PREFERENCES OF GROWING FOWLS FOR DIFFERENT LIGHT INTENSITIES IN RELATION TO AGE, STRAIN AND BEHAVIOUR

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Abstract *Animal Welfare 1999,* ***8:*** 193-203

The preferences of broiler and layer strains of fowl for four different intensities of incandescent luminaire (6, 20, 60 and 200 lux; Osram, 60W, pearl) were tested at 2 and 6 weeks of age. With each strain, four replicates of 12 birds were each allowed to move freely between four compartments illuminated continuously at the different intensities for 6 days. The distribution of light intensities among the compartments was changed daily. After 2 days of conditioning, the birds' location and behaviour were recorded once every 15min over 23h on each of the remaining 4 days. The other hour was devoted to changing light intensities and refilling the feeders and drinkers. Six, mutually exclusive behaviours were defined: resting, perching, feeding, drinking, litter-directed activity and locomotion.

With both strains, most time was spent in the brightest (200 lux) environment at 2 weeks of age, but in the dimmest (6 lux) at 6 weeks. This apparent change in preference was associated only with the two behaviours which took up most time, resting and perching, whereas the highest intensity was consistently preferred for all other behaviours. Older birds thus preferred to be in dim light when they were relatively inactive.

The finding that older birds prefer to spend much of their time in a light environment of < 10 lux intensity, depending on behaviour, is contrary to current recommendations that minimum light intensities for broilers and laying hens should be increased to as much as 20 lux. Some variation in the spatial or temporal distribution of ambient light intensity, to provide both dimly (< 10 lux) and brightly (eg > 50 lux) lit environments, might benefit the welfare of older poultry, although further work is needed to establish their optimal light environment.

Keywords: *animal welfare, behaviour, broilers, environmental preference, layers, light intensity*

Introduction

Light is arguably the most important stimulus that the domestic fowl, *Gallus gallus domesticus*, receives from the physical environment (Perry & Lewis 1993). Its manipulation, whether through photoperiod, intensity, source or wavelength has profound effects upon the physiology and behaviour of fowl (for a review see Manser [1996]). That fowl have preferences for different

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light environments has been shown by various researchers (Savory & Duncan 1982/83; Appleby *et al* 1984; Alsam & Wathes 1991; Widowski *et al* 1992).

In the UK, the majority of domestic fowl are housed in environmentally controlled buildings in which the light environment is provided artificially. Light intensity has been found to have a significant positive relationship with general activity and energy expenditure in fowl (Proudfoot & Sefton 1978; Boshouwers & Nicaise 1987). Therefore, by maintaining low light intensities, typically 1–10 lux, food conversion rates and growth rates can be improved through reduced activity, and fuel costs reduced (Appleby *et al* 1992). Another advantage of low light intensities is that they help prevent outbreaks of feather pecking and cannibalism. Pecking damage in caged layer pullets kept in areas illuminated between 11 and 44 lux was greater than in those in areas lit at 3–11 lux (Hughes & Duncan 1972), which matches commercial experience.

Very low light intensities, however, are regarded as undesirable for a number of reasons. First, they make it difficult or impossible for all birds to be inspected clearly. Second, commercial light intensities may impose a degree of visual sensory deprivation, perhaps inhibiting foraging, exploration or the successful transmission of visually mediated social information. Third, light intensities, photoperiod and other features significantly different from those naturally encountered may affect the functional development of the eye (Li *et al* 1995; Stone *et al* 1995). Fourth, mortality, leg disorders and bruised carcases in broilers were all found to occur at higher frequencies with dim lighting (6 lux) than with brighter light (180 lux) (Newberry *et al* 1988). There was little effect of light intensity on production parameters in this study, or in another where layers were housed at 0.75 lux or 12.4 lux (Tucker & Charles 1993). Fifth, Hughes and Black (1974) showed that layers housed in low light intensities (17–22 lux) were more fearful, and avoided novel objects, when compared with those housed at high light intensities (55–80 lux). Finally, low light intensities may be perceived by the public as unpleasant for the animals.

In response to these problems, the Farm Animal Welfare Council (FAWC) and the Royal Society for the Prevention of Cruelty to Animals (RSPCA) have condemned the practice of providing very low light intensities in poultry housing. FAWC, commenting on the paucity of information on the welfare implications of low light intensities, recommended a light intensity for broilers of 20 lux with an absolute minimum of 10 lux (FAWC 1992), and a 10 lux minimum for laying hens (FAWC 1997). The RSPCA recommend a minimum intensity of 20 lux for broiler chickens (RSPCA 1994a) and 10 lux for laying hens (RSPCA 1994b). While the need to optimize the light environment in poultry houses is clear, many farmers are concerned that the recommended increases in intensity will result in increased pecking damage, particularly among laying hens.

The aim of this investigation was to determine what preferences, if any, modern strains of fowl show among a range of different light intensities (6, 20, 60 and 200 lux), and whether such preferences are influenced by age (at 2 vs 6 weeks), strain (broiler vs layer) and behaviour. Circadian variation in the use of different light environments was also assessed. A better understanding of lighting preferences should help in the development of management practices and guidelines that are best suited to poultry welfare.

Materials and methods

Subjects and rearing environment

A total of 60 broilers (Ross International, mixed sex) and 60 layers (ISA Brown, females) were the subjects for the investigations. They were obtained as day-old chicks, in one batch of 15 of each strain in each week, over 4 consecutive weeks. Each batch was reared separately in a

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temperature- and ventilation-controlled room, in a 2.5m^2 pen provided with a perch (1.8m long and 8cm above the floor), wood shavings litter, and *ad libitum* supplies of water. The birds were fed a conventional, pelleted starter diet (Poultry Growers' Pellets ACS; W Jordan & Sons, Biggleswade, UK).

The lighting environment during rearing was controlled using many incandescent bulbs (Osram, 60W, pearl). Lighting was continuous at 60 lux intensity for the first 72h and then changed to a 20L: 4D schedule. The 20h photoperiod was divided into eight, 2.5h periods, when light intensity was changed every day according to the following sequence: 6, 20, 60, 200, 200, 60, 20 and 6 lux. These were the same intensities as were tested in the preference experiment; this schedule in the rearing environment was designed to give the birds an equal experience of each light intensity. Light intensity, both here and for the experiment, was measured by angling the cosine-corrected photoreceptor sensor of a light meter (Macam Photometer, Model L103; Macam Photometrics Ltd, Livingston, UK) in the direction of maximum radiance; a method defined by Tucker and Charles (1993). All intensities were measured 25cm above the litter.

Preference chamber

The experiment was conducted in a preference chamber, described fully by Jones *et al* (1996). The chamber consisted of eight, identical, interconnecting compartments arranged in an annulus, and divided into two blocks of four compartments for this experiment. Each compartment was trapezoidal in shape, with a floor area of 1.6m^2 and access to the adjacent compartment(s) through an opening measuring 45x22 cm in the end wall(s). Each compartment was provided with a feeder and drinker containing *ad libitum* starter diet and water, a perch and wood shavings litter, all as in the rearing environment. Continuous illumination was provided from five incandescent bulbs (Osram, 60W, pearl) situated above the Perspex lid of each compartment and diffused through tissue paper. The lamps for each compartment were connected to separate dimmer switches set to provide 6, 20, 60 or 200 lux. The variation in light intensity within each compartment was ± 5 per cent of the mean, as recorded from 16 measurements taken 25cm above the litter. Compartments were well ventilated with fresh air (c 57 air changes h^{-1}); ambient temperature was not closely controlled, and it varied between 22.3 and 29.3 °C over the course of the experiment. Increasing the light intensity from minimum (6 lux) to maximum (200 lux) was found to increase ambient temperature by between 0.3 to 0.7 °C. Given the rapid ventilation rate and the low heat output of the birds, the temperature of the compartments would not have been greatly affected by occupancy/non-occupancy by the birds.

Experimental design and protocol

One batch of each strain was tested in each week, at 2 and 6 weeks of age, over 8 consecutive weeks. Each batch consisted of 12 birds chosen at random from the original 15, which were kept in half of the preference chamber (four compartments) for 6 days at each age. The first 2 days were for conditioning and the remaining 4 for testing. The light intensity in each compartment was changed every 24h. Allocation of the four intensities among compartments was random during the conditioning phase, but according to a Latin square arrangement during the testing phase, to allow for any inherent preferences for particular compartments (eg possible 'end effects'). During the testing phase, the birds' behaviour was recorded on video for 1min at 15min intervals over 23h in each day, from a time-lapse camera situated directly above the Perspex lid of each compartment. In the remaining hour of each day, feeders and drinkers were refilled, light intensities reallocated among compartments, and new videotapes put in the recorder. Between testing at 2 and 6 weeks of age, the birds were returned to their rearing pens with the same lighting regime as during rearing.

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Data recording

From each minute of recording, one instantaneous observation ('on the dot'; Slater [1978]) was made of every bird and its behaviour in each compartment. These data were summed over the whole day (12 birds x 23h x 4 observations h^{-1}) to give estimates of the total time spent, and the particular behaviour of the birds, in each compartment. Since some activities could not be identified reliably from the overhead cameras, behaviour was recorded according to six, broad, mutually exclusive categories. These were: resting (sitting, standing, preening or dustbathing while on the floor); perching (sitting, standing or preening while on the perch or feeder); feeding (actively at the feeder); drinking (actively at the drinker); litter-directed activity (any litter-directed pecking or scratching); and locomotion (walking or running). Daily food and water consumption in each compartment were also recorded.

Statistical analysis

The total times spent in the four light environments by the four batches (replicates) of each strain at each age were analysed by ANOVA, using Genstat, version 5 (Lawes Agricultural Trust 1989), to test the effects of light intensity (6, 20, 60, 200 lux) and its interaction with age (2 vs 6 weeks) and strain (broiler vs layer). All data were square root transformed to approximate a normal distribution – except the amount of water drunk which was transformed by the empirical logistic function.

The circadian variation in occupancy of the brightest (200 lux) and dimmest (6 lux) compartments was tested by using chi-square tests for each strain and age. The number of birds observed in each environment per hour gave the 'observed' values; the means of these for each hour were then calculated to give the 'expected' values. A similar analysis tested the circadian variation in the number of birds engaged in the relatively inactive behaviours (resting and perching).

Results

Total occupancy

The total times spent in particular compartments differed significantly according to light intensity; the effect of light intensity was dependent on the age of birds but not on genetic strain; and strain did not affect the interaction between light and age (Table 1).

Table 1 Significance of effects of age, light, strain and their interactions, on total time spent in particular compartments, on behaviour, and on food and water consumption. (Data taken from ANOVA, n = 256.) **P < 0.01; ***P < 0.001; – not significant (P > 0.05); n/a – not applicable.

	A	L	S	AxL	AxS	LxS	AxLxS
Total time	n/a	***	n/a	***	n/a	-	-
Resting	-	**	**	***	-	-	-
Perching	**	**	***	***	-	-	-
Feeding	-	***	**	**	-	-	-
Drinking	-	***	***	-	-	-	-
Litter-directed	***	***	-	***	-	-	-
Locomotion	**	***	-	***	-	-	-
Food	***	***	-	-	-	-	-
Water	***	***	***	-	-	-	-

A = age; L = light; S = strain; x = interaction between treatments.

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Thus, 2-week-old birds spent most time in the brightest light (200 lux) and least time in the dimmest light (6 lux), whereas the opposite was the case with the 6-week-old birds (Figure 1; this shows combined values from both strains because there was no significant interaction with strain).

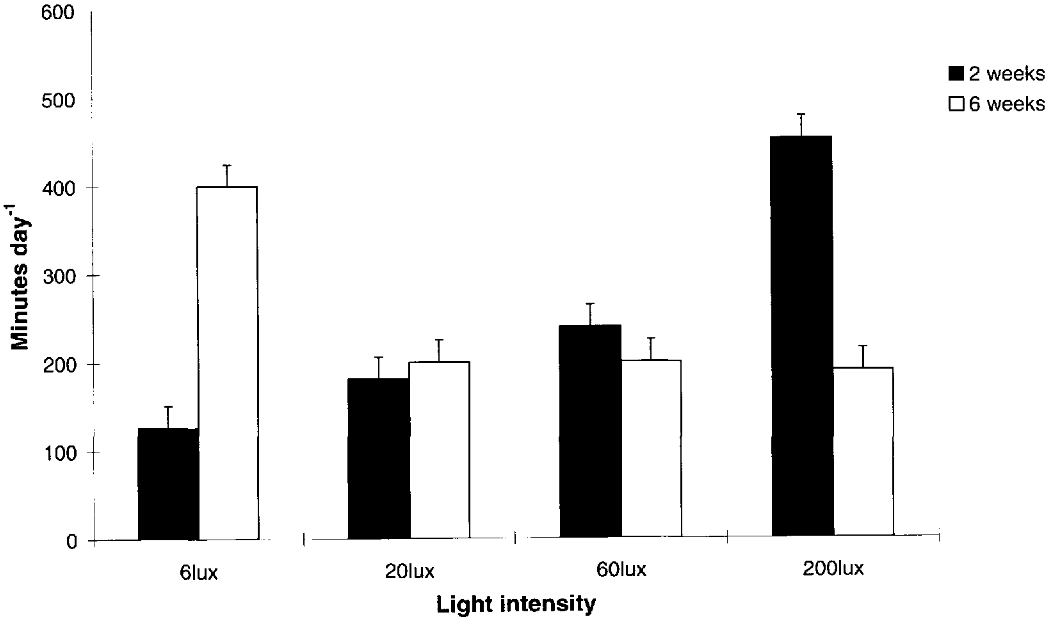

Figure 1 **Mean (± SED) overall occupancy (min day^{-1}) at the four different light intensities.**

Associations between light intensity and behaviour

The times spent in the six behavioural categories differed significantly between light environments in every case; the effect of light intensity was dependent on age for all behaviours except drinking; and there was no significant interaction with strain (Table 1). Thus, times spent resting and perching increased from the dimmest to the brightest light at 2 weeks, but decreased from the dimmest to brightest light at 6 weeks (Figure 2). The similarity of these responses to those of total occupancies (see above) was because resting and perching were the dominant behaviour categories, together comprising 58 per cent and 68 per cent of total time at 2 and 6 weeks respectively (Table 2). With feeding, drinking, litter-directed activity and locomotion, ie those behaviours which took up less time, there were consistent trends for more of these behaviours to occur in brighter light than in dimmer light, but, with the exception of drinking, these trends were less marked at 6 weeks than at 2 weeks (Figure 2).

More time was spent perching and less time was spent in litter-directed activity and locomotion at 6 weeks than at 2 weeks; and broilers spent more time resting and drinking but less time perching and feeding than did layers (Tables 1 and 2).

Food and water consumption differed significantly between light environments (Table 1), being highest in bright light (overall means 50g and 68ml bird^{-1} day^{-1}, respectively) and lowest in dim light (23g and 52ml bird^{-1} day^{-1}, respectively) at both 2 and 6 weeks of age. Both food

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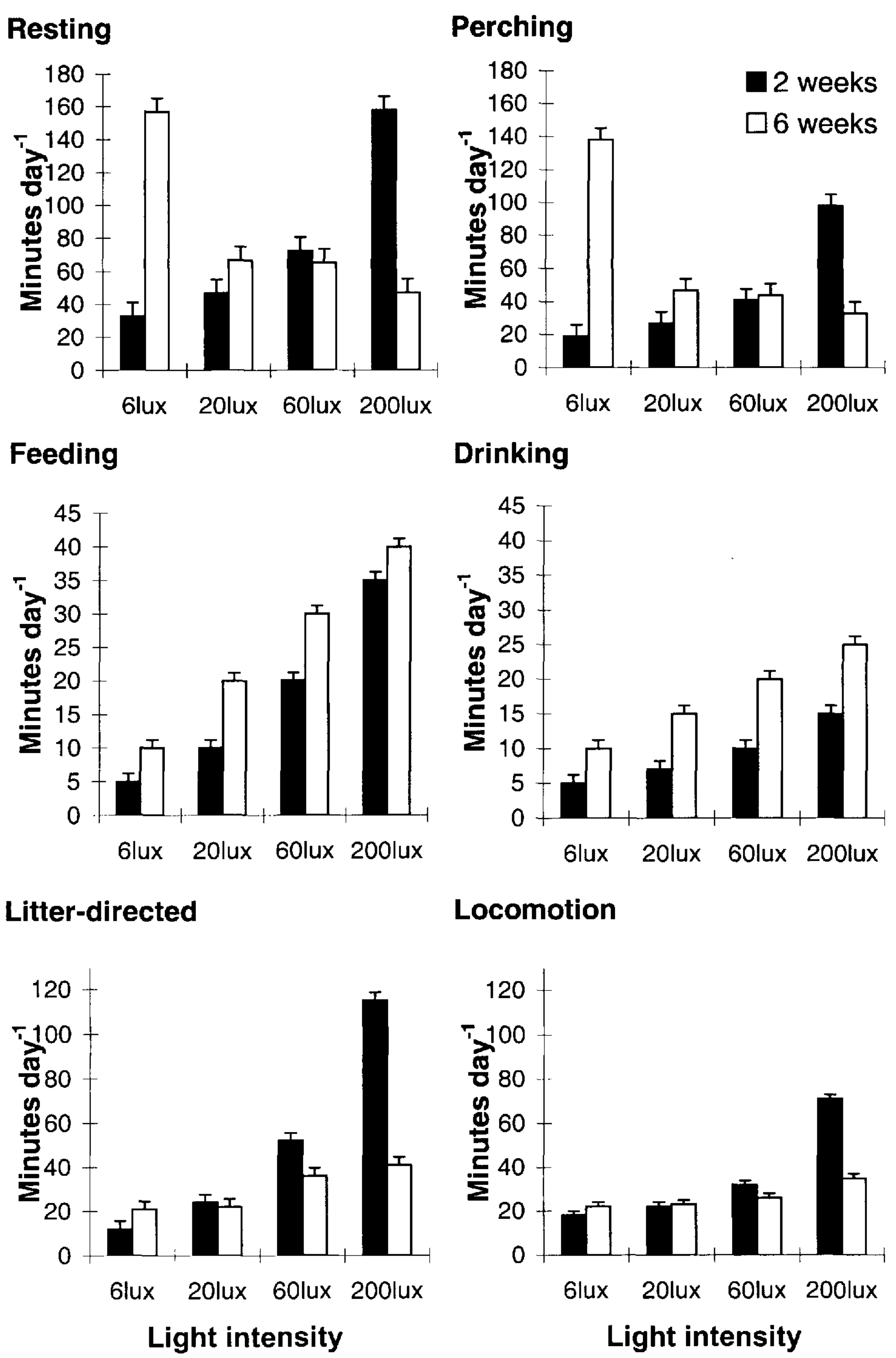

Figure 2 **Mean (± SED) distribution of behaviours (min day^{-1}) among the four different light intensities.**

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Table 2 **Mean (± SEM) proportions of time (percentages) spent in different behaviours for both broilers and layers at 2 and 6 weeks of age.**

	Broilers		Layers	
	2 weeks	**6 weeks**	**2 weeks**	**6 weeks**
Resting	41.6 ± 2.8	45.4 ± 1.4	27.5 ± 1.5	29.5 ± 2.4
Perching	16.6 ± 3.4	22.3 ± 1.7	30.2 ± 1.8	37.5 ± 2.4
Feeding	3.4 ± 0.7	4.3 ± 0.7	5.4 ± 1.0	6.3 ± 1.2
Drinking	4.0 ± 1.1	4.7 ± 1.2	1.9 ± 0.6	1.9 ± 0.5
Litter-directed	21.8 ± 2.5	13.4 ± 1.7	19.1 ± 1.8	13.3 ± 1.6
Locomotion	12.3 ± 1.5	9.7 ± 1.5	16. 0 ± 1.8	11.6 ± 1.0

and water intake increased with age and strain (Table 1). Six-week-old broilers consumed more water than 2-week-old ones, and broilers consumed more than layers. Although there was no significant difference in food intake between strains, layers spilled more food onto the floor than broilers, making this comparison unreliable.

Circadian variation in the use of different light environments

There was no significant circadian rhythm in the usage of the 6 lux or 200 lux compartments, or resting or perching behaviour by the broilers at 2 or 6 weeks, or the layers at 2 weeks. At 6 weeks, however, the layers exhibited a significant rhythm in their usage of the 6 lux compartment ($P < 0.01$), and in perching ($P < 0.05$). Here, the high incidence of perching behaviour between 2300h and 1000h was closely correlated with a strong preference for the 6 lux compartment.

Discussion

The results of this investigation indicate that chicks of commercial strains of fowl show significant preferences when allowed to choose among a range of different light intensities. Both broilers and layers spent most time in the brightest light available (200 lux) at 2 weeks of age, but in the dimmest light (6 lux) at 6 weeks. This apparent reversal of overall preference was mainly due to changes associated with the two activities which took up most time, ie resting and perching (Figure 2). Feeding (and food intake), drinking (and water intake), litter-directed activity and locomotion were seen more in bright light than in dim light at both ages, although these trends were less marked at 6 weeks.

At 2 weeks, therefore, all activities occurred mostly in bright light; whereas at 6 weeks resting and perching were seen mainly in dim light and other activities mainly in bright light. This raises the question of whether, at 6 weeks of age, birds entered a particular light environment in order to perform a particular activity – or whether the light intensity they happened to be experiencing at the time influenced the type of behaviour shown.

Exposure to light stimuli is known to induce behavioural arousal (movement) and desynchronization of the electroencephalogram (physiological arousal) in rats (Sasaki *et al* 1996). Both physical activity and energy expenditure of laying hens were found to increase progressively in response to a range of increasing light intensities between 1 lux and 120 lux (Boshouwers & Nicaise 1987). In another comparison, growing broilers kept in brightly lit (180 lux) pens were more active than others in dimly lit (6 lux) pens (Newberry *et al* 1988). There thus appears to be a fundamental positive relationship between light intensity and arousal/activity level within the range of intensities tested in the present study. This could account for the associations between reduced activity (resting and perching) and dim light, and

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increased activity (feeding, drinking, litter-directed, locomotion) and bright light, seen with broilers and layers at 6 weeks of age.

It is possible that a developmental change in behaviour could account for the observed overall preference for dim light in 6-week-old chicks. Both strains in the present study spent less time in litter-directed activity and locomotion, and more time perching, at 6 weeks than at 2 weeks (Tables 1 and 2). Similar changes in behaviour have been observed in other studies where broiler and/or layer strains were kept in pens with little local variation in light intensity (and intensities ranging from 6–180 lux). In these studies, times spent in more active behaviours, including feeding, drinking, litter-directed activity and locomotion, declined over the first 6 weeks of life, while less active behaviours, including sitting and preening, increased (Newberry *et al* 1988; Blokhuis & van der Haar 1990; Bessei 1992; Savory & Mann 1997). Thus, growing chicks tend to spend more time inactive as they grow older and heavier, regardless of light intensity. In the present study, most (68%) of their time at 6 weeks of age was spent being relatively inactive in dim light. This suggests that the older chicks may have preferred to be in the dimmest environment when they were inactive, because that was where they were least aroused by illumination, and to be in bright light when they were active. In other words, they may have entered particular environments in order to perform particular activities. Other evidence to support this suggestion is the significant circadian variation found at 6 weeks of age in the occupancy of the dimmest environment and perching by the layer chicks. The suggestion could be tested by measuring the motivation of chicks to enter particular light environments at different ages and times of day, by using an operant procedure for example (cf Savory & Duncan [1982/83]).

This suggestion does not seem to apply to the younger, 2-week-old, chicks which also spent most (58%) of their time being relatively inactive, and yet preferred to be in the brightest light at all times, regardless of the behaviour shown (Figure 2). It is possible that the small (0.3–0.7 °C) increment in ambient temperature (and possible additional radiant heat) in the most brightly lit compartment compared with the dimmest may have been sufficient to account for the observed preference for 200 lux at 2 weeks of age, when the background temperature (22.3 – 29.3 °C) could sometimes have been below the lower limit of the chicks' thermoneutral zone (Freeman 1963). The possibility that the 2-week-old chicks' choice of the brightest light was a thermoregulatory response, rather than a preference for bright light per se, cannot, therefore, be ruled out. This would not have been the case at 6 weeks, when feathering and homeothermy are more complete (Barott & Pringle 1946; Wathes & Clark 1981). However, our data are consistent with other studies. In an experiment where growing broilers were allowed to move freely between a continuously illuminated (20 lux) compartment and an unlit (0.05 lux) compartment, the proportion of time they spent in the dark compartment remained at less than 1 per cent until 4 weeks of age, and then increased progressively to 33 per cent at 6 weeks (Berk 1995). Background temperature in this study, which 'was 31°C at the first day and then reduced to 21°C', should have remained within the broilers' thermoneutral zone as defined by Wathes *et al* (1982) if the temperature decline accounted for no more than 0.5°C per day. Similarly, Alsam and Wathes (1991) also showed a declining preference for brighter light (between 34 lux and 1 lux) among chicks aged between 1 and 14 days of age at a temperature which was reduced from 31°C by 0.5°C day^{-1}.

Another possibility is that the observed choice of light environment could have been associated with fearfulness, which has been reported to increase with age in chicks (Candland *et al* 1963; Jones 1995). It is conceivable that older, 6-week-old, chicks may have preferred to be in the dimmest light when inactive because they were fearful in bright light; whereas younger chicks may not have been fearful in bright conditions.

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Whether these effects are applicable to fluorescent or other types of luminaire is unknown, since light sources differ markedly in their spectral power output or colour balance (Prescott & Wathes 1999b in press). Therefore, there may be interactions between intensity and colour depending on the light source. More importantly perhaps, the intensity of these light sources will be perceived differently even if lit to the same intensity on the lux scale, since this unit is a function of the spectral power output of the lamp and the spectral sensitivity of the human, which differs from that of a fowl (see Nuboer [1992]; Prescott & Wathes [1999a in press]). Therefore, the absolute values of light intensity (in lux) in this experiment, may not produce the same effect(s) in other luminaire types lit to a similar intensity when measured in lux. For example, Prescott and Wathes (1999a in press) calculated that a typical fluorescent luminaire would be perceived by fowl as 30 per cent brighter than a typical incandescent luminaire if lit to the same lux intensity.

Animal welfare implications

In the present study, young broiler and layer chicks spent most of their time in the most brightly lit (200 lux) environment, regardless of their behaviour; whereas older ones preferred to be in the dimmest (6 lux) light when they were relatively inactive but in bright light when they were active. The conclusion that older birds prefer to spend much of their time in a light environment of < 10 lux intensity, depending on behaviour, is contrary to current recommendations by the FAWC and RSPCA that average minimum light intensities for broilers and laying hens should be increased to as much as 20 lux (see, *Introduction*). It could be argued that the experimental set-up in the present study, where illumination was provided continuously, is not comparable with conventional poultry housing, where birds are in darkness for up to 16h day^{-1}. Even so, the proportions of time spent in different activities in the present study (Table 2) were similar to those reported from previous research where penned growing broilers and layers were provided with light for 14h each day, at intensities ranging from 70–150 lux (Blokhuis & van der Haar 1990; Savory & Mann 1997). The implication is that, with either continuous or intermittent lighting, some variation in ambient light intensity to provide both dimly (< 10 lux) and brightly (eg > 50 lux) lit environments might benefit the welfare of poultry aged more than, say, 4 weeks old. Such variation could be either spatial (in extensive housing systems) or temporal. Further work is required to establish optimal conditions.

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