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Photoperiod and oviposition time in broiler breeders

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Abstract 1. Oviposition times were recorded for broiler breeder hens under 8-, 10-, 11-, 12-, 13-, 14- and 16-h photoperiods.
2. Mean oviposition time (MOT) was delayed relative to dawn by approximately 0·5 h for each 1-h increase in photoperiod up to 14 h, but was similar for 14- and 16-h photoperiods. However, the 0·5 h/h regression for the time when half the eggs were laid continued through to 16 h.
3. The rate of change in MOT for each 1-h increase in ≤14-h photoperiod was similar to that reported for early and modern egg-type hybrids, but, compared with modern genotypes, time of lay itself was 1 h later than white-egg and 2·5 h later than brown-egg hybrids.
4. At photoperiods ≤12·25 h, the number of eggs laid before dawn increased by 4·5% for each 1-h reduction in daylength.

INTRODUCTION

Daylength, in particular the transition from day to night (dusk), exerts a powerful influence on the timing of the preovulatory release of luteinising hormone (LH) in domestic hens and, in turn, the time of egg laying (Bhatti and Morris, 1978). However, not all breeds of fowl lay their eggs at the same time when given a common daylength; for example, egg laying in brown-egg hybrids is consistently about 1·5 h earlier than white-egg hybrids (Lewis, 1987; Lewis *et al*., 1995). A genetic difference in the phase setting of the open period for LH release is thought to be the likely reason for this disparity. In contrast, both types of fowl exhibit a similar rate of change in oviposition time for a given change in photoperiod (Lewis *et al*., 1995).

There is, however, a dearth of information on the effect of photoperiod on oviposition time for control-fed broiler breeders. Fortuitously, an opportunity to study this relationship presented itself when the designs for two concurrently run trials included photoperiods ranging from 8 to 16 h. This paper reports the findings.

MATERIALS AND METHODS

The first trial involved a nominal 3200 Cobb '500' broiler breeder hens housed on the floor in 8 light-proof rooms, each room comprising 4 pens of 100 females (and 10 males). Photoperiods within a 24-h cycle were 10, 11 (two rooms), 12 (two rooms), 13, 14 or 16 h, and all started at 07:00 h. Subsequent to all eggs being cleared on the preceding evening, egg collections were conducted continuously from 04:30 h until egg laying had finished at 18:30 h (times determined by a preliminary investigation) for one day at 33 weeks of age. The second trial used the same genotype, but with 60 hens housed in individual cages in each of two light-proof rooms; one room on 8-h and the other on 16-h photoperiods. As in the first trial, eggs were cleared on the preceding evening, and collections made continuously throughout each day's egg-laying period. Six collections were made over three 2-d periods during weeks 37 and 38 of age. Oviposition times for hens in the second trial were later than for those in the first trial because age-related increases in egg weight cause egg laying to be progressively delayed as hens age (Lewis and Perry, 1991). This difference was removed by fitting a constant to the Trial 2 data by least squares. Data for the proportion of eggs laid before dawn were divided into two sets with regression lines fitted above and below a hinge point, as described by Lewis *et al*. (1998). The hinge point was found by iteration at 0·25-h intervals to identify the model that minimised the residual sums of squares about the fitted model.

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RESULTS

The length of the complete ovulatory cycle from the beginning of the surge in LH release to the resulting oviposition is about 35 h, and so the zeitgeber for the preovulatory LH release that initiates an ovulation is not the light–dark interface that immediately precedes an oviposition, but the one that occurred 24 h before that (initiating dusk). Therefore, for physiological correctness, regression equations in this paper are expressed and Figure 1 drawn using the initiating dusk as the reference point. However, to facilitate practical use, data in the Table and Figure 2 have been referenced to the start of the photoperiod in which the eggs were laid. It should be noted that as photoperiod is extended, oviposition times are advanced relative to dusk, but delayed relative to dawn. For example, if mean oviposition time (MOT) occurs at 09:00 h for hens given an 11-h photoperiod from 06:00 to 17:00 h, and at 10:00 h for birds given a 13-h photoperiod from 06:00 to 19:00 h, the laying of the latter birds is delayed by 1 h relative to dawn (+4 h compared with +3 h), but advanced by 1 h relative to dusk (+15 h compared with +16 h). Obviously when referenced to the initiating dusk, these figures become +39 h compared with +40 h, respectively.

A regression of MOT (using daylengths of ≤14 h, and adjusted data for Trial 2) on photoperiod showed that it was advanced by about 0·5 h for each 1-h extension of the photoperiod between 8 and 14 h relative to the initiating dusk (but delayed by 0·5 h relative to the current dawn).

$$y = 45{\cdot}7 - 0{\cdot}485p \quad (P < 0{\cdot}001, \quad r^2 = 0{\cdot}990, \quad \text{Slope SE} = 0{\cdot}020, \quad \text{SD} = 0{\cdot}096)$$

where y = MOT (h relative to the initiating dusk) and p = ≤14-h photoperiod (h). Mean oviposition times were similar for 14- and 16-h photoperiods, at about 5 h after dawn (Table). In contrast, the time at which half of the day's eggs had been laid continued to advance by about 0·5 h/h, relative to the initiating dusk, throughout the range of photoperiods tested. The equation describing the regression is

$$y = 46{\cdot}3 - 0{\cdot}555p \quad (P < 0{\cdot}001, r^2 = 0{\cdot}981, \text{Slope SE} = 0{\cdot}030, \text{SD} = 0{\cdot}227)$$

where y = time when half a day's eggs have been laid (h relative to the initiating dusk) and p = photoperiod (h).

Under short daylengths, some eggs are laid before the start of the photoperiod (Figure 2). A 'hinge' analysis indicated that the number of eggs laid before dawn will be minimised by

Table. *Mean oviposition time and time when 50% of eggs had been laid (h:min) relative to the start of the photoperiod in which the oviposition occurred for broiler breeder hens given various photoperiods*

Photoperiod	Mean oviposition time	50% eggs laid
Trial 1		
10	2:42 ± 0:08	2:25 ± 0:07
11	3:21 ± 0:06	3:00 ± 0:05
12	3:49 ± 0:07	3:37 ± 0:07
13	4:16 ± 0:06	4:08 ± 0:13
14	5:00 ± 0:10	4:48 ± 0:10
16	5:03 ± 0:01	5:27 ± 0:10
Trial 2		
8	2:44 ± 0:19 (1:52)[1]	2:27 ± 0:23 (2:03)[1]
16	5:57 ± 0:05 (5:05)[1]	5:32 ± 0:02 (5:08)[1]

[1]Means adjusted by least squares for differences from Trial 1 in parentheses.

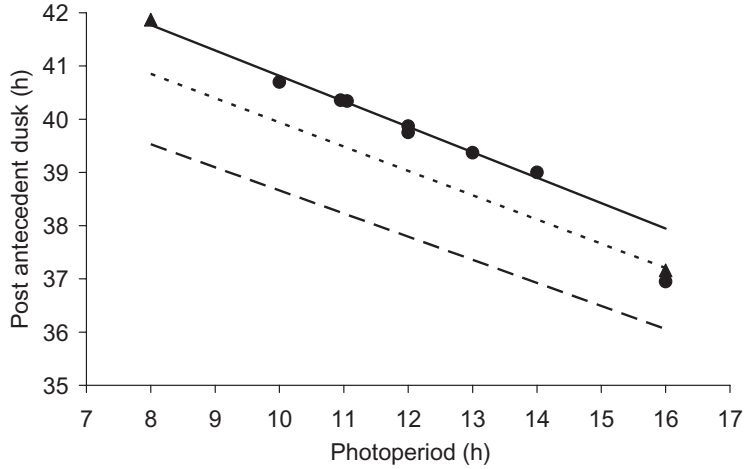

Figure 1. *Mean oviposition time relative to the antecedent dusk (but one) for Cobb 500 broiler breeder hens maintained on various photoperiods (● Trial 1, ▲ adjusted Trial 2); the solid line represents the regression for photoperiods between 8 and 14 h. The dashed line represents a regression for ISA Brown brown-egg hybrids and the dotted line a regression for Shaver 288 white-egg hybrids (from Lewis* et al.*, 1995).*

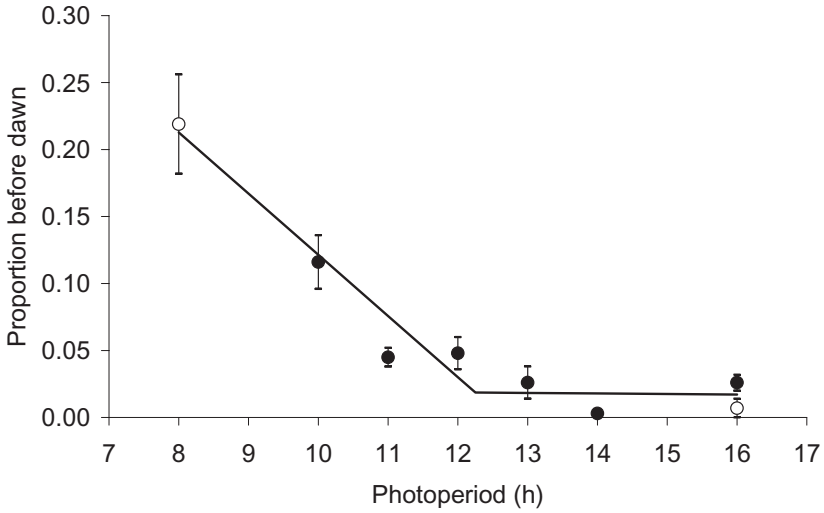

Figure 2. *The proportion of eggs laid before the dawn of various photoperiods by Cobb 500 broiler breeder hens (● = Trial 1, ○ = Trial 2), with SEMs indicated by vertical bars.*

providing a photoperiod of ≤12·25 h and, for daylengths shorter than this, numbers will increase by about 0·045 for each 1-h reduction in photoperiod. The regressions are described by the equations:

For photoperiods ≤ 12 · 25 h:

$$y = 0{\cdot}5784 - 0{\cdot}0457p \quad (\text{Slope SE} = 0{\cdot}0089)$$

For photoperiods ≥ 12·25 h:

$$y = 0{\cdot}0235 - 0{\cdot}0004p \quad (\text{Slope SE} = 0{\cdot}0155)$$

Overall regression: $P = 0{\cdot}004$, $r^2 = 0{\cdot}916$

where y = proportion of eggs laid before dawn and p = photoperiod (h). The change in the proportion of eggs laid before dawn for photoperiods between 12·25 and 16 h is negligible and for practical purposes can be regarded as being constant at less than 0·01.

DISCUSSION

The −0·485 h/h estimated rate of change in oviposition time relative to the initiating dusk with increasing photoperiod compares remarkably well with regression slopes of −0·434 (ISA Brown) and −0·456 (Shaver 288) reported by Lewis *et al.* (1995), −0·546 (various white-egg hybrids) from Lewis (1987), and −0·495 (unknown genotype) from Etches (1990). The equation constant, however, shows that for a given photoperiod MOT was about 1 h later than Shaver 288, 2·5 h later than ISA Brown (Figure 1), but similar to the historical white-egg hybrid data reviewed by Lewis (1987) and the findings of Etches (1990). An unpublished review of oviposition-time data for ISA Brown hens involved in experiments conducted by the senior author at Bristol University between 1984 and 1998 showed that egg laying advanced by about 10 min per generation for a given photoperiod (Figure 3). The rates of advance in egg-laying time for hens on 8- and 16-h photoperiods were not significantly different, and the mean slope was described by the equation:

$$y = 335{\cdot}3 - 0{\cdot}170x + 0{\cdot}394p \ (P = 0{\cdot}0004,$$
$$r^2 = 0{\cdot}972, \text{ Slope SE} = 0{\cdot}0237)$$

where y = MOT relative to dawn (h), x = year of the trial, and p = photoperiod (h).

This earlier egg laying is a likely consequence of the intense selection for increased egg production in modern hybrids and the associated reduction in egg-formation time (Gow *et al.*, 1984). This suggests that the later time of egg laying by broiler breeders, compared with modern egg-type hybrids, is probably the result of the relatively relaxed selection pressure for egg numbers in broiler breeding programmes during that period, relative to egg-type hybrids, and not a difference in the location of the open period for preovulatory LH release.

The discontinuation of the delay in egg laying beyond 14 h concurs with findings for egg-type hens exposed to photoperiods exceeding 18 h (Etches, 1990). Differences in egg formation time for meat-type and egg-type fowl might account for this disparity. Ovulation does not occur until about 30–45 min after the preceding oviposition (Etches, 1996), and so a possible scenario could be that broiler breeders need a longer time for egg formation, and that the extra time spent in the oviduct by the potentially penultimate egg of a sequence prevents the potentially ultimate egg from being ovulated because the end of the open period has

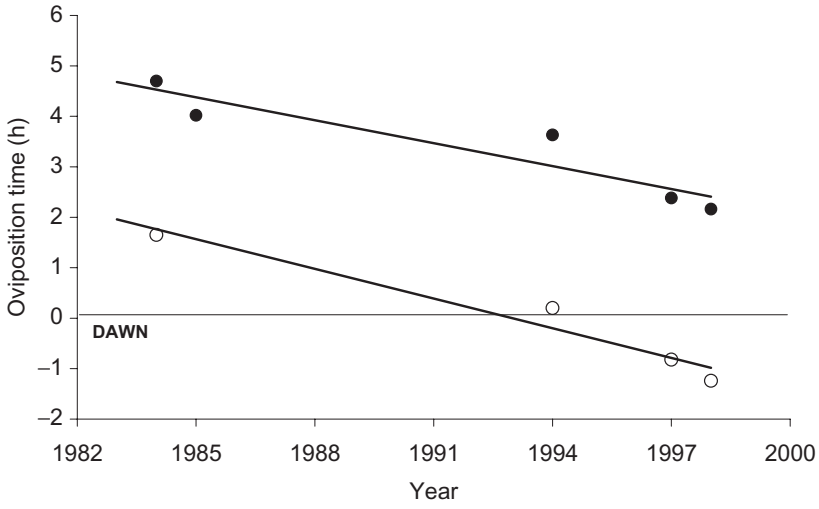

Figure 3. *Mean oviposition time (relative to dawn) for ISA Brown hybrids given an 8-h (○) or 16-h (●) photoperiod. Data from various trials conducted between 1984 and 1998 at University of Bristol, UK.*

been reached before the endocrine cascade of events has been initiated. Thus the earlier-laid, potentially penultimate egg becomes the ultimate in the sequence, the period of egg laying is curtailed, and mean oviposition is similar for 14- and 16-h photoperiods despite a 1 h delay in oviposition time for the eggs laid earlier in the sequence. The termination of the open period under long daylengths (or short nights) is associated with low concentrations of plasma melatonin at the beginning of the photoperiod and an absence of an increase in plasma progesterone and, in turn, preovulatory LH release and no ovulation (Nøddegaard, 1996). The 0·5 h/h continued advance in the time that half the day's eggs are laid, relative to the initiating dusk, confirms that it is an earlier cessation of egg laying for long photoperiods, rather than the lack of a shift in the phase setting of the open period, that is the most likely reason for the MOT for the 14- and 16-h photoperiods being similar.

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