Broilers perform better on short or step-up photoperiods

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Abstract

Rearing broilers on 6-h photoperiods and transferring them to 23 h at 21 d has been shown to reduce mortality and the incidence of leg disorders without adversely affecting final body weight or feed conversion efficiency. However, in many countries, welfare codes for meat chickens currently stipulate a minimum photoperiod of 8 h, and are likely to specify a minimum uninterrupted dark period of 8 h in the future. This paper reports a study of the response of two genotypes of broiler females to a lighting regimen that complies with these requirements: an initial 8-h photoperiod followed by a 16-h photoperiod from 21 to 42 d. Constant 8- and 16-h photoperiods were provided as controls. The two breeds responded similarly to all lighting treatments. Constant 8-h and photostimulated birds had significantly heavier body weights, and strong tendencies towards larger feed intakes and superior feed conversion, than the 16-h controls. Lighting treatment had no significant effect on mortality or the incidence of leg problems. Ross birds had a significantly slower growth to 21 d, higher feed intake after 21 d, and inferior feed conversion efficiency throughout than Cobb birds. Ross birds had significantly lower mortality and fewer leg disorders than Cobb, due possibly to their slower initial growth.

Keywords: Photoperiod, broiler growth, feed conversion efficiency
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Introduction

Since the beginning of the broiler industry in the 1950s, though less so now, it has been common practice to provide either continuous (LL) or near continuous illumination in the belief that this maximizes feed intake and growth rate (Moore, 1957; Beane *et al*., 1962; 1965; Morris, 1967; Weaver & Siegel, 1968; Classen, 1992). In contrast, Skoglund *et al*. (1966) observed differences of no more than 3.4% in feed intake and 2.5% in body weight among 3, 6, 12 h and LL groups, with 12 h not significantly different from LL. More recently, Renden *et al*. (1992; 1993; 1996) and Gordon & Tucker (1995) found no significant differences in either feed intake or body weight among broilers given photoperiods varying between 8 and 23 h. However, these later findings showed important interactions between age and the response to photoperiod: feed intake and growth rate were positively correlated with photoperiod during the initial 21 d, but negatively correlated thereafter, especially when the daylength was ≥ 12 h.

Although photoperiod only minimally affects performance, longer daylengths detrimentally influence most aspects of broiler welfare, and do so at all ages. Longer photoperiods and LL are associated with an increase in total mortality and a higher incidence of leg disorders (Buckland *et al*., 1976; Renden *et al*., 1993; 1996; Gordon & Tucker, 1995), and the development of various forms of ocular abnormality (Jensen & Matson, 1957; Shutze *et al*., 1960; Whitley *et al*., 1984; Oishi & Murakami, 1985; Li *et al*., 1995; Stone *et al*., 1995).

The slower initial growth, but subsequent compensatory weight gain of broilers kept on shorter photoperiods, and the closer connection of skeletal development with age than body weight (Wise, 1970), stimulated the research of lighting regimens that involved a 6-h daylength to 14 or 21 d and a 23-h, or step up to 23-h, daylength thereafter as a technique for reducing mortality and improving skeletal integrity (Classen & Riddell, 1989, Classen *et al*., 1991; Renden *et al*., 1991; 1992; 1993; 1996; Blair *et al*., 1993). The programmes consistently improved liveability to ≥ 42 d, reduced the incidences of sudden death syndrome and leg disorders, improved feed conversion efficiency, and had no adverse effect on body weight; though the improvements were greater for males than females. Despite the clear benefits to bird health, the use of 6- and 23-h photoperiods are likely to be prohibited in future poultry welfare codes. Already, laying hens in the European Union must have at least 8 h, and growing turkeys 4 h but ideally 8 h, of uninterrupted darkness, and, in the UK, broilers must be given at least 8 h of light and not less than 30 min of darkness. This paper describes the findings of a trial in which broilers were started on 8 h and transferred abruptly to 16 h at 21 d, or maintained on 8 or 16 h throughout.

Materials & Methods

Cobb 500 and Ross 308 female broilers, which had been feather sexed and vent sexed to exclude males, were placed at 1 d of age on the litter floor in each of nine lightproof rooms. Each room was divided into two pens with a mesh fence, and 200 Cobb or 200 Ross birds placed in each pen at a stocking density of 8.4/m². All birds were given constant illumination for the first day, then three rooms were randomly allocated to each of three lighting regimens from 2 d: constant 8 h, constant 16 h, or 8 h to 21 d and 16 h from 22 to 42 d (INC) (3 lighting treatments x 3 rooms x 2 breeds x 200 birds = 3600 birds). In each pen light was provided by two 11W compact warm-white fluorescent lamps located 1.8 m above the floor, giving a mean illuminance of 29 ± 2.3 lux at a height of 20 cm. All groups received the same feeding regimen: a proprietary broiler starter crumb (12.8 MJ ME /kg, 200 g crude protein/kg) to 14 d, a broiler grower pellet (12.8 MJ ME /kg, 160 g crude protein/kg) 15 to 28 d, and a broiler finisher pellet (13.0 MJ ME/kg, 160 g crude protein/kg) 29-42 d. All feed was delivered from manually filled hanging tube feeders.

A sample of 60 birds from each pen were bulk weighed at 7-d intervals between 7 and 35 d, and all birds bulk were weighed at 42 d. Feed was weighed back every 7 d. Mortality was recorded daily, and any ailing birds examined for signs of leg disorder and culled if appropriate. All data were analysed using a 2-way ANOVA with light and breed as variables (Analytical Software, 2003). There were no significant light x breed interactions, so this term was dropped from the model. Significant differences between treatments were identified using a Students *t* test.

Results

Lighting did not affect feed intake, growth, or feed conversion efficiency to 21 d ($P > 0.05$). The constant 8-h and INC birds had higher body weight gains ($P < 0.01$) and more efficient feed conversion efficiency ($P < 0.05$), and the 8-h birds a higher feed intake ($P < 0.05$), than 16-h birds between 22 and 42 d (Table 1). Overall to 42 d, the 8-h and INC birds had a higher feed intake ($P = 0.15$) and heavier body weights ($P < 0.05$) than the 16-h birds. The INC birds converted feed more efficiently than the 16-h birds ($P < 0.05$), with 8-h birds intermediate. Lighting treatment had no effect ($P > 0.05$) on mortality, culling, or leg problems at any age (Table 2).

Feed intakes were similar, but Cobb had a heavier body weight at ($P < 0.05$), and converted feed more efficiently to ($P < 0.01$) 21 d than Ross (Table 3). Body weight gain between 22 and 42 d was similar for the two breeds ($P > 0.05$), but, in this period, Ross consumed more feed ($P < 0.01$), though converted it less efficiently ($P = 0.058$), than Cobb. Body weights at 42 d did not differ ($P > 0.05$), but Ross had a higher feed intake ($P < 0.01$) and converted feed less efficiently ($P < 0.01$) to 42 d than Cobb. There were no culls or leg problems in the first 21 d, and mortality was similar ($P > 0.05$) for the two breeds (Table 3), but in the final 21 d and overall to 42 d, Ross had lower mortality ($P < 0.05$) and lower incidences of culling and leg problems ($P < 0.01$) than Cobb.

Discussion

The non-significant differences between the constant 8-h and 16-h groups for feed intake and body weight gain to 21 d and the higher feed intakes and faster growth by the 8-h birds between 22 and 42 d (Table 1) contrast with the significantly lower 8-h values at 21 d but similar values at 42 d reported by Gordon & Tucker (1995). This may be the result of changes in patterns of feed intake and growth since that work was conducted. For example, in 1996, Ross I broilers grown to 42 d ate 30% (1.08 kg) of their total feed consumption during the first 21 d (Ross Breeders, 1996), however, the figure for the current genotype is only 25% (1.02 kg); a marked and surprising reduction in both percentage and absolute terms considering that total feed intake to 42 d has increased by about 0.40 kg over the same period (Aviagen, 2007). Meat-type poultry on short photoperiods learn to eat in the dark to satisfy their desire for food (Morris, 1967; Lewis *et al*., 1998) and, when kept in total darkness from 7 d, have been observed to have a feed intake and body weight similar to LL birds (Cherry & Barwick, 1962). Thus, an alternative scenario for the improved performance to 21 d under 8 h is that the genetically larger appetite and faster growth of the modern broiler (McKay *et al*., 2000) has forced it to eat in the dark at a younger age than did its predecessors, thus avoiding

Table 1 Mean body weight, feed intake and feed conversion ratio 0-21 d, 22-42 d, and 0-42 d for Cobb 500 and Ross 308 females maintained on 8- or 16-h photoperiods, or given 8-h photoperiods to 21 d and 16-h photoperiods from 22 to 42 d (INC)

Breed	Lighting treatment	Body weight (g)	Feed intake (g/bird)	Feed conversion ratio (g/g)
		0 - 21 d		
Ross	constant 8 h	856	1163	1.44
	constant 16 h	865	1176	1.44
	INC	858	1198	1.47
Cobb	constant 8 h	887	1152	1.37
	constant 16 h	897	1188	1.39
	INC	880	1165	1.39
Mean	constant 8 h	871	1158	1.40
	constant 16 h	881	1182	1.42
	INC	869	1158	1.43
	P value	0.577	0.210	0.402
	Pooled s.e.d.	12.3	14.1	0.020
		22 - 42 d		
Ross	constant 8 h	1681	3835	2.28
	constant 16 h	1512	3709	2.46
	INC	1658	3761	2.27
Cobb	constant 8 h	1636	3724	2.28
	constant 16 h	1580	3627	2.29
	INC	1656	3663	2.21
Mean	constant 8 h	1659^{a}	3779^{a}	2.28^{b}
	constant 16 h	1546^{b}	3668^{b}	2.38^{a}
	INC	1657^{a}	3712^{ab}	2.24^{b}
	P value	0.004	0.038	0.024
	Pooled s.e.d.	31.8	38.9	0.044
		0 - 42 d		
Ross	constant 8 h	2537	4998	2.01
	constant 16 h	2378	4885	2.10
	INC	2516	4954	2.01
Cobb	constant 8 h	2523	4876	1.97
	constant 16 h	2478	4815	1.98
	INC	2535	4827	1.94
Mean	constant 8 h	2530^{a}	4937	1.99^{ab}
	constant 16 h	2428^{b}	4850	2.04^{a}
	INC	2526^{a}	4891	1.97^{b}
	P value	0.018	0.151	0.072
	Pooled s.e.d.	34.9	41.8	0.028

^{a,b} Within columns, means with different superscripts are significantly different at $P < 0.05$
Res df = 14 for all analyses

Table 2 Total mortality, and incidence of culling and leg problems 0-21 d, 22-42 d, and 0-42 d for Cobb 500 and Ross 308 females maintained on 8- or 16-h photoperiods, or given 8-h photoperiods to 21 d and 16-h photoperiods from 22 to 42 d (INC)

Breed	Lighting treatment	Total mortality (%)	Culls (%)	Leg problems (%)
		0 - 21 d		
Ross	constant 8 h	2.7	-	-
	constant 16 h	2.7	-	-
	INC	2.0	-	-
Cobb	constant 8 h	2.5	-	-
	constant 16 h	2.5	-	-
	INC	2.3	-	-
Mean	constant 8 h	2.6	-	-
	constant 16 h	2.6	-	-
	INC	2.2	-	-
	P value	0.599		
	Pooled s.e.d.	0.85		
		22 - 42 d		
Ross	constant 8 h	1.0	0.0	0.3
	constant 16 h	2.2	0.3	0.5
	INC	1.5	0.3	0.2
Cobb	constant 8 h	2.8	1.3	1.7
	constant 16 h	3.0	0.7	0.7
	INC	3.2	0.5	0.8
Mean	constant 8 h	1.9	0.7	1.0
	constant 16 h	2.6	0.5	0.6
	INC	2.3	0.4	0.5
	P value	0.678	0.737	0.244
	Pooled s.e.d.	0.75	0.32	0.30
		0 - 42 d		
Ross	constant 8 h	3.7	0.0	0.3
	constant 16 h	4.8	0.3	0.5
	INC	3.5	0.3	0.2
Cobb	constant 8 h	5.3	1.3	1.7
	constant 16 h	5.5	0.7	0.7
	INC	5.5	0.5	0.8
Mean	constant 8 h	4.5	0.7	1.0
	constant 16 h	5.2	0.5	0.6
	INC	4.5	0.4	0.5
	P value	0.644	0.737	0.244
	Pooled s.e.d.	0.81	0.32	0.30

[a,b] Within columns, means with different superscripts are significantly different at P < 0.05
Res df = 14 for all analyses

the suppression of feed intake and growth before 21 d observed in earlier studies. As soon as short-day birds have learnt to eat during the scotoperiod, they are obviously able to feed continuously, as if on LL, and to eat to their potential. In contrast, 16-h birds may be able to satisfy their hunger without eating in the dark, but the shorter feeding time inevitably leads to a lower feed intake, despite a theoretical higher energy expenditure

(MacLeod *et al*., 1988), and a reduction in final body weight. Although eating in the dark may not be the complete explanation for the difference in feed intake under 8- and 16-h photoperiods between 22 and 42 d, it does emphasize the importance of ensuring that feed is available throughout the dark period when commercial birds are kept on short days. The non-significant difference in feed conversion efficiency between the constant 8- and 16-h groups agrees with the findings of Gordon & Tucker (1995).

Table 3 Mean body weight, feed intake, feed conversion ratio, mortality and incidence of leg problems 0-21 d, 22-42 d, and 0-42 d for Cobb 500 and Ross 308 females, with data pooled for the three lighting treatments

Breed	Body weight (g)	Feed intake (g/bird)	Feed conversion ratio (g/g)	Total mortality (%)	Leg problems (%)
			0 - 21 d		
Ross	860 [b]	1177	1.45 [a]	2.4	0
Cobb	888 [a]	1168	1.39 [b]	2.4	0
P value	0.013	0.448	0.002	1.000	-
Pooled s.e.d.	10.0	11.5	0.017	0.315	-
			22 - 42 d		
Ross	1617	3768 [a]	2.34	1.6 [b]	0.3 [b]
Cobb	1624	3671 [b]	2.26	3.0 [a]	1.1 [a]
P value	0.794	0.009	0.058	0.034	0.011
Pooled s.e.d	26.0	31.8	0.036	0.62	0.25
			0 - 42 d		
Ross	2477	4946 [a]	2.04 [a]	4.0 [b]	0.3 [b]
Cobb	2512	4839 [b]	1.96 [b]	5.4 [a]	1.1 [a]
P value	0.235	0.008	0.005	0.034	0.011
Pooled s.e.d.	28.5	34.1	0.023	0.62	0.25

[a,b] Within columns, means with different superscripts are significantly different at P < 0.05
Res df = 14 for all analyses

The previous work with step-up lighting programmes, which invariably included an increase from 6 to 23 h at 21 d (Classen & Riddell, 1989, Classen *et al*., 1991; Renden *et al*., 1991; 1992; 1993; 1996; Blair *et al*., 1993) showed that feed intakes and body weights were usually lower at 21 d, but similar at 42 and 49 d, to those of birds maintained throughout on 23 h. Although the differences in body weight at 21 d failed to reach significance in some of these earlier trials, a paired-*t* test of all the data showed a significant reduction in body weight at 21 d (P < 0.001), but no significant difference at 42 d (P = 0.527). The trials generally involved only males, and it was suggested that the compensatory feed intake and growth after 21 d were consequences of an increased production of anabolic steroids following the transfer from 6 to 23 h (Classen, 1992). Physical feed restriction during the early growing period has also resulted in compensatory growth in the later stages (Plavnik & Hurwitz, 1985; 1988), but the findings of the current trial question this conclusion and offer an alternative explanation. The similarity of the feed intakes and body weights for the 8- and 16-h treatments at 21 d meant that no compensatory growth was required between 22 and 42 d; yet both the constant 8-h and the photostimulated groups had higher feed intakes and larger body weight gains in that period than 16-h birds. Notwithstanding that broiler females can experience a photosexual response at 21 d (Dunn *et al*., 1990), there is doubt as to the relevance of this phenomenon because a transfer from 6 to 23 h is predicted to have minimal effect on gonadal development (Lewis & Morris, 2004), and both the photostimulated (8 to 16 h) and un-photostimulated (constant 8 h) groups in this trial out-performed the constant 16-h birds after 21 d (Table 1). The alternative explanation is that birds on 8 h learned to eat in dark during the initial 21 d, but those on 16-h days did not, and the photostimulated birds continued to use the talent during the final 21 d, even though they were receiving 16 h of light. Unfortunately, none of the early studies included a constant short-day control, so comparisons can only be with 23 h photoperiods, and the possibility that dark-time feeding was the explanation cannot be explored.

The significantly more efficient feed conversion of the photostimulated birds, relative to the constant 16-h controls, agrees with the numerically superior difference observed by Renden *et al.* (1993), but disagrees with the similar conversion efficiencies reported for these treatments by Renden *et al.* (1992). There were no direct comparisons of increasing photoperiod with constant 16 h in the other studies, because the long-day control was always 23 h. Nevertheless, a paired-*t* test of all data (Classen & Riddell, 1989; Classen *et al*., 1991; Renden *et al*., 1992; 1993; Blair *et al*., 1993) showed a strong tendency towards more efficient feed conversion for birds transferred from 6 to 23 h (P = 0.075).

The main benefits to be obtained from a step-up lighting programme for broilers, be it an abrupt or gradual increase, are improved liveability and fewer leg abnormalities, and these are thought to arise from slower initial growth, because the same improvements in health and skeletal integrity have been reported for birds that had their initial growth restricted by dietary energy control (Haye & Simmons, 1978) or by exposure to shorter daylengths (Gordon & Tucker, 1995). A paired-*t* test of five sets of data from earlier step-up lighting research suggested that the incidence of leg problems was generally about half that of birds given 23-h daylengths (P = 0.069). The lack of a lighting effect on bird health in this trial (Table 2) may be due to a combination of the generally low mortality and small incidence of leg problems, female birds having better liveability and fewer leg disorders than males (most of the earlier work used males), the long photoperiod being 16 h (which has been shown to have fewer deaths and leg troubles than the 23 h used in previous trials), and the initial growth in the short day and step-up groups being similar to the 16-h controls.

Although the slower initial growth of the Ross birds, compared with Cobb, may have been a consequence of genetic selection, it was not the result of a smaller feed intake but of inferior feed conversion efficiency, and this continued throughout the trial (Table 3). The significantly lower mortality and incidence of leg disorders in the Ross birds in the 22-42 d period may have been a consequence of their significantly slower growth during the first 21 d.

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