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Constant photoperiods and sexual maturity in broiler breeder pullets

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Abstract 1. Broiler breeder pullets were maintained on 10-, 11-, 12-, 13-, 14- or 16-h photoperiods to determine the effect of constant photoperiods on sexual development in broiler breeders. The birds were fed to achieve a 2100 g body weight at approximately 17 or 20 weeks to see if the photosexual response was modified by rate of growth.

2. In both body weight groups, pullets maintained on 10 h were the first to reach sexual maturity (50 eggs/100 bird-d), and these and the 11-h pullets matured significantly earlier than any of the other photoperiod groups. Pullets maintained on 13 or 14 h matured latest, at about 3 weeks after the 10-h pullets, though both were only marginally later than the 12- or 16-h birds. These differences in maturation probably reflect the different rates at which photorefractoriness is dissipated in broiler breeders reared on photoperiods that vary in their degree of stimulatory competence.

3. There were no significant interactions among the photoperiods and the ages at 2100 g; faster-growing birds consistently matured about 10 d earlier than conventionally grown pullets.

INTRODUCTION

The changes in photoperiod that constitute a lighting programme for growing pullets exert a far greater influence on the timing of sexual development than any of the individual component photoperiods (Morris, 1967). Nevertheless, responses to the individual photoperiods *per se* are still important because they form an integral part of any model that predicts sexual maturity. Lewis *et al.* (1998) produced a model for the effect of constant photoperiods on sexual development in *ad libitum*-fed egg-type pullets, and this indicated that sexual maturity is earliest for birds maintained on 10-h photoperiods, but delayed by 1·7 d/h for shorter photoperiods, and by 0·3 d/h for longer photoperiods. In contrast, Lewis *et al.* (2003) reported that whereas control-fed broiler breeder pullets maintained on 8-h photoperiods matured only 4 d later than 11 h, a difference similar to that predicted for egg-type pullets, the 2- to 3-week later maturity of birds kept on 16-h photoperiods was a significantly bigger delay than the 1·5 d expected for egg-type pullets. This strongly indicated that broiler breeding stock exhibit juvenile photorefractoriness. Although, with only three constant photoperiods tested, the identification of an 11-h hinge point (the photoperiod at which birds achieve the earliest sexual maturity), and a linear delay in sexual maturity between 11 and 16 h by Lewis *et al.* (2003) might be conjectural, the findings were consistent with the proposals for the effects of daylength on the dissipation of juvenile photorefractoriness and sexual maturation described by Sharp (1984).

Lewis *et al.* (2003) also contrasted the lack of photosensitivity in 10-week-old broiler breeders reared on 8-h daylengths with the elimination of photorefractoriness in full-fed seasonal-breeding avian species by 8 weeks of short days (Follett, 1991), and suggested that the degree of feed control implicit in broiler breeder nutrition was such that it probably retarded the dissipation of juvenile photorefractoriness.

Accordingly, we conducted a trial to (a) more accurately identify the photoperiod at which the earliest sexual maturity is achieved (the hinge point), (b) determine if the delay in sexual maturation is linear between 11 and 16 h, and (c) ascertain if a relaxation of feed control accelerates the dissipation of juvenile photorefractoriness and advances the timing of sexual maturation, especially in pullets kept on longer daylengths.

MATERIALS AND METHODS

Four hundred and twenty-eight Cobb 500 broiler breeder pullets were reared on a litter floor

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(11·5 birds/m^2) from 1 d until 12 weeks in each of 8 identical, light-proofed rooms. All birds were given an initial 2 d of continuous illumination before an abrupt transfer to constant 10-, 11- (two rooms), 12- (two rooms), 13-, 14- or 16-h photoperiods; each starting at 07:00 h. Illumination was provided by 15 W compact fluorescent lamps yielding a mean illuminance of 40 lux at a height of 40 cm. Each room was subdivided into two pens by a wire partition, and the 214 birds in each pen either fed according to the breeding company's recommendation (to reach 2100 g body weight at 20 weeks) or given increased daily feed allocations to achieve 2100 g at 17 weeks. At 12 weeks, the birds were transferred, without a change in photoperiod, to 8 identical, light-proofed laying rooms. Each room was subdivided into 4 pens of 100 pullets (5 birds/m^2), with two pens of birds from the normal growth and two pens from the accelerated growth regime. Light was provided by a single 100 W incandescent lamp located at a height of 2·2 m in the centre of each pen, resulting in a mean light intensity of 25 (±4·4) lux at a height of 40 cm.

Egg production was recorded daily to pen, and age at sexual maturity defined as the second of 2 d over which the rate of lay first reached or exceeded 50 eggs/100 bird-d. The data were subjected to a two-way ANOVA using a model from *Genstat 6th Edition* (Lawes Agricultural Trust, 2002), with photoperiod and growth as the variables. Significant differences between pairs of means were identified using a *t*-test and two degrees of freedom (DF) for light comparisons and 18 DF for the growth comparison.

RESULTS AND DISCUSSION

It was possible for data for the two growth regimes to be pooled to assess the effects of photoperiod because there were no significant interactions among the lighting treatments and age at 2100 g. Photoperiod was confounded with 'room' in 4 of the lighting groups (10, 13, 14 and 16 h) because only the 11- and 12-h treatments were replicated; therefore, comparisons of means for photoperiods that were only pen-replicated within a single room need to be made with caution. Nevertheless, there was a clear trend in photoperiod means (Figure), and a division into two significantly different groups (10 and 11 h, and 12 to 16 h) that occurred between the two lighting treatments that were replicated. The pullets maintained on 10 h were the first to reach a 50 eggs/100 bird-d rate of lay, and these and the 11-h pullets matured at least 2 weeks significantly earlier than those on ≥12-h photoperiods (Table). Pullets maintained on 13 or 14 h matured latest, at about 3 weeks later than 10-h pullets, though each was only marginally later than, but not significantly different from, the 12- or 16-h birds. The 16- to 17-d difference in maturity between 11- and 16-h photoperiods is smaller than the 22- to 24-d delay reported by Lewis *et al.* (2003), though for a different meat-type genotype, but it still demonstrates the retardatory effect of constant long days on sexual development in broiler breeding stock. It also contrasts markedly with the minimal difference in sexual maturity reported for egg-type pullets maintained on the same photoperiods (Lewis *et al.*, 1998). The 2- to 4-d difference in

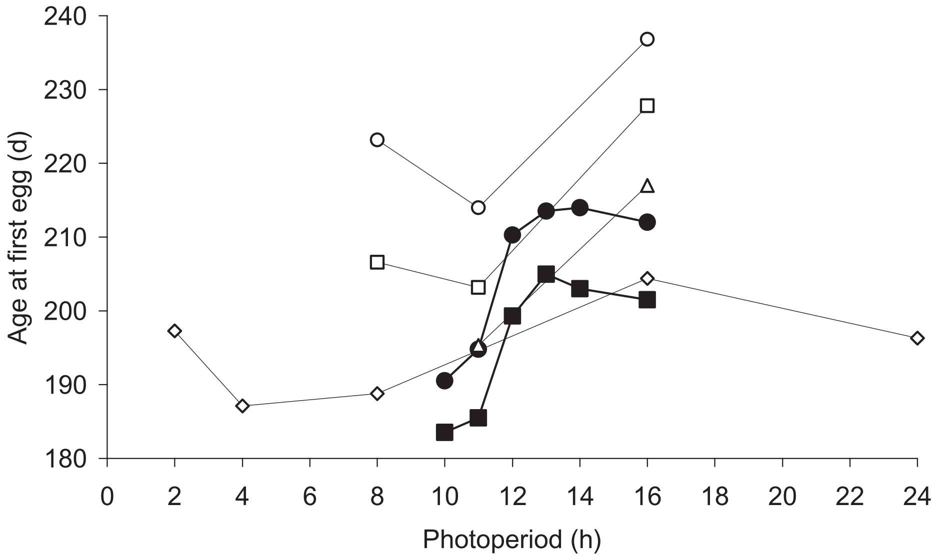

Figure. *Mean age at sexual maturity (50 eggs/100 bird-d or first egg) for broiler breeders maintained on constant photoperiods from about 2 d of age: pullets in this trial,* ● *= 2100 g body weight at 20 weeks,* ■ *= 2100 g at 17 weeks; pullets in Lewis* et al. *(2003),* □ *= male-line pullets in cages,* ○ *= female-line pullets in cages,* △ *= female-line pullets on litter floor;* ◇ *= cockerels in Renden* et al. *(1991).*

Table. *Mean age at sexual maturity (50 eggs/100 bird-d) for Cobb broiler breeder pullets maintained on various photoperiods between 10 and 16 h and fed to achieve a body weight of 2100 g at 17 or 20 weeks*

Photoperiod	Age at 50 eggs/100 bird-d (d)		
	2100 g at 17 weeks[1]	2100 g at 20 weeks[1]	Mean
10	183·5	190·5	187·0[a]
11	185·5	194·8	190·2[a]
12	199·3	210·3	204·8[b]
13	205·0	213·5	209·3[b]
14	203·0	214·0	208·5[b]
16	201·5	212·0	206·8[b]
Mean	195·3[a]	205·0[b]	

Pooled SED for comparing photoperiods (mean for growth curves): 11 and 12 h = 2·98; 10, 13, 14 or 16 h with 11 or 12 h = 3·65; 10, 13, 14 and 16 h = 4·22 with two residual DF.
Pooled SED for growth comparison = 0·91 with 18 residual DF.
[1]Within a body weight group, $n = 2$ for 10, 13, 14 and 16 h, and $n = 4$ for 11- and 12-h photoperiods.
Within the lighting column and body weight row, means not sharing a common superscript are significantly different at $P < 0·05$.

sexual maturity between 10 and 11 h, but 2-week difference between 11 and 12 h, suggests that juvenile photorefractoriness in broiler breeders is more rapidly dissipated by ≤11-h than by ≥12 h photoperiods, and this might indicate the transition point where photoperiod changes from being non-stimulatory to stimulatory. This concurs with the 3- to 8-d later mean age at first egg reported for Ross broiler breeders maintained on 8 h, compared with constant 11-h photoperiods, but 23- to 25-d delay for those kept on 16 h (Lewis *et al.*, 2003). Irrespective of body weight treatment, the amount of change in sexual maturity between 11 and 13 h in this trial was almost 10 d/h; a rate more than double the 4·36 d/h reported by Lewis *et al.* (2003) for broiler breeders and 30 times steeper than the 0·30 d/h reported by Lewis *et al.* (1998) for egg-type hybrids. This sharply defined demarcation between the age at sexual maturity for pullets given an apparently non-stimulatory photoperiod and those given a stimulatory one also concurs with endocrinological evidence showing that the critical and the saturation daylengths for luteinising hormone release in Cobb 500 broiler breeders (Cobb Breeding Company, Chelmsford, UK, personal communication) and Ross PM3 dwarf broiler breeders (Dunn and Sharp, 1990) lie in a narrow window between 10·5 and 12·75 h.

Although these findings show that the photoperiod that produces the fastest rate of sexual maturation is shorter than the 11 h suggested by Lewis *et al.* (2003), the 10 h indicated by these data is still conjectural, because fractional photoperiods between 9 and 11 h have not been tested. However, it is unlikely that the hinge point will be more categorically defined because, typically, the variation in age at sexual maturity for birds on constant photoperiods is such that the amount of replication in most poultry lighting experiments would be insufficient to permit identification of significant differences for such small increments in daylength. These data also clearly demonstrate that the correlation of rate of sexual development with photoperiod is not linear between 11 and 16 h; indicating, instead, that age at sexual maturity either plateaus or becomes progressively weaker when the photoperiod exceeds 13 h (Table and Figure). Notwithstanding that Lewis *et al.* (1998) considered a linear regression satisfactorily described the response of egg-type pullets to daylengths longer than 10 h, the residual sums of squares (RSS) for a quadratic response in that model was also lower than, though not significantly different from, the RSS for a linear one. It is extremely probable, therefore, that the response for broiler breeders is curvilinear beyond 13 or 14 h, because ultra-long photoperiods are less sexually stimulatory (Dunn and Sharp, 1990), and such photoperiods will, as a corollary, be less supportive of juvenile photorefractoriness. This means that the inverse relationship of photoperiod with rate of photorefractoriness dissipation reported by Farner and Follett (1966) does not persist through to 24 h, but inflects somewhere after 13 or 14 h. Evidence to support a positive relationship between sexual development and very long photoperiods has been given by Renden *et al.* (1991); broiler breeder males reared on continuous illumination reached sexual maturity 8 d earlier than those maintained on 16-h photoperiods (Figure). This −1·0 d/h rate of change agrees remarkably well with the −0·8 d/h for pooled 13-, 14- and 16-h data in this trial.

The significantly later maturity for broiler breeders reared on long, sexually stimulatory days in this trial and in the trial reported by Lewis *et al.* (2003) questions the validity of the belief that spring-hatched birds housed in non-light-tight facilities (exposed to increasing natural daylengths) should be reared on constant long photoperiods. This recommendation, originally made by Morris (1967) to avoid the adverse consequences of precocity in full-fed, non-photorefractory egg-type pullets, might not be appropriate for control-fed, photorefractory meat-type pullets. Indeed, the rate of sexual development in broiler breeders would arguably be influenced more by the size of the daily feed allocation than by the relatively mild stimulatory effects of the weekly increments in daylength experienced during spring at tropical and temperate latitudes.

The consistent 7- to 11-d difference in sexual maturity between the conventionally reared pullets and those allowed accelerated growth (Table), and the consequential similarity in the response curves (Figure), suggest that any influence of feed restriction on sexual development is independent of the photoperiodic effect, and that a relaxation of feed restriction does not permit a more rapid dissipation of juvenile photorefractoriness for long than for short days.

An integration of the results from this trial with those reported by Lewis *et al.* (2003) for pullets and by Renden *et al.* (1991) for males reveals no disagreement among the data-sets (Figure), even though insufficient data points in the earlier work had led to the conclusion that the response was linear above 11 h. The Figure shows that more work needs to be conducted before a robust model can be constructed to predict the effect of all photoperiods on sexual maturity, especially studying those between 9 and 11 h (to attempt to determine more accurately the hinge point), very short (to establish if the response is linear below the hinge) and very long daylengths (to check whether sexual maturity plateaus beyond 14 h or becomes negatively correlated with photoperiod).

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