PHOTOPERIOD EFFECTS ON BROILER

PERFORMANCE AND BEHAVIOR

by

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(Under the Direction of A. Bruce Webster)

ABSTRACT

Light environments (determined by the factors of light source, wavelength, intensity, and photoperiod) in commercial poultry houses play important roles in growth, maintenance, and performance of chickens. In modern houses, producers have greater control over the light environment, particularly photoperiod. Manipulating photoperiod can be an effective way to alter behavior and optimize performance. The present studies were conducted to evaluate the effects of 3 different photoperiod regimens (**20 h**, **18 h**, and **SD/SU 12L:12D**) on performance and behavior of Cobb 500 broilers. Based on the data, the **SD/SU** program resulted in slower growth rates compared to the **20 h** and **18 h** treatments to 3 wk of age; however broilers in all treatments finished with comparable 6 wk BW. Behaviorally, at 22 d, broilers under the **SD/SU** treatment (12L:12D at this age) were more active during the dark period than those under either the **20 h** or **18 h** treatments. However, the amount of time partitioned for each of the behaviors over a 24 h day was not altered. There were no statistically significant differences in gait scores at 6 wk or heterophil:lymphocyte (H:L) ratios at 38 d for the 3 photoperiod treatments.

INDEX WORDS: broilers, light programs, performance, behavior, photoperiod, activity levels

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TABLE OF CONTENTS

INTRODUCTION

Lighting is a key environmental factor in poultry production that is known to affect performance and behavior. The use of solid or opaque side walls in poultry houses has given producers greater control over the light environment, which is determined by the light source, the wavelength and intensity of the light, and the photoperiod. There are several light sources available, but the two most commonly used in broiler houses are compact-fluorescent tubes and incandescent bulbs. Producers can control the brightness of the lights, known as light intensity (measured in lumens per unit area and expressed as either foot candles or lux), provided to the chickens. The photoperiod is the duration of the light period and scotoperiod is the duration of the dark period perceived in a light:dark cycle, which is typically 24 h in length.

Modern broiler stocks have been genetically selected for rapid growth, heavy BW, feed efficiency, and high breast meat yield. The inactive nature of fully-fed broilers in combination with early attainment of heavy BW has contributed to developmental leg abnormalities. Photoperiods have been shortened (< 24 h) to slow early growth rate of modern broiler stocks in an attempt to reduce the prevalence of leg abnormalities and metabolic diseases such as ascites without detriment to final BW. Additional studies are needed to evaluate how different lighting programs will affect modern high yield strains of broilers. Observing performance and behavior simultaneously could help researchers and producers to understand how to maximize profitability and welfare of broilers.

CHAPTER 1

LITERATURE REVIEW

PHOTOPERIOD

Domestic chickens are believed to have derived from the wild Red Junglefowl. This species has been observed to be active during the day in its native equatorial environment which has a constant light schedule close to 12L:12D (Collias and Collias, 1996). However, the poultry industry does not typically provide constant light:dark programs throughout the life of the flock. In a 24 h period, producers can provide light as continuous lighting for 24 h, a light and a dark period, or intermittent lighting regimes that present broilers with several periods of light and dark throughout a day. Common photoschedules consist of one period of light and one period of dark totaling 24 h (e.g., 23L:1D, 20L:4D, or 18L:6D). Lighting programs have been developed based on their effectiveness in the industry to optimize performance. Organizations such as the National Chicken Council (2005) have published husbandry guidelines based on scientific advice that include suggested light schedules to be used for broilers.

Performance

Depending on the photoperiod schedule that is used, performance of broilers can be affected either negatively or positively. The performance parameters of broilers in which producers are most interested are BW, feed efficiency, and livability. Continuous lighting leads to significantly higher BW for meat-type chickens compared to those under 8L:16D (Beane et al., 1962; Weaver and Siegel, 1968) or 12L:12D (Freeman et al., 1981). Broilers had significantly lower 42 d BW when raised under 6L:18D from 1 to 14 d followed by either 23L:1D or 6 x 1L:3D compared to those under 23L:1D from 1 to 56 d (Renden et al., 1991). These broilers grown under the shorter photoperiods from 1 to 14 d gained sufficient weight between 42 to 56 d to finish at similar BW as those under the 23L:1D light schedule from 1 d of age. Broilers have also been reported to have significantly higher BW when raised under 24L:0D compared to 8L:16D, or 20L:4D compared to 12L:12D (Charles et al., 1992). Brickett et al. (2007b) reported significantly higher BW for broilers raised from 4 to 35 d with 20L:4D compared to those under 12L:12D. A recent study reported no significant differences in BW of broilers raised with 23L:1D from 1 to 8 d, 18L:6D from 8 to 42 d, and 23L:1D from 42 to 49 d compared to those under 23L:1D from 1 to 49 d (Lien et al., 2007). Even though these studies reported higher early BW for broilers under longer photoperiods, there is potential for sufficient growth during the final weeks for those provided shorter photoperiods during the early weeks followed by longer photoperiods during the final weeks to finish with comparable BW.

Although longer photoperiods have typically led to heavier broilers, the overall feed efficiency has varied between studies. Compared to longer photoperiods, some studies showed that shorter photoperiods resulted in broilers with better feed efficiency (Osei et al., 1989; Charles et al., 1992; Brickett et al., 2007b; Lien et al., 2009), whereas other studies had different results between trials (Beane et al., 1962), and yet more studies showed no significant differences for broiler feed efficiency between light schedules (Weaver and Siegel, 1968; Renden et al., 1991; Blair et al., 1993; Lien et al. 2007). Of these studies, those that reported feed consumption noted that broilers ate more feed when exposed to longer photoperiods when compared to shorter photoperiods. Therefore, the increased BW in birds under longer photoperiods was likely due to the increased feed consumption associated with longer photoperiods. The variations among these studies for feed efficiency suggest that further examination is needed to understand how light schedules affect feed efficiency of each strain of broiler.

Mortality attributed to ascites in modern broiler strains has been associated with excessive, rapid growth rate. Ascites was found in about 77% of congestive heart failure deaths in broilers that had unlimited access to feed under 24L:0D (Nain et al., 2009). However, the broilers showed no signs of congestive heart failure or ascites when feed was restricted 30%. Lott et al. (1996) showed that using 12L:12D was effective at reducing feed intake and prevalence of ascites in broilers compared to those under 23L:1D. Additionally, mortality and culls have been reported at higher percentages for birds under 23L:1D compared to those under an increasing light program (Charles et al., 1992; Blair et al., 1993) and those under 12L:12D (Brickett et al., 2007b). Other studies found no differences in mortality for broilers raised with either 23L:1D compared to those with 1L:3D (Renden et al., 1991) or 18L:6D (Lien et al., 2007) Therefore, based on these studies it seems that shortening the length of the photoperiod from 24 or 23 h is not detrimental to broiler performance and may even improve livability.

Behavior

Photoperiod has been shown to be a powerful cue for chickens to develop daily feeding rhythms (Ballard and Biellier, 1975). Siegel et al. (1962) reported that chickens ate at higher rates during the 4 h periods immediately following or prior to an 8 h scotoperiod. Similarly, Weaver and Siegel (1968) reported that broilers develop daily patterns for feeding at the beginning and the end of the photoperiod. Other studies have shown that chickens eat the most feed during the 2 h before the lights turn off and for 2 h after the lights turn on (Savory, 1980; May and Lott, 1992). The results from these studies suggest that chickens are capable of predicting and preparing for the ensuing scotoperiods. Also, the chickens seem to compensate for hunger incurred during the dark period by feeding at higher rates when the photoperiod begins.

Comfort behaviors, such as preening, wing flapping, stretching, and dust bathing, are believed to be important for the maintenance of feathers by chickens. It is known that interactions with conspecifics (Nicol, 1989) as well as space availability (Keeling and Duncan, 1991; Keeling, 1994) alter the rates of comfort behaviors in laying hens. However, the effects of photoperiod on the performance of comfort behaviors of broilers have not been extensively studied. Alvino et al. (2009) showed that preening behavior of broilers was almost non-existent during a 1 h scotoperiod. However, they did show that preening occurred a little less than 5% of the time throughout the 24 h period. There are potential welfare implications with the performance or absence of comfort behaviors in broilers. Although the performance of comfort behaviors should be seen, abnormally high levels of preening could indicate frustration for chickens (Appleby et al., 2004). Observing how the different components of lighting programs affect comfort behaviors may help researchers understand how well broilers cope to these programs.

There have not been many studies that have documented how photoperiods affect the behavior of modern broilers, but light schedules and intensities have been manipulated by producers to control general activity levels of broilers. Broilers were recorded as more inactive during the scotoperiod compared to the photoperiod (Alvino et al., 2009; Blatchford et al., 2009). The broilers in these studies, however, did not cease activity entirely during the scotoperiod. It is possible that the light intensity of 1 lux, though minimal during the scotoperiod, enabled some activity among the broilers. Since there are limited data available with regards to how different light regimens affect behavioral time budgets of broilers beyond feeding behavior, additional studies are needed to evaluate the effects.

Light can affect birds physiologically depending on the length of the photoperiods and scotoperiods that are perceived throughout a day. For example, hormone production in chickens is affected by photoperiod and scotoperiod. Melatonin (a hormone synthesized from serotonin (Binkley et al., 1973) and secreted via the pineal gland) and *N*-acetylserotonin (a precursor to melatonin) peak during scotoperiods in chickens, quails, and pigeons (Pang et al., 1983). Furthermore, Binkley and Geller (1975) and Silversides et al. (1992) reported that levels of *N*-acetyltransferase (an enzyme responsible for converting serotonin to *N*-acetylserotonin) increased during dark periods in chickens. Melatonin aids in immune response in Japanese quail (Moore and Siopes, 2000; Moore and Siopes, 2003) and broilers (Kliger et al., 2000). Melatonin affects performance, for instance, increased gain, gain to feed ratio, and energy retention were recorded in 3 to 4 wk old broilers given melatonin supplemented feed (semi-purified diet) raised under either 16L:8D or 24L:0D in battery brooders (Osei et al., 1989). Additionally, Osei et al. (1989) reported significantly lower levels of triiodothyronine and thyroxine (both thyroid hormones responsible for normal growth and development in poultry) in broilers housed under 24L:0D compared to those in 16L:8D. Therefore, there are potential benefits to including scotoperiods in the light schedule for growth, development, and health of broilers through their influence on the production of melatonin.

Leg Condition and H:L Ratios

Leg conformation has been a growing concern over the past 20 years. The rapid growth rates of modern broilers have led to increased prevalence of leg abnormalities. Tibial dyschondroplasia (TD), a common leg ailment in lame broilers, has been shown to decrease in prevalence with slower BW gains (Classen and Riddell, 1989; Wong-Valle et al., 1993; Sorensen et al., 1999). The lower BW in these studies was attained by restricted feed intake due to short photoperiods. These results suggest that light schedules can indirectly influence leg health by slowing BW gain. Classen and Riddell (1989) reported fewer leg abnormalities in broilers reared with 6L:18D when compared to those reared with 23L:1D from 3 to 21 d of age. Sorensen et al. (1999) recorded lower prevalence of TD in broilers raised with 8L:16D compared to those under 16L:8D, or those under 16L:8D compared to those under 21L:3D, and those under 16L:8D compared to those under 23L:1D. The increased prevalence of TD was attributed to increased BW gain recorded for the broilers under the longer photoperiods.

Prevalence of leg abnormalities and other disorders affecting mobility can be assessed by obtaining gait scores in flocks of broilers (Kestin et al., 1992; Webster et al., 2008). Sanotra et al. (2002) reported that a step-down/step-up light schedule or a 16L:8D schedule from 4 to 30 d followed by an abrupt change to 23L:1D resulted in better gait scores than a constant light schedule (24L:0D) for broilers. Also, broilers reared with 20L:4D had worse gait scores compared to those provided 12L:12D (Brickett et al., 2007a). Based on the results from these studies, it seems that gait scores are better when broilers are raised with shorter photoperiods compared to longer photoperiods.

Graded increases in circulating heterophil:lymphocyte ratios (H:L) were observed in chickens given feed supplemented with increasing levels of corticosterone (Gross and Siegel, 1983). The H:L ratios were determined to be reliable measures of chronic stress in the chickens. Puvadolpirod and Thaxton (2000) showed that H:L ratios in broilers are increased by treatments that stimulate the physiological stress response, e.g. administration of ACTH. Recent studies have reported that differences between H:L ratios were not statistically different in layers raised with either 23L:1D or14L:10D (Campo and Davila, 2002) or broilers under 23L:1D compared to an increasing light program (Blair et al., 1993) or 18L:6D (Lien et al., 2007). Due to the limited data available, it is worth evaluating if different photoperiod regimens stress modern high yield broilers similarly to the chickens in the previously mentioned studies.

CONCLUSION

In the past, flock performance was the determining factor for which light schedule would be best for broilers. Recent studies have focused on genetic stocks and welfare parameters (such as prevalence of leg abnormalities, H:L ratios, and behavior) in association with photoperiod. Currently, identifying the strengths and weaknesses of each genetic stock is becoming increasingly important. The use of an optimal light schedule should help minimize the negative effects associated with early rapid growth while maximizing final BW. The guidelines that have been published by organizations such as the National Chicken Council remain a standard for the industry, but there are different opinions as to what is the best program.

Due to the differences seen with performance and the limited knowledge of how photoperiod affects broiler behavior, more research should be done to evaluate these parameters. Ultimately, the association between broiler behavior and performance and light environment should be made to develop an optimal lighting program. The objectives of the research presented were to compare how lighting programs advocating 4 h of darkness (National Chicken Council, 2005) or at least 6 h of darkness which was promoted as a preferable alternative by animal welfare advocates at the time of the inception of this study, and a step-down/step-up program, which was chosen based on data from a previous study (A. Brown, unpublished data) for its potential to decrease growth rate from 7 to 21 d while producing a broiler of comparable 42 d weight to the other treatments affect the performance and behavior of Cobb 500 broilers.

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CHAPTER 2

PHOTOPERIOD EFFECTS ON BROILER PERFORMANCE[1]

[1] Brown, A., B. D. Fairchild, A. B. Webster, and R. J. Buhr. To be submitted to *Poultry Science.*

ABSTRACT

This study evaluated the effects of 3 photoperiod regimens on Cobb 500 broiler performance. All birds received 24L:0D at 1 d followed by 23L:1D from 2 to 6 d. The 3 photoperiod treatments were **20 h** (20L:4D), **18 h** (18L:6D) applied from 7 to 37 d, and a step-down/step-up (**SD/SU**) program (dropped to 18L:6D at 7 d and stepped down in 3 h increments at 10 and 13 d to reach 12L:12D and increased to 18L:6D by 1 h daily increments from 23 to 28 d). The **20 h** and **18 h** treatments were increased to 23L:1D at 38 d and the **SD/SU** program was increased to 23L:1D by 1 h daily increments from 38 to 42 d. Light intensity was maintained at 20 lux using incandescent lights. Two trials were conducted and each light treatment was applied to 2 rooms with 6 replicate pens in each room. Broiler management protocols followed the Cobb 500 company recommended guidelines with an initial stocking density equated to 0.7 ft^2/bird. Water and non-medicated University of Georgia broiler starter and grower diets were provided ad libitum.

At 21 d, BW was significantly lower for the birds raised under the **SD/SU** (12L:12D) program compared to the birds under either the **20 h** or **18 h** treatments. From 8 to 21 d, BW gain and FC were also significantly lower for the birds under the **SD/SU** program compared to the **20 h** and **18 h** treatments. However, there were no significant differences among treatments for these variables at 42 d. Mortality and culls ranged from 3.7 to 4.4% and G:F ratios ranged from 0.64 to 0.66 from 0 to 42 d and were not statistically different among the photoperiod treatments. These results indicate that the **SD/SU** treatment was effective in reducing early 21 d growth rate in the Cobb 500 broiler and that they were able to compensate thereafter to achieve 42 d BW comparable to those in the other treatments.

Key words: broiler, performance, photoperiod regimens, BW

INTRODUCTION

Modern broiler stocks have been genetically selected over the years for rapid growth rates, heavy BW, feed efficiency, and high breast meat yield. The increased growth rates and heavy BW have been associated with leg abnormalities (Dibner et al., 2007) and metabolic disorders, such as ascites (Acar et al., 1995). Slowing the growth rate at young ages, as outlined below, allows broilers to mature anatomically/physiologically at lower BWs and reduces the prevalence of metabolic diseases and disorders (Olkowski et al., 1999). The light regimen provided to a flock is one method that can help regulate growth and improve livability.

Photoperiod regimens have been reported to affect broiler performance. Performance is generally evaluated based on differences in BW, feed efficiency, and livability. Beane et al. (1962) reported that male broilers reared to 9 wk with 24L:0D were significantly heavier than broilers with 8L:16D or an intermittent system of 1L:2D. However, the broilers raised with 24L:0D had poorer feed conversion. Male broilers at 13, 21, and 42 d of age were significantly heavier when raised with constant light compared to 6L:18D from 1 to 14 d followed by either an abrupt increase to 23L:1D or an intermittent regimen of 6 x 1L:3D (Renden et al., 1991). No significant differences in feed efficiency among the treatments were reported in that study. Charles et al. (1992) reported significantly higher BW but poorer feed conversion ratios at 3 and 5 wk for male broilers with constant light compared to a step-down/step-up photoperiod program (23L:1D from 0 to 3 d, 18L:6D from 3 to 7 d, 6L:18D from 7 to 14 d, and 4 h weekly increases until 23L:1D was achieved). Brickett et al. (2007) observed higher BW in broilers raised to 35 d when provided 20L:4D compared to those with 12L:12D. Feed efficiency was better for broilers raised with the 12L:12D photoperiod treatment. The common trend seen in the studies above was that longer photoperiods (> 12 h) resulted in heavier broilers, but poorer feed efficiency.

Total mortality due to ascites was less than half at 3% for broilers under an increasing photoperiod regimen (12L:12D from 3 to 21 d, 14L:10D from 21 to 28 d, and 1 h weekly increases until 41 d when a 23L:1D photoperiod was applied) compared to 8% for those under 23L:1D from 3 to 41 d (Lott et al. 1996). Sorensen et al. (1999), and Sanotra et al. (2002) reported a 5 to 20% increase in the prevalence of tibial dyschondroplasia in broilers under photoperiod regimens that were no shorter than 21L:3D, 23L:1D, or 24L:0D compared to those raised with photoperiod regimens that went as low as 16L:8D. Improving welfare with regards to metabolic diseases and leg disorders should increase profitability for producers as a result of lower mortality and fewer lame birds culled.

Understanding how photoperiod can be manipulated to improve performance and welfare of modern broiler strains is important for increasing profits for commercial farms. The present study sought to compare lighting programs advocating 4 h of darkness (National Chicken Council, 2005) or at least 6 h of darkness which was promoted as a preferable alternative by animal welfare advocates at the time of the inception of this study, and a step-down/step-up program, which was chosen based on data from a previous study (A. Brown, unpublished data) for its potential to decrease growth rate from 7 to 21 d while producing a broiler of comparable 42 d weight to the other treatments.

MATERIALS AND METHODS

Animal care and handling procedures were approved by The University of Georgia Institutional Animal Care and Use Committee prior to the start of the trials. Two trials were conducted, each using 1,320 straight run Cobb 500 broilers raised to 43 d of age. In each trial, the birds were weighed and evenly distributed at day of hatch into 6 rooms with 6 pens each. Each room had 4 pens that housed 40 birds and 2 pens that housed 30 birds with an initial stocking density equal to 0.7 ft^2/bird in each pen. The pens were constructed with polyvinyl chloride (PVC) pipes and divided using black plastic mesh. The floor of each pen was bedded with new pine shavings. The rooms were lit to 20 lux at litter floor height using 60 watt incandescent light bulbs. A light meter (Light ProbeMeter, Extech Instruments, Waltham, MA) was used to ensure light intensity was uniform among the pens and to accurately maintain light intensity throughout each trial. The lights were attached to rheostats to regulate light intensity and an external time clock to regulate photoperiod. Light data loggers (Hobo Temperature/Light Data Loggers, Onset Computer Corporation, Bourne, MA) were placed in each room at the top of a centrally located pen in each trial to monitor temperatures and photoperiods. The birds were fed a non-medicated standard crumbled broiler starter diet ad libitum from 1-10 d and a standard pellet broiler grower diet ad libitum for the remaining time. Feed was supplied with a hanging tube feeder in each pen and water was provided ad libitum via nipple drinker lines.

Three photoperiod regimens (Figure 2.1) were applied to 2 rooms each in each trial. All birds received 24L:0D at 1 d and 23L:1D from 2 to 6 d. The **20 h** (20L:4D) and **18 h** (18L:6D) photoperiod treatments were applied from 7 to 37 d followed by 23L:1D photoperiods thereafter. The step-down/step-up (**SD/SU**) photoperiod treatment consisted of light schedules of 18L:6D from 7 to 9 d, 15L:9D from 10 to 12 d, 12L:12D from 13 to 22 d, then increased by daily 1 h increments between 23 to 28 d to 18L:6D which was maintained until 37 d, followed by daily 1 h increment increases from 38 to 42 d to reach a 23L:1D. All photoperiod treatments were 23L:1D at 43 d. The shifts in light schedule were accomplished by either adding or subtracting hours from the end of the photoperiod. All photoperiods began at 07:00.

BW and feed consumption were recorded at 0, 7, 21, and 42 d. Mortality (which included culls) was recorded daily. BW gain, feed consumption, and G:F averages (adjusted for mortality) were calculated from 0 to 7 d, 8 to 21 d, 22 to 42 d, and 0 to 42 d. All data were subjected to analysis of variance using the GLM procedure of SAS (SAS Institute, 2005). The main effects were trial and treatment. Room effects were nested within treatment. Differences between means were evaluated using the REGWQ multiple range comparison test in SAS (SAS Institute, 2005) and considered significant when $p \leq 0.05$.

RESULTS

The data loggers placed in each room confirmed that the light environments in each room were maintained throughout the study. BW at 21 d (Table 2.1), BW gain from 8 to 21 d (Table 2.2), and feed consumption from 8 to 21 d (Table 2.3) were significantly lower for broilers in the **SD/SU** treatment compared to those in the **20 h** and **18 h** treatments. The **SD/SU** treatment means for these variables were 89% to 93% of the values of those for the **20 h** and **18 h** treatments. From 22 to 42 d, birds in the **SD/SU** treatment grew sufficiently to finish with body weights that were not significantly different from those in the other two treatments. Despite the nominally improved growth rate for **SD/SU** birds from 22 to 42 d, differences in BW gain and G:F ratios between treatments were not statistically significant during this period. Treatment means for BW, BW gain, and feed consumption were not statistically different at 42 d. G:F means ranged from 0.64 to 0.66 from 0 to 42 d and were not significantly affected by the photoperiod treatments (Table 2.4). There were no significant differences between the treatments at 42 d for ADG (69.9, 71.1, 69.7 g/d for the **20 h**, **18 h**, and **SD/SU** treatments respectively). Neither total mortality at 42 d (4.4, 4.2, 3.7%) nor percent of cumulative survivability (Figure 2.2) differed between the treatments.

DISCUSSION

The significant differences in BW, BW gain, and feed consumption existed at 21 d when the differences between the photoperiod treatments were the most extreme. At that time the **SD/SU** treatment had been at 12L:12D for 8 d. Broilers in this treatment had lower BW as a result of reduced feed intake associated with the shorter photoperiod. Similarly, Charles et al. (1992) recorded lower BW for 3 wk old broilers under a step-down/step-up photoperiod regimen compared to 23L:1D. The step-down/step-up regimen used by Charles et al. (1992) dropped from 18L:6D to 6L:18D at 7 d, followed by 4 h increases in photoperiod on 14, 21, and 28 d to reach 18L:6D, an increase to 21L:3D at 32 d, and an increase to 23L:1D at 35 d. They observed compensatory gain in the following weeks resulting in no differences between the treatments for 56 d BW. Also, Brickett et al. (2007) reported consistently lower BW for broilers at 6, 13, 20, and 27 d of age for a 12L:12D treatment compared to a 20L:4D treatment. However, Brickett et al. (2007) found that feed to gain ratios were consistently better at all ages tested for the broilers receiving 12L:12D, whereas in the present study the differences (reported as G:F rather than feed to gain) between the **20 h** and **SD/SU** treatments were not statistically significant. This different result for the 2 studies may be due to the ages at which the photoperiod treatments began; Brickett et al. (2007) provided the photoperiod treatments starting from 3 d and the **SD/SU** treatment in the present study did not reach 12L:12D until 13 d. The broilers in the Brickett et al. (2007) study were exposed to the 12L:12D light schedule for more days by 20 d of age. A study by Lien et al. (2009) reported that male broilers raised to 54 d were heavier at 7, 14, and 28 d when raised with 23L:1D compared to broilers under a step-down/step-up program (20L:4D from 1 to 10 d, 12L:12D from 10 to 21 d, 15L:9D from 21 to 28 d, 18L:6D from 28 to 35 d, 20L:4D from 35 to 54 d). These lighting programs were maintained at 2 and 0.1 FC respectively from the day of placement of the birds. By 35 d, there were no differences for BW between the treatments. Though BW was not recorded at 35 d, this result was similar to the findings of the present study as there were no differences between treatments for 42 d BW. However, contrary to the present study, Lien et al. (2009) reported significantly better feed to gain ratios for the step-down/step-up light schedule at 7, 14, and 28 d. In the present study, the same light intensity was applied to all 3 treatments and the broilers were straight run compared to only males in the Lien et al. (2009) study, which may account for the different results between the studies.

Mortality and culls to 42 d were numerically lowest for the **SD/SU** treatment (3.7%) compared to the **20 h** and **18 h** treatments (4.4 and 4.2% respectively) though none of the differences were statistically significant. During the final two days of grow out, there was a decrease of approximately 1% for cumulative survivability of broilers from each treatment (Figure 2.2). This decrease was a result of culling birds with leg disorders. Necropsies were not performed on dead birds thus the causes of death cannot be reported.

Overall, neither BW nor G:F ratio was affected by photoperiod treatment at 42 d. Broilers raised with the **SD/SU** treatment had lower BW at 21 d, but gained sufficient weight thereafter to achieve comparable BW to broilers in the **20 h** and **18 h** treatments at 42 d. The fact that the **SD/SU** treatment had the lowest mortality on a numeric basis may make it worth examining the photoperiod regimen on a larger scale to determine if it has a true effect on mortality. Although there are potential benefits associated with the **SD/SU** treatment associated with reduced early growth rate without detriment to BW at 42 d, the Cobb 500 broilers can be managed well with any of the **18 h**, **20 h**, or **SD/SU** treatments.

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TABLE 2.1. Body weights at 0, 7, 21, and 42 d of age for each light treatment

	BW (g)			
Treatment	**0 d**	**7 d**	**21 d**	**42 d**
20 h[1]	41.7	186.0	928.9[a]	2908.9
18 h[2]	41.7	182.5	919.3[a]	2958.7
Step-down/step-up[3]	42.1	185.3	858.6[b]	2900.6
SEM	0.25	1.60	13.64	45.71
P-value	NS	NS	0.0009	NS

[a-b] Means within a column with no common superscript differ significantly (*P* < 0.05).
[1]20 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 20L:4D from 7 to 37 d; 23L:1D from 38 to 43 d.
[2]18 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 37 d; 23L:1D from 38 to 43 d.
[3]Step-down/step-up = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 9 d; 15L:9D from 10 to 12 d; 12L:12D from 13 to 22 d; daily 1 h increases from 23 to 28 d; 18L:6D from 28 to 37 d; daily 1 h increases from 38 to 42 d to reach 23L:1D; 23L:1D on 43 d.

TABLE 2.2. BW gain from 0 to 7, 8 to 21, 22 to 42, and 0 to 42 d for each light treatment

	BW gain (g)			
Treatment	**0-7 d**	**8-21 d**	**22-42 d**	**0-42 d**
20 h[1]	144.2	742.9[a]	1980.1	2867.2
18 h[2]	140.8	736.8[a]	2039.4	2917.0
Step-down/step-up[3]	143.1	673.3[b]	2042.0	2858.4
SEM	1.53	13.14	43.42	45.71
P-value	NS	0.0005	NS	NS

[a-b] Means within a column with no common superscript differ significantly ($P < 0.05$).
[1]20 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 20L:4D from 7 to 37 d; 23L:1D from 38 to 43 d.
[2]18 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 37 d; 23L:1D from 38 to 43 d.
[3]Step-down/step-up = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 9 d; 15L:9D from 10 to 12 d; 12L:12D from 13 to 22 d; daily 1 h increases from 23 to 28 d; 18L:6D from 28 to 37 d; daily 1 h increases from 38 to 42 d to reach 23L:1D; 23L:1D on 43 d.

TABLE 2.3. Feed consumption from 0 to 7, 8 to 21, 22 to 42, and 0 to 42 d for each light treatment

	Feed Consumption (g)			
Treatment	**0-7 d**	**8-21 d**	**22-42 d**	**0-42 d**
20 h[1]	165.2	1069.6[a]	3271.5	4506.4
18 h[2]	167.4	1059.1[a]	3244.8	4471.3
Step-down/step-up[3]	168.2	956.8[b]	3227.9	4352.9
SEM	4.35	15.50	68.81	82.46
P-value	NS	<0.0001	NS	NS

[a-b] Means within a column with no common superscript differ significantly ($P < 0.05$).
[1]20 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 20L:4D from 7 to 37 d; 23L:1D from 38 to 43 d.
[2]18 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 37 d; 23L:1D from 38 to 43 d.
[3]Step-down/step-up = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 9 d; 15L:9D from 10 to 12 d; 12L:12D from 13 to 22 d; daily 1 h increases from 23 to 28 d; 18L:6D from 28 to 37 d; daily 1 h increases from 38 to 42 d to reach 23L:1D; 23L:1D on 43 D.

TABLE 2.4. Gain to feed ratio from 0 to 7, 8 to 21, 22 to 42, and 0 to 42 d for each light treatment

	Gain:Feed (g)			
Treatment	**0-7 d**	**8-21 d**	**22-42 d**	**0-42 d**
20 h[1]	0.89	0.70	0.61	0.64
18 h[2]	0.85	0.70	0.63	0.66
Step-down/step-up[3]	0.86	0.71	0.64	0.66
SEM	0.02	0.01	0.02	0.01
P-value	NS	NS	NS	NS

[1]20 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 20L:4D from 7 to 37 d; 23L:1D from 38 to 43 d.
[2]18 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 37 d; 23L:1D from 38 to 43 d.
[3]Step-down/step-up = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 9 d; 15L:9D from 10 to 12 d; 12L:12D from 13 to 22 d; daily 1 h increases from 23 to 28 d; 18L:6D from 28 to 37 d; daily 1 h increases from 38 to 42 d to reach 23L:1D; 23L:1D on 43 d.

Figure 2.1. Photoperiod treatments used in the study.

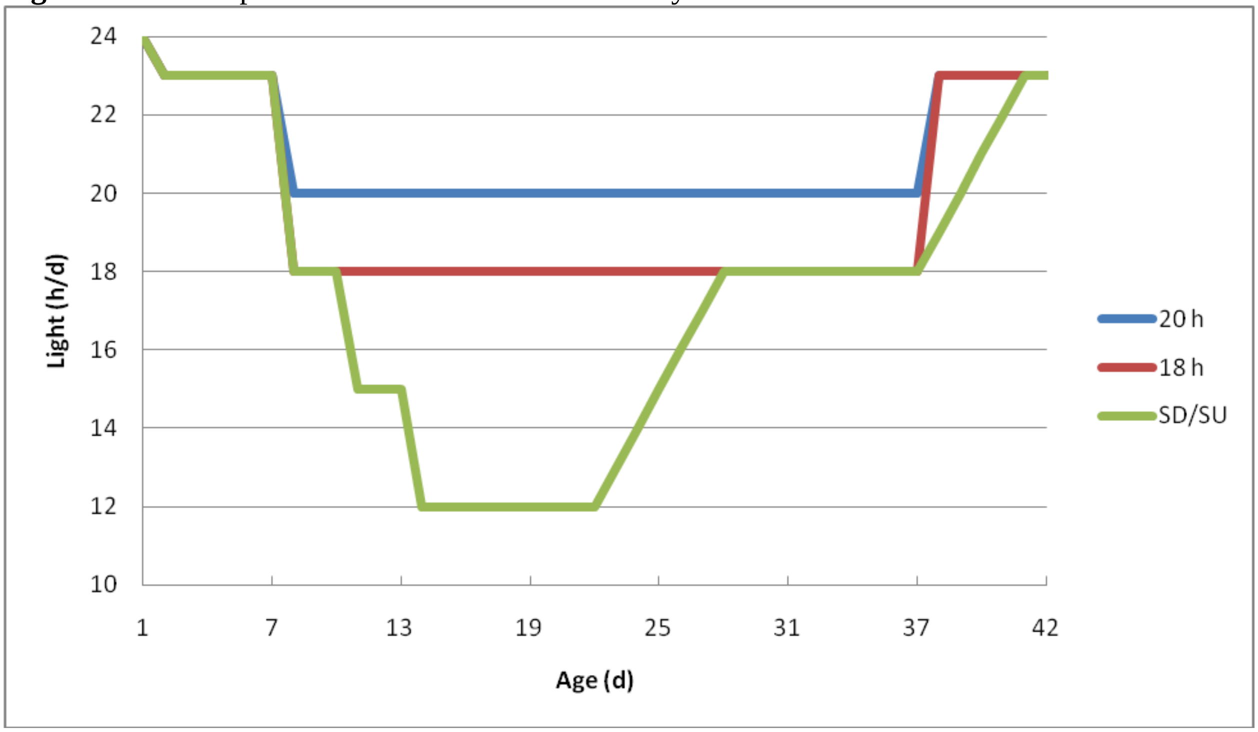
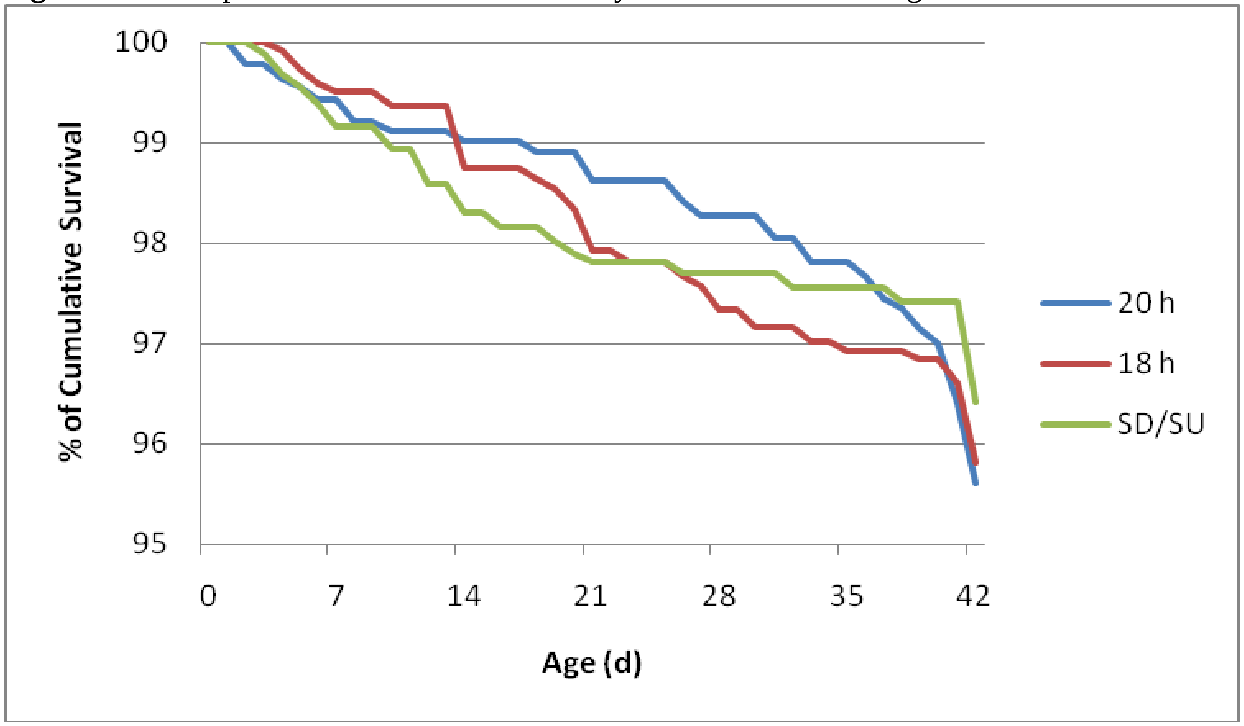


Figure 2.2. The pooled cumulative survivability for broilers in each light treatment.



CHAPTER 3

PHOTOPERIOD EFFECTS ON BROILER BEHAVIOR[1]

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[1] Brown, A., A. B. Webster, B. D. Fairchild, and R. J. Buhr. To be submitted to *Poultry Science.*

ABSTRACT

This study evaluated the effects of 3 photoperiod regimens on behavior of broilers. The broilers in all 3 treatments were provided 24L:0D at 1 d and 23L:1D from 2 to 6 d. In the **20 h** and **18 h** treatments, 20L:4D and 18L:6D were applied from 7 to 37 d, respectively, after which the photoperiod was 23L:1D. In the step-down/step-up treatment (**SD/SU**), the photoperiod was 18L:6D at 7 d, decreased by 3 h at 10 d and again at 13 d to reach 12L:12D, then increased to 18L:6D by 1 h daily increments from 23 to 28 d, and to 23L:1D by 1 h daily increments from 38 to 42 d. Light intensity was 20 lux. Initial stocking density was 0.7 ft^2/bird. In each of 2 trials, each light treatment was applied to 2 rooms, with 6 pens per room. In trial 1, videos were taken of 2 pens in each room at 22, 29, and 43 d, and at only 9 d for trial 2. Behaviors were recorded from the video tapes. Heterophil to lymphocyte (H:L) ratios were calculated at 38 d in both trials and gait scores were observed during wk 6 of trial 2. Management protocols followed the Cobb 500 company guidelines, with water and non-medicated University of Georgia starter and grower broiler diets provided ad libitum.

At 22 d, when the photoperiods differed most, broilers spent a higher percentage of time inactive under the **18 h** and **SD/SU** treatments than those under the **20 h** treatment over the 24 h period. During the scotoperiod at 22 d, broilers in the **SD/SU** treatment stood and walked significantly more than those in the other treatments. The percentage of broilers feeding during the light period at 29 d was higher in the **18 h** and **SD/SU** treatments. There were no significant differences among treatments in H:L ratios or gait scores, suggesting that these light:dark schedules did not differentially affect broiler stress or mobility.

Key words: broiler, behavior, photoperiod, scotoperiod, light

INTRODUCTION

Modern broiler stocks have been selected over many generations for rapid growth rate, heavy BW, and higher breast meat yields at younger ages. Genetic selection for growth rate has been shown to alter feeding behavior in broilers (Howie et al., 2009). Generally, chickens feed during the photoperiod, particularly at the start and the end of the photoperiod (Siegel et al., 1962; Weaver and Siegel, 1968; Savory, 1980). According to May and Lott (1992), 8 and 29 d old broilers were capable of quickly adapting feeding behavior to a changing light environment (24L:0D to 12L:12D and 12L:12D to 24L:0D at 8 and 29 d respectively). The broilers learned to prepare for the onset of the long dark period (12L:12D) by increasing feed intake 2 h before the scotoperiod. When continuous lighting was restored at 29 d, the broilers exhibited feeding behavior similar to that of broilers that had been raised with continuous lighting from 1 d. Lott et al. (1996) reported lower BW for 12 and 22 d old broilers reared with 12L:12D from 3 to 21 d compared to 23L:1D. The lower BW was due to reduced feed consumption as a result of the shorter photoperiod. However, if provided even longer dark periods (8L:16D), modern broilers will eat during the scotoperiod (Lewis et al., 2008). These broilers ate approximately 50% of their feed during the scotoperiod and ate similar amounts of feed as broilers raised with 16L:8D.

Incidence of leg abnormalities and metabolic diseases, which lead to losses for commercial producers, has increased with rapid growth rates and attainment of heavy BW (Bessei, 2006). Leg disorders have become a leading animal welfare issue in regards to modern broiler stocks. Observing walking ability (gait scoring) is a method used to assess leg health in flocks of broilers. The 6-point Kestin system (Kestin et al., 1992) and the 3-point system (Webster et al., 2008) are two common methods of gait scoring. Lower growth rate is associated with better gait scores in broilers (Kristensen et al., 2006; Brickett et al., 2007). Although the correlation between photoperiod length and gait score is not clear (Sorensen et al., 1999), growth rate can be slowed by shortening the photoperiod.

Continuous lighting (24L:0D) has been found to be more stressful for chickens than 12L:12D (Freeman et al., 1981). Buckland et al. (1976) reported higher concentrations of plasma corticoids in broilers housed under continuous day lengths than in those exposed to intermittent 1L:3D light programs. Heterophil to lymphocyte (H:L) ratios, which can be used to measure chronic stress in chickens, increase with increased levels of corticosterone (Gross and Siegel, 1983). Lien et al. (2007) showed that H:L ratios for broilers raised under 23L:1D were not statistically different from those raised with 18L:6D and these broilers were not considered stressed with an average H:L ratio of 0.45. Due to the limited data available, it is essential to evaluated how common photoperiods influence the level of stressfulness in modern broilers for accurate assessment of animal welfare.

The purpose of this study was to examine how 3 different photoperiod treatments (**20 h**, **18 h**, **SD/SU**; described in the Materials and Methods) affect Cobb 500 broiler behavior, gait scores, and H:L ratios. The **20 h** and **18 h** treatments were derived from the suggested light schedules for broilers by the National Chicken Council (2005) and animal welfare advocates as a preferable alternative at the time of the inception of this study respectively. The step-down/step-up (**SD/SU**) treatment was chosen based on data from a previous study (A. Brown, unpublished data) for its potential to decrease growth rate from 7 to 21 d while producing a broiler of comparable 42 d weight to the other treatments.

MATERIALS AND METHODS

Bird Husbandry

Animal care and handling procedures were approved by The University of Georgia Institutional Animal Care and Use Committee. Two trials were conducted each using 1,320 Cobb 500 straight run broilers obtained from a commercial hatchery in Northeast Georgia and reared to 43 d of age. In each trial, chicks were weighed on the day of hatch and distributed among 6 rooms, each having 4 pens that housed 40 broilers and 2 pens that housed 30 broilers resulting in an initial stocking density equal to 0.7 ft^2/bird in each pen. The rooms were lit at 20 lux at floor height using rows of 60 watt incandescent light bulbs to distribute light evenly. A handheld light meter (Light ProbeMeter, Extech Instruments, Waltham, MA) was used weekly to verify that the light intensity was uniform across the pens at the litter surface and to accurately maintain light intensity throughout each trial. The lights were attached to rheostats to control light intensity and an external time clock to regulate photoperiod. Light data loggers (Hobo Temperature/Light Data Loggers, Onset Computer Corporation, Bourne, MA) were placed in each room in each trial to monitor temperature, light intensity, and photoperiod. Each pen was equipped with a hanging feeder and a nipple drinker line. Broilers were provided unlimited access to water and feed. The diets were formulated based on the University of Georgia standards which included a broiler starter crumble feed and broiler grower pellets with no anticoccidial.

Light Treatments

Three light regimens (Figure 2.1) each were applied to 2 rooms in each trial. All broilers received 24L:0D at 1 d and 23L:1D from 2 to 6 d. The **20 h** and **18 h** photoperiod treatments consisted of 20L:4D and 18L:6D respectively applied from 7 to 37 d followed by an abrupt increase to 23L:1D at 38 d which was maintained throughout the rest of the grow out. The step-down/step-up (**SD/SU**) photoperiod treatment was 18L:6D from 7 to 9 d, 15L:9D from 10 to 12 d, and 12L:12D from 13 to 22 d. The photoperiod was then increased by daily 1 h increments between 23 to 28 d to 18L:6D and maintained until 37 d, followed by another daily 1 h increment increase from 38 to 42 d to reach 23L:1D. All photoperiod treatments were 23L:1D at 43 d. The shifts in light schedule were accomplished by either adding or subtracting hours from the end of the photoperiod. All photoperiods began at 07:00.

Behavior Recordings

The area of 2 pens in each room was decreased by 25% to allow cameras to capture the entire pen. Cameras were set on tripods and connected to quad splitters which were attached to time lapse VCRs to video record 24 h periods (3 8-h tapes were used to record each 24 h period). Behavioral recordings were taken at 22, 29, and 43 d of age in the first trial and at 9 d of age in the second trial. Behavioral readings were taken from the tapes every 20 min as instantaneous samples. Each behavior was recorded as the number of broilers engaged in the behavior divided by the total number of broilers in the pen (n = 30). Thus, the data were recorded as proportions ranging from 0 to 1. The behaviors of interest were:

Standing – the legs extended and the torso is not in contact with the ground

Sitting – crouched with the torso in contact with the floor; standing and sitting were mutually exclusive from each other, but not from the other behaviors

Walking – taking at least 3 consecutive steps

Feeding – pecking into the feeder

Drinking – pecking at the nipple drinker and tilting head back to ingest water

Wing flapping – moving wings up and down

Preening – manipulation of feathers with the beak

Non-nutritive pecking – pecking toward objects not in the feeder, including litter and other broilers

Other – other behaviors, such as postural adjustment and stretching (the leg or wing is extended away from the body and brought back immediately); these behaviors were too infrequent to report in their own designated categories

Inactivity – immobile other than head movements; could be sleeping or resting (upon observation of videos, the video quality did not allow distinction between resting and somnolence)

Walking, feeding, drinking, wing flapping, preening, non-nutritive pecking, other, and inactivity were mutually exclusive from each other, but not from standing or sitting.

Gait Scoring

Gaits of broilers from 4 pens in each room in trial 2 were scored during wk 6 of grow out (n = 320 per treatment). Broilers were individually placed at the far end of a pathway constructed with wire catch pens and having wood shavings on the floor and were observed walking back toward the broilers in their home pen. The broilers were rated on a 3 point system of 0, 1, or 2 (Webster et al., 2008). A score of 0 signifies no impairment in the gait, 1 signifies obvious impairment in the gait but the bird can walk at least 5 ft, and 2 means there is severe impairment in the gait and the bird cannot walk though it may shuffle on shanks or hocks with assistance of wings. The detection of a broiler with a gait score of 2 would dictate immediate euthanasia to remain compliant with the Animal Care protocol.

Heterophil to Lymphocyte (H:L) Ratios

Blood was collected in both trials from 1 male in each pen (n = 12 per treatment/trial) at 38 d through the brachial vein. The blood was collected as late in the grow-out as possible to take into account the cumulative effect of the changing light regimens without interfering with other management practices, such as measuring BW. A blood smear was made immediately after blood collection and allowed to air dry. The blood cells were fixed by placing the slides in 100% methanol for 30 min. The smears were then stained using a May-Grunwald Giemsa protocol (Sigma Aldrich, St. Louis, MO). The PBS solution used in the staining process was made from a dry powder (Sigma P-3813, Sigma Aldrich, St. Louis, MO) dissolved in one liter of deionized water. The heterophils and lymphocytes were viewed under a light microscope and distinguished between each other by appearance (heterophils appear granular and lymphocytes appear non-granular).

Data Analysis

The behavior data were evaluated for the whole 24 h period (24 h) and for the light period and the dark periods separately. In addition, at 9 d, the data for the amount of time broilers spent performing behaviors for the **18 h** and **SD/SU** treatments were combined and compared to the **20 h** treatment as the **18 h** and **SD/SU** treatments had followed the same photoperiod regimen to that point. The proportions were also multiplied by the number of hours in each section (Light, Dark, and 24 h) to estimate the amount of time spent performing each of the five behaviors recorded at the highest frequencies (standing, walking, drinking, and inactivity) during those partitions of time.

The number of broilers scored for each gait score designation within each room was divided by the total number of broilers observed in the room to calculate the proportion of broilers in each category. A combined total of 100 heterophils and lymphocytes were counted from each blood smear slide. The number of heterophils was divided by the number of lymphocytes to calculate the H:L ratios.

Proportion data from the behavior recordings, gait scores, and H:L ratios were transformed using an arc sine square-root transformation (Snedecor and Cochran, 1980) and analyzed using the GLM procedure of SAS (SAS Institute, 2005). The main effects were trial and treatment. Room effects were nested within treatment. Differences between treatment means were evaluated using the REGWQ multiple range comparison test in SAS (SAS Institute, 2005) and considered significant when $p \leq 0.05$. The data are reported as untransformed means. The proportion data were multiplied by 100 to calculate percentages and are reported as such.

RESULTS

The data loggers placed in each room confirmed that the temperatures and light environments were maintained consistently throughout the study.

9 Days of Age

At 9 d (**20 h** 20L:4D, **18 h** 18L:6D, and **SD/SU** 18L:6D), during the light period, broilers spent a little over 70% of their time inactive, as defined in this study, measured as the proportion of broilers engaged in the behavior at any given time (Table 3.1). Broilers spent 22 to 23% of their time standing, 10 to 11% feeding, 6 to 7% drinking, and 4 to 5% walking. Lesser amounts of time were devoted to wing flapping, preening, non-nutritive pecking, and other behaviors. The only significant difference between treatments at this age during the light period was for wing flapping, a relatively infrequent behavior. The average percentage of broilers wing flapping during the light period was significantly higher for the **20 h** (20L:4D) and **18 h** (18L:6D) treatments compared to the **SD/SU** (18L:6D at that age) treatment but the greatest difference between the treatments amounted to only 0.4%. During the dark period, the broilers in all treatments showed very little activity (98 to 99% inactive) and there were no significant differences among the treatment means for the percentage of broilers performing any of the behaviors. Over the 24 h period, broilers spent 17 to 18% of their time standing, 8 to 9% feeding, 5% drinking, and 4% walking. The average percentage of broilers inactive in the **SD/SU** treatment (80%) was 2% higher than broilers in the **18 h** and **20 h** treatments (both 78% at this age) and the differences were statistically significant. Although wing flapping occurred at progressively higher rates as photoperiod increased, the largest difference between the treatment means during this period was 0.4%.

During the light period, the broilers in the shorter photoperiod (18L:6D) spent 4.1 h standing and 13.0 h inactive compared to 4.3 h and 14.7 h respectively for those in the **20 h** treatment (Table 3.2). These broilers walked for 0.9 to 1.0 h, fed for 2.0 to 2.1 h, and drank for 1.2 to 1.3 h. During the dark period, broilers under 18L:6D spent significantly more time inactive than those in the 20L:4D photoperiod with the difference equal to 2 h. Performance of the other behaviors was almost non-existent in the dark. Over the 24 h period, the broilers from all the treatments spent about 19 h inactive and 4 h standing followed by 2 h feeding, 1 h drinking, and 1 h walking. These differences between treatment means were not statistically different.

22 Days of Age

At 22 d (**20 h** 20L:4D, **18 h** 18L:6D, and **SD/SU** 12L:12D), when the photoperiods were most different, during the light period, the broilers were inactive for 72 to 78% of the time (Table 3.3). Otherwise, they spent 17 to 24% of their time standing, 9 to 12% feeding, 5 to 6% drinking, and 3 to 5% walking. During the dark period, broilers in the **SD/SU** treatment stood and walked at significantly higher percentages (1.8%) compared to broilers in the **20 h** (0.1%) and **18 h** (0.4%) treatments. These differences for standing and walking between the treatments were small and did not exceed 2%. In this dark period, the broilers devoted little time (< 1%) to any of the other recorded behaviors while spending 98 to 99% of their time inactive. Over the 24 h period, broilers in the **18 h** and **SD/SU** treatments were inactive 84% of the time which was significantly higher than 79% for the broilers in the **20 h** treatment.

During the light period, broilers in the **20 h** treatment stood 1 h longer than those in the **18 h** and **SD/SU** treatments (Table 3.4). These differences were statistically significant. Broilers in the **20 h, 18 h,** and **SD/SU** treatments spent 15.0, 14.0, and 8.6 h inactive respectively and the differences between each treatment mean were statistically significant. The broilers spent 1.5 to 1.9 h feeding, 0.8 to 1.9 h drinking, and 0.6 to 0.9 h walking. During the dark period, the average number of hours broilers spent inactive was significantly different among all treatments with those receiving the shorter photoperiod spending progressively more time inactive (4.0, 5.9, and 11.7 h for the **20 h**, **18 h**, and **SD/SU** treatments respectively). There was very little time devoted to any other behavior during this period with the most equal to 0.2 h for broilers in the **SD/SU** treatment standing. Over the 24 h period, however, there were no significant differences among the treatments in the average amounts of time individual broilers spent performing any of the five behaviors. The broilers were inactive for 19.0 to 20.0 h while standing for 3.0 to 3.8 h, walking for 0.6 to 0.8 h, feeding for 1.6 to 1.8 h, and drinking for 0.8 to 1.2 h.

29 Days of Age

At 29 d (**20 h** 20L:4D, **18 h** and **SD/SU** 18L:6D), the average percentages of broilers feeding during the light period for the **18 h** and **SD/SU** treatments were 9% and these means were significantly higher than the **20 h** treatment at 6% (Table 3.5). At this age, both the **18 h** and **SD/SU** treatments were at 18L:6D. The broilers were inactive 75 to 78%, stood 16 to 19%, walked 4 to 5%, and drank 5 to 6% of the time. During the dark period, 98 to 99% of the flock in all treatments was inactive. There was little time devoted to any other behavior with the largest amount roughly 1% for standing and walking behavior for broilers under the **18 h** treatment. None of the differences between the treatment means during this period were statistically significant. Over the 24 h period, the broilers were inactive 81 to 82% of the time followed by 13 to 15% standing, 5 to 7% feeding, 3 to 4% walking, and 3 to 4% drinking.

During the light period, broilers in the **20 h** treatment were inactive for 15.6 h while broilers in the **18 h** and **SD/SU** treatments were inactive for 13.6 and 13.5 h respectively (Table 3.6). The majority of the remaining lighted hours were spent standing and feeding for 3.2 to 3.5 h and 1.3 to 1.7 h respectively while 1 h or less was spent performing either walking or drinking. During the dark period, the broilers spent 4 to 6 h inactive and very little time was devoted to any of the other behaviors. Over the 24 h period, broilers spent 19.4 to 19.6 h inactive, 3.2 to 3.5 h standing, 1.2 to 1.7 h feeding, 0.8 to 1.0 h drinking, and 0.8 to 0.9 h walking.

43 Days of Age

At 43 d (**20 h**, **18 h**, and **SD/SU** all at 23L:1D), during the light period, the broilers spent 81 to 82% of the time inactive (Table 3.7). They spent 13 to 14% of the time standing, 5 to 6% feeding, 4 to 5% drinking, and 2 to 3% walking. During the 1 h dark period, the broilers were mostly inactive (94 to 100%). The percentages of time devoted to each of the behaviors over the 24 h period were similar to those during the light period. The differences among the treatment means for the percentages of the flock performing any of the behaviors during the light, dark, and 24 h periods were not statistically significant.

The behaviors seen over the 24 h period directly reflect the behaviors seen during the light period with the exception of 1 extra h of inactivity from the dark period (Table 3.8). The broilers spent 19.5 to 19.8 h inactive while standing only 3.0 to 3.2 h, feeding 1.2 to 1.5 h, drinking, 0.9 to 1.1 h, and walking 0.6 to 0.7 h. The differences between treatment means were not statistically significant.

Gait Score and H:L Ratios

The majority (90 to 93%) of the broilers were categorized as 0 for their gait (Table 3.9). Only 7 to 10% and 1% were scored as 1 or 2 respectively. The H:L ratios ranged from 0.43 to 0.46 (Table 3.10) and the differences between treatment means were not significantly different.

DISCUSSION

Apportioning of Time for Behavior

The broilers in this study were able to adjust their behavioral schedules within 2 d of the photoperiod shifts at 9 d of age and again at 29 and 43 d of age for the broilers in the **SD/SU** treatment. For instance, the number of hours spent inactive during the light and dark changed almost exactly the same amount as the change in the number of available hours in each period (i.e., increasing the scotoperiod by 2 h resulted in an additional 2 h inactive, Table 3.6).

At all ages, the Cobb 500 broilers in this study spent the majority of their time inactive. Ross 308 broilers under 23L:1D (Weeks et al., 2000) and Cobb 500 broilers under 23L:1D from 1 to 3 d followed by 16L:8D for the remainder of the grow out (Alvino et al., 2009) have been previously reported to spend the majority (> 65%) of their day inactive. The changes in light schedule affected inactivity more than any other behavior. Broilers in the shorter photoperiods spent higher percentages of their time inactive over the 24 h period than those under longer photoperiods. This was expected since the scotoperiod accounted for a larger portion of the day and chickens are typically inactive in the dark. At 22 d, when the light treatments were the most different, the significant differences for standing during the dark period were equal to approximately 12 min between the **SD/SU** treatment and the other two treatments. Even though this was an active behavior, it did not affect inactivity significantly and the broilers in all treatments remained mostly inactive. Broilers in each treatment made sufficient changes to their behavioral schedules as the light schedules changed, resulting in similar amounts of time spent inactive over the 24 h period at all ages. This result means that the broilers adjust their schedules based on the photoperiod provided, but overall they seem to have a propensity to spend 19 to 20 h inactive.

Feeding behavior was the most common behavior following inactivity and standing. The significant difference between treatment means at 29 d for the percentage of the flock feeding during the light period may have been a result of the broilers under the **18 h** and the **SD/SU** treatments (both at 18L:6D at this age) compensating for their longer scotoperiod by feeding at higher rates during the light period. The greatest difference between the treatment means was 25 minutes, which was relatively short compared to the 18 and 20 h of light provided. Since there were no differences over the 24 h period for the percentage of the flock feeding or the amount of time individual broilers spent feeding, it seems as though the broilers only require a certain amount of time to feed.

The percentages of broilers feeding during the light period at 9 and 22 d (9 to 12%) were similar to Cobb 500 broilers in a study by Alvino et al. (2009). However, there was less than 2% of the flock feeding during the dark period at any given age in this study, whereas the Alvino et al. (2009) study reported approximately 10%. This was likely due to the 1 lx provided during the scotoperiod in their study while 0 lx was provided in this study. The additional feeding behavior seen during the scotoperiod accounted for the higher percentage over the 24 h period seen by Alvino et al. (2009). At 29 d, the longer dark periods in the **18 h** and **SD/SU** treatments (both 18L:6D) resulted in broilers feeding at higher rates during the light hours than broilers in the **20**

h treatment. Since chickens prefer to feed during the light hours (Savory, 1982/83), those exposed to the longer scotoperiod may have been preparing for the dark period by eating more before the transition from light to dark.

The comfort behaviors recorded were wing flapping, preening, and stretching (included in other behavior). Wing flapping was a rare behavior (< 1%) at any given point and the differences between the treatment means at 9 d were small (≤ 0.4%) and only amounted to less than one more broiler wing flapping at any given time. Preening, which occurred at slightly higher rates than wing flapping, was consistently between 1 and 3% over the 24 h period regardless of the age of the broilers. Alvino et al. (2009) reported similar rates of preening for Cobb 500 broilers under 23L:1D. They also recorded very little preening during the scotoperiod which is consistent with the findings of this study. It has been suggested that if preening occurs at high rates, the birds may be frustrated and perform the behavior as a displacement activity (Appleby et al., 2004). Therefore, the low rates of performance of comfort behaviors by the broilers in this study could be an indication that these broilers were not subjected to particularly stressful environments.

Gait Scores and H:L Ratios

Overall, the majority of broilers in all 3 treatments were scored as having no gait abnormality (89 to 93%, Table 3.9). The gait score procedure used in this study, which required people to be in close proximity to the chickens as they walked, was likely to induce a fear response in the broilers which may have overridden discomfort associated with a leg problem. Thus, some gait impairment due to minor problems that might have been evident with a less intrusive gait scoring procedure may not have been noted in the present study. Sorensen et al. (1999) reported no differences in gait scores for broilers as a result of photoperiod treatments

(8L:16D, 16L:8D, 21L:3D, and 23L:1D). Brickett et al. (2007) observed worse gait scores for 25 and 32 d old broilers raised with 20L:4D compared to 12L:12D. A difference between this study and Brickett et al. (2007) was that their study applied the 12L:12D schedule from 4 to 32 d whereas the **SD/SU** treatment in the present study did not reach 12L:12D until 13 d and ended at 27 d of age. Additionally, in the Brickett et al. (2007) study, the broilers under 20L:4D were significantly heavier than those under 12L:12D when the gait scores were recorded whereas there were no differences in BW (Table 2.1) for the broilers in this study when the gait scores were recorded. It is possible that the shorter amount of time exposed to the short photoperiod and the absence of differences in BW in this study prevented the occurrence of significant differences in walking ability between our treatments.

The H:L ratios ranged from 0.43 to 0.46 for the broilers in the three treatments, which indicates that the broilers were not chronically stressed by the treatments at the time of the measurements (Table 3.10). Blair et al. (1993), Campo and Davila (2002), and Lien et al. (2007) all reported that photoperiod did not significantly affect H:L ratios of chickens when light schedules different from the light treatments in this study were used.

The data from this study suggest that the Cobb 500 broilers easily adjust their behavior to changes in light schedules. The adjustments were seen during the light or the dark period, which resulted in similar behavioral schedules (amounts of time spent performing each behavior) over the 24 h period. Therefore, there seemed to be a certain amount of time that the broilers would devote to each behavior at each age with the majority of the time spent inactive. The Cobb 500 broiler can be raised with these 3 light schedules without adverse effects on leg condition as measured by gait score. Each of the treatments can be used for raising Cobb 500 broilers without causing chronic stress as measured by H:L ratios.

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TABLE 3.1. Behavior at 9 d of age. Percentage of broilers performing each behavior at any given time during the photoperiod (Light), scotoperiod (Dark) and the overall 24 h period (24 h)

		Behaviors								
Period	**Treatments**	**Stand**	**Walk**	**Feed**	**Drink**	**Wflap[1]**	**Preen**	**NN peck[2]**	**Other**	**Inactive**
Light	**20 h[3]**	21.7	4.9	10.2	6.3	0.7^{a}	1.4	2.2	0.4	73.3
	18 h[4]	22.8	4.4	11.3	6.8	0.5^{a}	1.6	2.9	0.4	71.3
	SD/SU[5]	22.1	5.1	10.7	6.1	0.3^{b}	1.5	2.2	0.2	73.4
	SEM	0.4	0.4	0.5	0.2	0.0	0.2	0.2	0.1	0.4
	P-value	NS	NS	NS	NS	0.011	NS	NS	NS	NS
Dark	**20 h[3]**	0.3	0.1	0.1	0.0	0.0	0.3	0.4	0.0	99.0
	18 h[4]	1.4	0.7	0.6	0.0	0.0	0.4	0.4	0.1	97.7
	SD/SU[5]	0.3	0.1	0.2	0.0	0.0	0.5	0.4	0.0	98.9
	SEM	0.3	0.2	0.2	0.0	0.0	0.3	0.2	0.0	0.7
	P-value	NS	NS	NS	NS	NS	NS	NS	NS	NS
24 h	**20 h[3]**	18.2	4.1	8.6	5.3	0.6^{a}	1.3	1.9	0.3	77.5^{b}
	18 h[4]	17.4	3.5	8.6	5.1	0.4^{b}	1.3	2.3	0.4	78.0^{b}
	SD/SU[5]	16.7	3.8	8.1	4.6	0.2^{c}	1.2	1.8	0.2	79.7^{a}
	SEM	0.3	0.3	0.4	0.1	0.0	0.2	0.1	0.1	0.2
	P-value	NS	NS	NS	NS	0.009	NS	NS	NS	0.008

[a-b] Means within a column with no common superscript differ significantly ($P < 0.05$).
[1]Wflap = wing flapping.
[2]NN peck = non-nutritive pecking.
[3]20 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 20L:4D from 7 to 9 d.
[4]18 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 9 d.
[5]SD/SU = Step-down/step-up = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 9 d.
Data for Trial 2 only.

Table 3.2. Behavior at 9 d of age. **N**umber of hours individual broilers performed each behavior during the photoperiod (Light), scotoperiod (Dark) and the overall 24 h period (24 h)[1]

		Behaviors									
		Stand		Walk		Feed		Drink		Inactive	
Period		**20 h[2]**	**18 h[3]/ SD/SU[4]**	**20 h**	**18 h/ SD/SU**	**20 h**	**18 h/ SD/SU**	**20 h**	**18 h/ SD/SU**	**20 h**	**18 h/ SD/SU**
Light		4.34[a]	4.05[b]	0.99	0.86	2.05	1.98	1.27	1.16	14.67[a]	13.03[b]
	SEM	0.08	0.05	0.07	0.05	0.09	0.06	0.05	0.04	0.15	0.11
	P-value	0.0357		NS		NS		NS		0.0008	
Dark		0.02	0.04	0.01	0.03	0.01	0.02	0.00	0.00	3.92[b]	5.92[a]
	SEM	0.03	0.02	0.03	0.02	0.01	0.01	0.00	0.00	0.04	0.03
	P-value	NS		NS		NS		NS		<0.0001	
24 h		4.36	4.10	1.00	0.88	2.06	2.00	1.27	1.16	18.61	18.92
	SEM	0.08	0.06	0.07	0.05	0.08	0.06	0.05	0.04	0.15	0.10
	P-value	NS		NS		NS		NS		NS	

[a-b] Means within a row and behavior with no common superscript differ significantly ($P < 0.05$).
[1]The 18 h and SD/SU treatments were pooled because these treatments followed the same light schedule at this age.
[2]20 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 20L:4D from 7 to 9 d.
[3]18 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 9 d.
[4]SD/SU = Step-down/step-up = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 9 d.
Data for Trial 2 only.

Table 3.3. Behavior at 22 d of age. Percentage of broilers performing each behavior at any given time during the photoperiod (Light), scotoperiod (Dark) and the overall 24 h period (24 h)

		Behaviors								
Period	**Treatments**	**Stand**	**Walk**	**Feed**	**Drink**	**Wflap**[1]	**Preen**	**NN peck**[2]	**Other**	**Inactive**
Light	**20 h**[3]	19.4	4.3	9.2	5.9	0.2	3.0	2.1	0.3	74.8
	18 h[4]	16.6	3.2	8.7	4.7	0.2	2.4	1.8	0.6	78.3
	SD/SU[5]	23.5	4.8	12.2	6.3	0.5	2.4	1.6	0.1	71.6
	SEM	1.2	0.6	1.0	0.4	0.2	0.4	0.2	0.1	1.2
	P-value	NS	NS	NS	NS	NS	NS	NS	NS	NS
Dark	**20 h**[3]	0.1[b]	0.1[b]	0.0	0.0	0.0	0.3	0.3	0.3	99.1
	18 h[4]	0.4[b]	0.2[b]	0.2	0.0	0.0	0.3	0.1	0.1	99.1
	SD/SU[5]	1.8[a]	0.7[a]	0.8	0.1	0.0	0.2	0.1	0.3	97.6
	SEM	0.00	0.1	0.2	0.0	0.0	0.2	0.2	0.2	0.7
	P-value	0.047	0.036	NS	NS	NS	NS	NS	NS	NS
24 h	**20 h**[3]	15.9	3.5	7.5	4.8	0.2	2.5	1.8	0.3	79.3[b]
	18 h[4]	12.5	2.4	6.5	3.5	0.2	1.9	1.3	0.4	83.6[a]
	SD/SU[5]	13.4	2.9	6.9	3.4	0.3	1.4	0.9	0.2	83.7[a]
	SEM	0.7	0.4	0.8	0.3	0.1	0.3	0.2	0.1	0.7
	P-value	NS	NS	NS	NS	NS	NS	NS	NS	0.034

[a-b] Means within a column with no common superscript differ significantly ($P < 0.05$).
[1]Wflap = wing flapping.
[2]NN peck = non-nutritive pecking.
[3]20 h = 20L:4D from 10 to 22 d.
[4]18 h = 18L:6D from 10 to 22 d.
[5]SD/SU = Step-down/step-up = 15L:9D from 10 to 12 d; 12L:12D from 13 to 22 d.

Table 3.4. Behavior at 22 d of age. Number of hours individual broilers performed each behavior during the photoperiod (Light), scotoperiod (Dark) and the overall 24 h period (24 h)

		Behaviors				
Period	**Treatment**	**Stand**	**Walk**	**Feed**	**Drink**	**Inactive**
Light	**20 h**[1]	3.89[a]	0.86	1.85	1.18	14.96[a]
	18 h[2]	2.99[b]	0.57	1.56	0.84	14.09[b]
	SD/SU[3]	2.82[b]	0.57	1.47	0.76	8.59[c]
	SEM	0.15	0.07	0.17	0.07	0.16
	P-value	0.0275	NS	NS	NS	0.002
Dark	**20 h**[1]	0.00	0.00	0.00	0.00	3.96[c]
	18 h[2]	0.04	0.02	0.02	0.01	5.93[b]
	SD/SU[3]	0.17	0.07	0.09	0.01	11.74[a]
	SEM	0.05	0.02	0.03	0.00	0.06
	P-value	NS	NS	NS	NS	0.000
24 h	**20 h**[1]	3.81	0.85	1.81	1.16	19.02
	18 h[2]	2.99	0.58	1.56	0.83	20.07
	SD/SU[3]	3.21	0.70	1.66	0.82	20.09
	SEM	0.18	0.08	0.18	0.07	0.17
	P-value	NS	NS	NS	NS	NS

[a-c] Means within a column with no common superscript differ significantly ($P < 0.05$).

[1]20 h = 20L:4D from 10 to 22 d.

[2]18 h = 18L:6D from 10 to 22 d.

[3]SD/SU = 15L:9D from 10 to 12 d; 12L:12D from 13 to 22 d.

Table 3.5. Behavior at 29 d of age. Percentage of broilers performing each behavior at any given time during the photoperiod (Light), scotoperiod (Dark) and the overall 24 h period (24 h)

		Behaviors								
Period	**Treatments**	**Stand**	**Walk**	**Feed**	**Drink**	**Wflap[1]**	**Preen**	**NN peck[2]**	**Other**	**Inactive**
Light	**20 h[3]**	15.9	4.2	6.3[b]	5.3	0.2	3.0	2.3	0.5	78.1
	18 h[4]	18.1	4.2	9.2[a]	4.5	0.5	2.9	2.1	0.6	75.7
	SD/SU[5]	19.4	5.1	8.6[a]	5.5	0.3	2.3	2.0	0.6	75.2
	SEM	0.8	0.6	0.5	0.5	0.1	0.8	0.5	0.3	1.8
	P-value	NS	NS	0.039	NS	NS	NS	NS	NS	NS
Dark	**20 h[3]**	0.2	0.2	0.0	0.0	0.1	0.2	0.2	0.7	98.6
	18 h[4]	1.1	0.7	0.0	0.0	0.0	0.1	0.0	0.9	98.3
	SD/SU[5]	0.4	0.1	0.3	0.0	0.0	0.1	0.1	0.5	99.0
	SEM	0.6	0.4	0.1	0.0	0.0	0.1	0.1	0.4	1.0
	P-value	NS	NS	NS	NS	NS	NS	NS	NS	NS
24 h	**20 h[3]**	13.1	3.5	5.2	4.4	0.2	2.5	1.9	0.6	81.7
	18 h[4]	13.8	3.3	6.9	3.3	0.4	2.2	1.5	0.7	81.3
	SD/SU[5]	14.7	3.9	6.6	4.2	0.2	1.7	1.6	0.6	81.0
	SEM	0.8	0.5	0.4	0.4	0.1	0.6	0.4	0.1	1.6
	P-value	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a-b] Means within a column with no common superscript differ significantly ($P < 0.05$).
[1]Wflap = wing flapping.
[2]NN peck = non-nutritive pecking.
[3]20 h = 20L:4D from 23 to 29 d.
[4]18 h = 18L:6D from 23 to 29 d.
[5]SD/SU = Step-down/step-up = daily 1 h increases from 23 to 28 d; 18L:6D from 28 to 29 d.

Table 3.6. Behavior at 29 d of age. Number of hours individual broilers performed each behavior during the photoperiod (Light), scotoperiod (Dark) and the overall 24 h period (24 h)

		Behaviors				
Period	**Treatment**	**Stand**	**Walk**	**Feed**	**Drink**	**Inactive**
Light	**20 h**[1]	3.17	0.85	1.25	1.06	15.62[a]
	18 h[2]	3.26	0.75	1.66	0.80	13.63[b]
	SD/SU[3]	3.50	0.93	1.55	0.99	13.53[b]
	SEM	0.15	0.10	0.09	0.10	0.34
	P-value	NS	NS	NS	NS	0.0375
Dark	**20 h**[1]	0.01	0.01	0.00	0.00	3.93
	18 h[2]	0.06	0.04	0.00	0.00	5.90
	SD/SU[3]	0.02	0.01	0.01	0.00	5.94
	SEM	0.04	0.02	0.01	0.00	0.78
	P-value	NS	NS	NS	NS	NS
24 h	**20 h**[1]	3.15	0.85	1.24	1.05	19.60
	18 h[2]	3.32	0.79	1.66	0.80	19.52
	SD/SU[3]	3.53	0.94	1.58	1.00	19.45
	SEM	0.18	0.12	0.10	0.09	0.38
	P-value	NS	NS	NS	NS	NS

[a-b] Means within a column with no common superscript differ significantly ($P < 0.05$).
[1]20 h = 20L:4D from 23 to 29 d.
[2]18 h = 18L:6D from 23 to 29 d.
[3]SD/SU = Step-down/step-up = daily 1 h increases from 23 to 28 d; 18L:6D from 28 to 29 d.

Table 3.7. Behavior at 43 d of age. Percentage of broilers performing each behavior at any given time during the photoperiod (Light), scotoperiod (Dark) and the overall 24 h period (24 h)

		Behaviors								
Period	**Treatments**	**Stand**	**Walk**	**Feed**	**Drink**	**Wflap**[1]	**Preen**	**NN peck**[2]	**Other**	**Inactive**
Light	**20 h**[3]	12.9	2.4	5.2	4.9	0.2	2.2	2.5	1.0	81.7
	18 h[4]	13.7	2.8	6.5	4.0	0.3	2.2	1.9	1.4	80.8
	SD/SU[5]	13.1	2.5	6.3	4.2	0.2	2.3	1.9	1.2	81.5
	SEM	0.9	0.8	0.4	0.6	0.2	0.2	0.3	0.3	1.3
	P-value	NS	NS	NS	NS	NS	NS	NS	NS	NS
Dark	**20 h**[3]	0.9	0.0	0.0	0.0	0.0	0.0	0.0	1.5	98.5
	18 h[4]	1.5	0.6	0.3	0.0	0.9	0.0	0.0	4.2	94.0
	SD/SU[5]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	SEM	1.0	0.3	0.2	0.0	0.5	0.0	0.0	2.6	3.6
	P-value	NS	NS	NS	NS	NS	NS	NS	NS	NS
24 h	**20 h**[3]	12.4	2.3	4.9	4.7	0.2	2.1	2.4	1.0	82.4
	18 h[4]	13.2	2.7	6.2	3.9	0.3	2.1	1.8	1.5	81.3
	SD/SU[5]	12.6	2.4	6.0	4.1	0.1	2.2	1.9	1.1	82.2
	SEM	0.9	0.8	0.4	0.6	0.2	0.2	0.3	0.4	1.3
	P-value	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]Wflap = wing flapping.
[2]NN peck = non-nutritive pecking.
[3]20 h = 20L:4D from 30 to 37 d; 23L:1D from 38 to 43 d.
[4]18 h = 18L:6D from 30 to 37 d; 23L:1D from 38 to 43 d.
[5]SD/SU = Step-down/step-up = 18L:6D from 30 to 27 d; daily 1 h increases from 38 to 42 d to reach 23L:1D; 23L:1D on 43 d.

Table 3.8. Behavior at 43 d of age. Number of hours individual broilers performed each behavior during the photoperiod (Light), scotoperiod (Dark) and the overall 24 h period (24 h)

		Behaviors				
Period	**Treatment**	**Stand**	**Walk**	**Feed**	**Drink**	**Inactive**
Light	**20 h**[1]	2.97	0.56	1.19	1.13	18.79
	18 h[2]	3.15	0.64	1.49	0.92	18.58
	SD/SU[3]	3.02	0.57	1.45	0.98	18.74
	SEM	0.22	0.18	0.09	0.14	0.30
	P-value	NS	NS	NS	NS	NS
Dark	**20 h**[1]	0.01	0.00	0.00	0.00	0.99
	18 h[2]	0.02	0.01	0.00	0.00	0.94
	SD/SU[3]	0.00	0.00	0.00	0.00	1.00
	SEM	0.01	0.00	0.00	0.00	0.04
	P-value	NS	NS	NS	NS	NS
24 h	**20 h**[1]	2.97	0.56	1.19	1.13	19.78
	18 h[2]	3.16	0.65	1.49	0.92	19.52
	SD/SU[3]	3.02	0.57	1.45	0.98	19.74
	SEM	0.22	0.19	0.09	0.10	0.14
	P-value	NS	NS	NS	NS	NS

[1]20 h = 20L:4D from 30 to 37 d; 23L:1D from 38 to 43 d.
[2]18 h = 18L:6D from 30 to 37 d; 23L:1D from 38 to 43 d..
[3]SD/SU = Step-down/step-up = 18L:6D from 30 to 27 d; daily 1 h increases from 38 to 42 d to reach 23L:1D; 23L:1D on 43 d.

Table 3.9. Gait scores at 6 wk of age. Percentage of broilers in each gait score category

	Gait Score								
	0			1			2		
	20 h[1]	**18 h**[2]	**SD/SU**[3]	**20 h**	**18 h**	**SD/SU**	**20 h**	**18 h**	**SD/SU**
	88.9	90.6	92.8	10.4	8.0	6.6	0.6	1.4	0.6
SEM	2.6	3.1	2.6	2.4	2.9	2.4	0.4	0.4	0.4
P-value		NS			NS			NS	

[1]20 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 20L:4D from 7 to 37 d; 23L:1D from 38 to 43 d.
[2]18 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 37 d; 23L:1D from 38 to 43 d.
[3]SD/SU = Step-down/step-up = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 9 d; 15L:9D from 10 to 12 d; 12L:12D from 13 to 22 d; daily 1 h increases from 23 to 28 d; 18L:6D from 28 to 37 d; daily 1 h increases from 38 to 42 d to reach 23L:1D; 23L:1D on 43 d.

Table 3.10. Average H:L ratios for broilers in each treatment at 38 d

Treatments	H:L
20 h[1]	0.44
18 h[2]	0.43
SD/SU[3]	0.46
SEM	0.03
P-value	NS

[1]20 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 20L:4D from 7 to 37 d; 23L:1D from 38 to 43 d.
[2]18 h = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 37 d; 23L:1D from 38 to 43 d.
[3]SD/SU = Step-down/step-up = 24L:0D on 1 d; 23L:1D from 2 to 6 d; 18L:6D from 7 to 9 d; 15L:9D from 10 to 12 d; 12L:12D from 13 to 22 d; daily 1 h increases from 23 to 28 d; 18L:6D from 28 to 37 d; daily 1 h increases from 38 to 42 d to reach 23L:1D; 23L:1D on 43 d.

CHAPTER 4

CONCLUSION

Cobb 500 broilers raised with any of the 3 photoperiod treatments in this study (**18 h**, **20 h**, or **SD/SU**) finished at similar BW and had similar G:F ratios. However, the **SD/SU** program slowed growth during the second and third week of grow-out, which could potentially reduce mortality due to metabolic diseases. The results for mortality within the settings of this study did not produce significant differences. The gait scores of the broilers were similar between the treatments during the final week of grow out. The H:L ratios suggested that the broilers can be kept under any of the 3 treatments with similar response and without causing chronic stress.

The behavioral schedules of the broilers in this study were altered by the three lighting programs. For instance, increased rates of activity were seen during the light period when the photoperiod was short. The broilers also spent the majority of the scotoperiods inactive. However, these changes in behavior scheduling did not affect the number of hours spent performing each of the behaviors over the 24 h period. At each age, the broilers were able to adjust their behaviors to the amount of time allotted to the light and dark periods.

Overall, the **20 h**, **18 h**, and **SD/SU** treatments were appropriate for Cobb 500 broilers as determined by the performance parameters measured and the ability of the birds to adjust their behaviors to the changes in the light schedules.