b}
2 - Petite 1	48.8^{b}	54.9^{b}	195^{b}	172^{ab}	63.2^{c}	62.8^{c}	5.61^{ab}	5.63^{ab}	75.5^{ab}	75.9^{a}
3 - Petite 2	54.7^{a}	60.4^{a}	179^{a}	161^{a}	65.0^{ab}	64.5^{ab}	5.63^{ab}	5.56^{b}	74.3^{bc}	74.0^{b}
4 - PG-1	52.2^{ab}	56.5^{ab}	197^{b}	183^{b}	64.6^{b}	65.2^{b}	5.73^{a}	5.76^{a}	76.1^{a}	75.9^{a}
Rations										
14	50.1	55.6	198	176	64.3^{x}	64.2^{b}	5.61	5.68	74.8	75.7^{a}
16	51.4	55.8	197	183	64.8^{y}	65.2^{a}	5.66	5.64	74.7	74.3^{b}
18	52.3	57.2	196	179	64.9^{y}	65.4^{a}	5.60	5.64	74.0	74.1^{b}
Average	51.2	56.2	197	179	64.7	65.0	5.62	5.65	74.5	74.7

^{a,b,c,x,y}Means within groups followed by different superscript a,b,c are significantly different at $P<.05$ and for those followed by superscript x,y at $P<.10$.

[1] Rate of lay during ahemeral periods calculated on the basis of 24-hr periods.

[2] Shell weight per unit of egg surface area.

numbers. The increase in shell weight was greater with 28 hr light cycles than with 26 hr cycles, which is in agreement with Morris (1973) who reported increasing shell thickness (and, hence, shell weight) for increased cycle lengths to 30 hr. However, the increase in egg weight that occurs with cycles 27 hr and longer (Fox *et al.*, 1971; Morris, 1973; Yannakopoulos and Morris, 1979; Nordstrom, 1982) but not with older hens exposed to 26 hr cycles (Fox *et al.*, 1971; Fox and Shaffner, 1972; Cooper and Barnett, 1976; Nordstrom, 1982) limits the improvement in shell quality. Nevertheless, the effective economical production period of the laying hen can be extended either before a molt or after a molt by the imposition of either 26- or 28-hr ahemeral light cycles. Labor scheduling and the currently available 7-day time clocks favor the 6-day week resulting from the use of 28-hr cycles. If the approximate 2 g increase in egg size resulting from exposure to the 28-hr cycle is objectionable, use of a 26-hr cycle is a viable alternative.

The lighted period of the ahemeral cycle can be interrupted by dark periods so that the total light allowed the hen could be reduced to no more than 12 hr per 28-hr cycle without detrimental effects. This is consistent with the reports previously cited with interrupted light periods in 24-hr light cycles. However, reducing light further to 10 hr per cycle, with a concomitant increase in darkness to 18 hr, resulted in decreased production.

There were considerable differences between the genetic strains in the various production parameters measured. All strains were affected equally by the various light treatments.

The lowest protein level fed in each experiment reduced egg weight but had negligible effect on shell weights. Again, these results parallel the effect of protein levels with hens on 24-hr light cycles (Scott *et al.*, 1976). This resulted in an improved shell quality from hens fed the lowest protein level. For the best shell quality with aged hens, it is advisable to feed the lowest protein level consistent with good nutrition.

There is a high degree of flexibility, therefore, in the application of ahemeral light cycles for the improvement of shell quality of older laying hens. Cycle length, light:dark ratios, interrupted light periods, and the protein level of the ration fed are variables that should be considered for their effects, costs, and convenience when a decision is made to use ahemeral light cycles.

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