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Changes in light intensity during the rearing period can influence egg production in domestic fowl

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Abstract 1. A total of 240 Shaver White and 240 ISA Brown pullets that had been reared in multi-bird cages on a 10-h photoperiod, and maintained at a light intensity of 3 or 25 lux, or changed from 3 to 25 lux or from 25 to 3 lux at 9 or 16 weeks of age, were moved into individual-bird cages at 20 weeks and transferred to 15-h photoperiods at 25 lux.

2. In both breeds, birds transferred from 3 to 25 lux at 16 or 20 weeks laid significantly more eggs than birds maintained on the brighter intensity from one day or increased to it at 9 weeks.

3. Mean egg weight, shell deformation, albumen height, feed intake and body weight gain in lay were not significantly affected by the light intensity treatments during the rearing period. There was, however, a small, but significant, negative correlation of egg numbers with mean egg weight, although this only partially explained the difference in egg numbers. The differences in egg production were unrelated to rate of sexual maturation.

INTRODUCTION

Morris (1967) concluded that the light intensity during the rearing period has minimal effect on egg production provided the illuminance in the laying period is sufficiently bright, and this was thought to be about 5 lux (Morris, 1981). Subsequently, Tucker and Charles (1993) suggested that modern egg-type hybrids were such prolific egg producers that light intensity might be irrelevant provided it exceeded about 0·4 lux, but a review of 10 sets of data originally published between 1946 and 1993 showed that the 5 lux 'optimum dose' recommended by Morris (1981) was still valid (Lewis and Morris, 1999). However, to accommodate welfare concerns and to ameliorate staff working conditions, recent publications considered 10 lux to be a more prudent recommendation. Accordingly, no difference in performance was anticipated when two egg-type hybrids that had been exposed to various light intensity regimens during the rearing period (Lewis *et al.*, 2004) were transferred to laying cages at 20 weeks of age and maintained at an illuminance of about 25 lux. This paper reports the data for these birds because, contrary to expectation, light intensity during rearing did have a significant effect on the rate of egg production, despite the illuminance exceeding the recommended optimum during the laying period.

MATERIALS AND METHODS

A total of 240 Shaver White and 240 ISA Brown pullets, selected for their closeness to the mean body weight for each of 6 treatment groups from an experiment that studied illuminance during the rearing period, was placed in two-tier individual-bird laying cages at 20 weeks of age. Within genotype, each of the 6 rearing treatment groups was replicated 10 times, with 4 adjacent cages forming a replicate plot (40 birds per treatment for each genotype). Details of the management protocols for the earlier rearing experiment that involved transfers from 3 to 25 lux or 25 to 3 lux at 9 or 16 weeks and constant 3 and 25 lux controls are reported by Lewis *et al.* (2004). On transfer to the common layer facilities, the photoperiod was abruptly increased from 10 to 15 h and the light intensity set to a mean of $25 \pm 0{\cdot}4$ lux (top tier: $31 \pm 0{\cdot}3$ lux, bottom tier: $20 \pm 0{\cdot}2$ lux). All birds were fed, *ad libitum*, an 11·7 MJ/kg, 186 g/kg crude protein (CP) crumbed diet from 20 to 36 weeks, and an

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11·3 MJ/kg, 174 g/kg CP diet from 37 weeks to the end of the trial at 72 weeks. Egg numbers were recorded daily, and egg weight and shell deformation (μm/500 g force) determined for the last two eggs laid by each bird in the 24th, 36th, 52nd and 72nd weeks of age. Albumen height (mm) was also measured in the 24th, 36th and 72nd weeks of age. Feed intake was recorded between 20 and 28 weeks, 32 and 36 weeks, 48 and 52 weeks, and 68 and 72 weeks of age. Birds were individually weighed at 20 and 72 weeks.

Data for 4-bird replicate plots from all 6 treatment groups were initially analysed using a general analysis of variance from *Genstat 6th Edition* (Lawes Agricultural Trust, 2002) with Rearing treatment*Genotype as the model. The results of these analyses indicated that there were no significant differences between the birds maintained on 25 lux from one day and those transferred from 3 to 25 lux at 9 weeks of age, or among the 4 groups that were given the final transfer to 25 lux at 16 or 20 weeks of age. The data were therefore pooled according to these two groupings and re-analysed to assess the responses to early and late transfer to 25 lux illuminance. Significant differences ($P<0{\cdot}05$) between means were identified using a *t*-test.

RESULTS

In both breeds, hens that had been transferred from 3 to 25 lux at 16 or 20 weeks of age, irrespective of whether or not they had received an initial exposure to 25 lux before 3 lux, laid significantly more eggs than birds transferred to 25 lux at or before 9 weeks (Table). Illuminance during rearing did not significantly affect egg weight in either genotype, but a regression of egg numbers on mean egg weight, using all 6 lighting data-sets, showed a significant negative correlation, with a reduction of about 5 eggs for each 1-g increase in egg weight ($P<0{\cdot}001$).

Shell deformation, albumen height, feed intake and body weight gain between 20 and 72 weeks were not significantly affected by the light intensity treatments imposed during the rearing period.

DISCUSSION

Contrary to the findings of Morris (1967), egg production was significantly affected in both genotypes by the light intensity provided during the rearing period, with birds given an increase in illuminance from 3 to 25 lux at 16 or 20 weeks laying significantly more eggs than those maintained throughout on 25 lux (tantamount to a transfer to 25 lux at one day) or those transferred from 3 to 25 lux at 9 weeks of age (Table). A regression of 4-weekly rates of lay from 24 weeks on egg production period indicated that, in each breed, birds given an increase in illuminance towards the end of the rearing period laid at a consistently higher rate than birds exposed to

Table. *Egg production (eggs/bird.d × 364) between 20 and 72 weeks and mean egg weight (g) at 24, 36, 52 and 72 weeks of age for Shaver White and ISA Brown hens reared under various illuminance regimens before transfer to 25 lux at 20 weeks*

Illuminance regimen in rearing period (code)	Age at final change to 25 lux (weeks)	Shaver White	ISA Brown	Breeds combined
Egg numbers				
Constant 25 lux (1)	0	332	314	323
3 to 25 lux at 9 weeks (2)	9	327	314	321
3 to 25 lux at 16 weeks (3)	16	340	328	334
25 to 3 lux at 9 weeks (4)	20	339	324	332
25 to 3 lux at 16 weeks (5)	20	337	320	329
Constant 3 lux (6)	20	338	319	328
Treatments 1 and 2	0 or 9	330	314	322 ± 2·9
Treatments 3, 4, 5 and 6	16 or 20	339	323	331 ± 1·6
				SED = 2·61
				DF = 116
Breed mean		336 ± 1·4	320 ± 2·1	
Mean egg weight				
Constant 25 lux (1)	0	59·5	65·2	62·3
3 to 25 lux at 9 weeks (2)	9	59·8	65·8	62·8
3 to 25 lux at 16 weeks (3)	16	59·6	64·3	62·0
25 to 3 lux at 9 weeks (4)	20	59·6	65·1	62·3
25 to 3 lux at 16 weeks (5)	20	59·6	64·8	62·2
Constant 3 lux (6)	20	59·8	63·8	61·8
Treatments 1 and 2	0 or 9	59·7	65·5	62·6 ± 0·56
Treatments 3, 4, 5 and 6	16 or 20	59·7	64·5	62·1 ± 0·36
				SED = 0·80
				DF = 116
Breed mean		59·7 ± 0·23	64·8 ± 0·31	

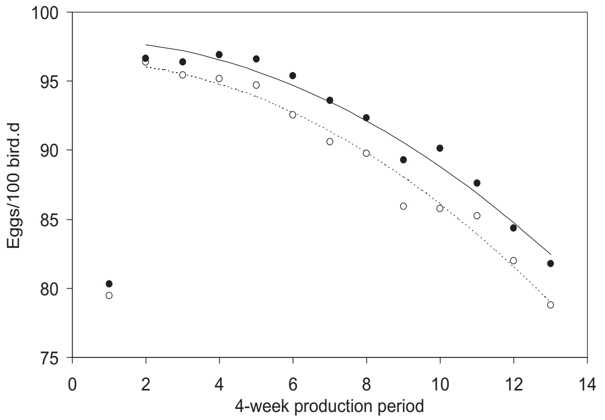

Figure 1. *Mean rate of lay (eggs/100 bird.d) for 4-week periods from 20 to 72 weeks of age for Shaver White and ISA Brown hybrid hens maintained during rearing at a mean illuminance of 25 lux or transferred from 3 to 25 lux at 9 weeks of age (○ and dotted line), or transferred from 3 to 25 lux at 16 or 20 weeks (● and solid line). The respective regression equations between 24 and 72 weeks for early and later transfers to 25 lux are:* $y = 96{\cdot}4 - 0{\cdot}104M^2$ *(*$r^2 = 0{\cdot}978$*, SE for constant = 0·427, SE for* $M^2 = 0{\cdot}005$*, curve SD = 0·907) and* $y = 98{\cdot}0 - 0{\cdot}092M^2$ *(*$r^2 = 0{\cdot}974$*, SE for constant = 0·413, SE for* $M^2 = 0{\cdot}005$*, curve SD = 0·877), where M = 4-week period. The regression curves are not significantly different from each other at* $P < 0{\cdot}05$*, but their elevations are significantly different at* $P < 0{\cdot}0001$*.*

25 lux from early in the rearing period, and that the difference between the two groups progressively widened with time (Figure). The regression line for the birds transferred to 25 lux at 16 or 20 weeks ($y = 98{\cdot}0 - 0{\cdot}092M^2$, where $M = $ 4-week period) had a significantly higher elevation, with the curve tending to be more shallow ($P = 0{\cdot}113$), than for birds given an increase in illuminance early in the rearing period ($y = 96{\cdot}4 - 0{\cdot}104M^2$).

Differences in egg production can frequently be explained by age at sexual maturity, egg weight, body weight or feed intake, however, none could credibly account for the differences in egg numbers observed in this trial. Firstly, there was less than one day between the two groups in the age at which they reached 50% egg production (Lewis *et al.*, 2004) but, according to Lewis *et al.* (1997), nearly 2 weeks advance in maturity would have been required to account for a 9-egg difference, and the earlier maturing group in this instance laid marginally fewer, not more, eggs. Secondly, whilst there was a significant negative correlation between egg numbers and mean egg weight of about 5 eggs per 1 g using data from both genotypes and all 6 treatment groups, the 0·5 g difference in mean egg weight between the two groups could only account for two to three eggs, and, in Shaver White, a 9-egg difference in numbers occurred despite the two groups having the same egg weight (Table). Thirdly, Leeson and Summers (1987) reported significant effects of body weight on egg laying performance, but in this trial there was only 10 g between the two groups at 20 weeks, and only 3 g at 72 weeks. Finally, mean feed intakes were remarkably similar at 103·4 and 103·2 g/d for early and late transfer to 25 lux, respectively (Shaver White: 98·6 and 99·9 g/d, ISA Brown: 108·1 and 106·6 g/d), and, at the mean feed conversion of 115 g/egg, 9 extra eggs would have equated to a 2·8 g higher daily feed intake. With egg weight and shell deformation not significantly different, it is also unlikely that the extra eggs were the result of a reduction in egg formation time.

It is difficult to postulate that changes in illuminance made close to puberty can have an amelioratory effect on the rate of ovulation or interval between ovipositions, particularly when it becomes more effective with time (Figure). However, such high levels of egg production as recorded for the groups that were increased from 3 to 25 lux at 16 or 20 weeks have not previously been recorded in these facilities, and their occurrence in both genotypes suggests that they were not chance effects. Differences in avian reproductive persistency following a change in illuminance during the pre-pubertal period were also observed by Bentley *et al.* (1998) when male starlings were transferred from 8-h days at 108 lux to 18-h days at 3, 13, 45 or 108 lux. Three months after the changes, the birds transferred to 3 lux had significantly larger testicular volumes and lower plasma T4 concentrations, and none were showing signs of a moult: all conditions were strongly indicative of the lack of adult photorefractoriness. Although Morris *et al.* (1995) concluded that modern egg-type hybrids do not exhibit photorefractoriness, and the light intensity was increased, not decreased, in this trial, the suggestion of Bentley *et al.* that the change in light intensity had caused a shift in the photoinducible phase of the starlings which in turn resulted in them perceiving a daylength different from 18 h, might have been the mechanism responsible for the improved persistency in egg production observed in this trial. This mechanism was also suggested as a candidate for the previously reported differences in sexual maturity for these birds (Lewis *et al.*, 2004), with the birds transferred from 3 to 25 lux having later, but birds changed from 25 to 3 lux having earlier, sexual maturity relative to constant illuminance controls.

Any management technique that can increase egg numbers, yet have minimal effect on egg weight, and no adverse effects on egg quality or feed intake, is of considerable economic importance to the commercial poultry industry, and further studies to elucidate the aetiology and to identify the most effective intensities and ratios are warranted.

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