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Constant photoperiods and eggshell quality in broiler breeder pullets

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Abstract 1. Broiler breeder pullets were exposed to constant 10-, 11-, 12-, 13-, 14- or 16-h photoperiods from 3 d of age. Egg weight, eggshell weight and shell thickness index were determined at 52 weeks of age.

2. Egg weight increased by 0·31 g, shell weight decreased by 30 mg and shell thickness index decreased by 0·57 mg/cm^2 for each one-hour increase in photoperiod.

3. Whilst the changes in egg weight and eggshell thickness index might be overstated because eggs were collected at the same chronological time, the effect of time of egg-laying within the day was minimal in comparison, and did not negate the conclusion that egg weight increases, and shell weight and thickness index decrease with lengthening photoperiods.

4. The effect of photoperiod on eggshell quality was not due to differences in the rate of lay between treatments. Shell weight was unaffected by time of lay.

INTRODUCTION

Both shell weight and shell thickness index for *ad libitum* fed commercial egg layers have been reported to decrease with photoperiod (Lewis *et al.*, 1994). However, increased rate of egg production, heavier egg weight and higher feed intake, which generally result from exposing egg-type hybrids to longer photoperiods, have been discounted as reasons for the variations in shell quality (Lewis *et al.*, 1994). Instead, differences in the temporal relationship that shell formation has with feeding patterns, plasma calcium concentrations, and the hormonal events that control the ovulatory cycle have been suggested as possible causal factors (Lewis *et al.*, 1994). Differences in the pattern of diurnal plasma melatonin concentration under the various photoperiods might also modify osteoclast and osteoblast activity and the mobilisation of calcium from medullary bone (Cardinali *et al.*, 2003).

The practical importance of an effect of photoperiod on shell quality is that reduced shell quality can adversely affect fecundity, with poor shells being associated with increased weight loss during incubation (McDaniel *et al.*, 1979); reduced hatchability and increased embryonic mortality, for eggs with a specific gravity <1·080 (McDaniel *et al.*, 1981; Roque and Soares, 1994).

Photoperiodic influences on shell quality in broiler breeders have not been reported. We determined shell weight and shell thickness index for 52-week broiler breeders maintained on 6 different photoperiods from 3 d of age.

Materials and methods

Four hundred Cobb 500 broiler breeder pullets were reared on a litter floor from one day until 12 weeks in each of 8 identical, light-proofed rooms and then transferred to light-proofed adult facilities (8 rooms of 4 pens, each pen holding 100 pullets). 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 for the remainder of the trial; each photoperiod 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 during rearing, and by 100 W incandescent lamps in the adult pens giving a mean illuminance of 25 (±4·4) lux at a height of 40 cm. Further details of the management protocol may be found in Lewis *et al.* (2004*a*).

Eggs were collected for shell quality determination using two protocols: (1) on one day at

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52 weeks, the first 10 eggs to be laid in each of the 32 pens following the initial egg-collection of the day (which started at 07:30 h), and (2) on one day at 53 weeks, hourly from the 8 pens in the two rooms given 13- or 14-h photoperiods. This second exercise was conducted to assess any effect on shell quality of eggs being laid at different times relative to both dawn and start of egg-laying (and so later in the sequence) by the groups on the various photoperiods. This information would then give a measure of the contribution that the changes in egg-laying time effected by the different photoperiods (Lewis *et al.*, 2004*b*) might have made towards shell quality when, in the first exercise, eggs were collected at the same time of day. Eggs were individually weighed to 0·1 g, the contents removed and shells dried to constant weight loss (4 to 5 h at 100°C). Eggshells were then weighed (EW, mg), the surface of the egg (S, cm^2) estimated using the equation $S = 3{\cdot}9782EW^{0{\cdot}7056}$ (Nordstrom and Ousterhout, 1982), and the shell thickness index (mg/cm^2) calculated.

The shell quality means were regressed on photoperiod using Genstat (Lawes Agricultural Trust, 2002). Whilst it is acknowledged that the design was unbalanced and 4 of the treatments were not replicated, the aim of the investigation was to identify the rate of change in shell quality caused by increasing photoperiod, and not to test whether one treatment was significantly different from another.

RESULTS AND DISCUSSION

Egg weight tended to increase by 0·31 g for each one-hour increase in photoperiod ($r^2 = 0{\cdot}635$, slope SE $= 0{\cdot}117$, $P = 0{\cdot}058$). Whilst this is slightly higher than the 0·25 g/h observed for egg-type hybrids throughout the laying year (P.D. Lewis, unpublished), broiler breeder eggs at 52 weeks are heavier than the mean weight for a laying cycle in egg-type birds and, in both cases, the hourly increase represented a 0·4% increase in egg weight. As shown in the Figure, shell weight tended to decrease with photoperiod by about 30 mg/h. Though not statistically significant, this is still in the same direction as the −61 mg/h change reported by Lewis *et al.* (1994) for ISA Brown egg-type hybrids. A combination of the increasing egg weight and decreasing shell weight resulted in a decrease in shell thickness index of 0·57 mg/cm^2 for each one-hour extension of the photoperiod ($r^2 = 0{\cdot}696$, slope SE $= 0{\cdot}189$, $P = 0{\cdot}039$). This compares with −0·48 mg/cm^2/h for ISA Brown hybrids (Lewis *et al.*, 1994). Whilst there were significant differences in rate of lay between photoperiods, no significant relationship was found between shell thickness index and rate of lay at 52 weeks.

In the secondary investigation, eggs laid in the first hour were omitted from the regression, because these would have included the first eggs of sequences which typically are abnormally larger and have disproportionately poorer shells than the remainder of the sequence (Belyavin *et al.*, 1987). Mean egg weight for the two photoperiod groups decreased by 0·27 g/h ($r^2 = 0{\cdot}543$, slope SE $= 0{\cdot}096$, $P = 0{\cdot}013$) from the second hour of lay onwards, regardless of photoperiod, although eggs from birds on 14-h photoperiods had a mean weight that was 1·55 g significantly heavier than from birds on 13-h photoperiods. Shell weight was unaffected by the time of lay. Eggshell thickness index increased marginally through the day by 0·16 mg/cm^2/h and eggs laid by hens on the 14-h photoperiod tended to have thinner shell thicknesses than eggs laid by hens on the 13-h

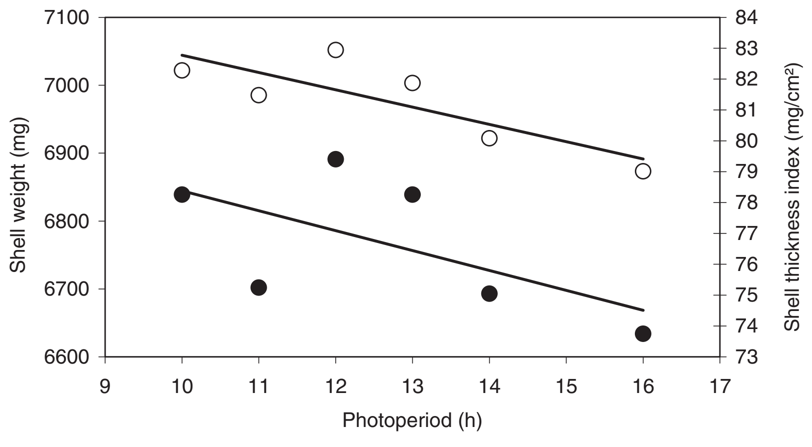

Figure. *Regressions of shell weight (●, mg) and shell thickness index (○, mg/cm^2) on photoperiod (h) for Cobb 500 broiler breeders at 52 weeks of age.*

photoperiod. Though not statistically significant, these differences are in the directions to be expected for later egg-laying (Belyavin *et al.*, 1987) and longer photoperiods (Lewis *et al.*, 1994).

It can be concluded that broiler breeder hens given longer photoperiods lay eggs that have shells that are lower in weight and have a lower shell thickness index than those on shorter photoperiods. Whilst shell weight did not change with time of lay within the day, it did decrease as day-length was increased, in the manner reported for egg-type hybrids where all eggs had been measured (Lewis *et al.*, 1994). The significant deterioration in shell thickness index with increasing day-length exceeded the non-significant 0·16 mg/cm^2/h of egg-laying time improvement for eggs laid later in the day (collecting eggs at the same chronological time in the first exercise would have resulted in eggs laid by hens on the shorter photoperiods being from a later part of the sequence, and so likely to have been of better quality, than those laid earlier in the sequence by birds on longer photoperiods). Oviposition time for broiler breeders was delayed by about 30 min for each one-hour extension of the photoperiod (Lewis *et al.*, 2004*b*), and, as a consequence, the improvement in shell thickness index predicted for eggs on the shorter photoperiods would only be half the 0·16 mg/cm^2/h improvement attributed to later egg-laying within the day. Therefore, a 0·49 mg/cm^2/h difference in quality deterioration is the estimated effect of different photoperiods. This concurs remarkably well with the 0·48 mg/cm^2/h observed in egg-type hybrids, for photoperiods between 8 and 16 h, where time of lay had no influence because all eggs laid in the day were measured (Lewis *et al.*, 1994). It is unknown whether an increase in photoperiod beyond 16 h would result in a further decrease in shell thickness index. Because shell quality and hatchability are closely correlated (McDaniel *et al.*, 1981; Roque and Soares, 1994), these findings suggest that the hatchability of eggs laid by hens on longer photoperiods, especially those produced later in the laying year, might well be inferior to that for birds maintained on shorter photoperiods, and be worthy of further investigation.

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