Department of Animal Science

LIGHTING PROGRAMS FOR BROILER CHICKENS CONTINUE TO EVOLVE

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Light is a critical environmental factor for broiler chickens, affecting numerous aspects of production such as behavior, health, physiology and welfare. The ability of light to influence production performance, growth and wellbeing of poultry is well documented and has attracted the attention of researchers for over 100 years (Lashley, 1916; Bowlby, 1957; Cherry and Barwick, 1962). In general, broilers are raised indoors in large flocks where food, water and environment are controlled to provide for their basic physiological needs (Newberry, 1999). However, this is a very different environment than that experienced by their junglefowl ancestors from which modern broiler chickens have evolved. In nature, chickens are exposed to a variety of circumstances and environmental conditions including varying day lengths and light intensities (Newberry, 1999; Collias and Collias, 1996). Lighting is a key management tool in broiler production, however, research to provide detailed characterizations of the internal lighting environment of commercial broiler houses is relatively recent (Linhoss et al., 2023). Use of LED lights have been demonstrated to improve efficiency and production performance, although further adaptation of LED technology may yield additional improvements by providing a more appropriate lighting environment for broilers (Aldridge, 2019). Recent reports have suggested that the optimal light environment for broiler production may not be a uniform distribution of light intensity (Davis et al., 1999; Raccoursier, 2016; Aldridge et al., 2022; Thornton and Tabler, 2023).

Light wavelength and intensity

Light is an important management factor for broiler production that can affect broiler growth, diurnal rhythms, behavior and welfare (Deep et al., 2010, 2012; Schwean-Lardner et al., 2012a, b, 2014). The lighting program remains of critical importance because lighting has been intimately associated with not only the establishment of rhythm and synchronous physiology of broiler chickens, but also the secretion of hormones associated with broiler maturation and growth (Wu et al., 2022). An appropriate lighting regimen, including proper source of lighting, intensity, duration and wavelength (color) of light, is critical to improve the growth performance and welfare of broilers (Wu et al., 2022). Light wavelength also influences fear and stress levels (Franco et al., 2022). Broilers raised under blue light had lower fear levels, assessed through tonic immobility, than birds raised under white light (Mohamed et al., 2014, 2017). Aldridge et al. (2021) reported that broilers provided a dual light (warm (2,700 K) and cool (5,000 K)) offering exhibited a clear preferential pattern for warm light during the first and last hour of a 16-hour light period. Impacts on bird behavior may suggest that lighting programs with varying wavelengths and light intensities may be a usable tool to improve welfare and production aspects. However, it is important to understand the origin of the behavioral changes and whether they are related to visual ability or another critical factor (Wu et al., 2022).

For example, leg health is one of the most prevalent causes of culling and late mortality in a flock during the grow-out of commercial broilers. Numerous researchers have indicated that increasing locomotor activity in broilers may improve bird welfare (Bizeray et al., 2002; Kristensen et al., 2004; Kang et al., 2020, 2023). Several studies addressing broiler leg health suggest that the stimulatory effect of bright light on locomotor activity can improve leg condition and thus welfare (Newberry et al., 1988; Shields et al., 2005; Blatchford et al., 2009). Kang et al. (2023) reported increased volunteer and natural behaviors and physical activity, which may improve footpad condition and leg health, under a variable broiler lighting program.

The effects of light intensity provided by artificial lighting on commercial broilers has been extensively studied in the past (Olanrewaju et al., 2006). Variable light intensity studies have indicated that when birds have a dual light choice they consumed more feed in the higher-intensity light area (20 lux (1.85 fc)) than in the lower intensity area (2 lux (0.19 fc)) (Raccoursier et al., 2019; Kang et al., 2020). While there was no significant difference in production parameters (body weight and feed conversion ratio), the results of central welfare indicator studies suggested better central welfare in variable lighting intensity-treated birds (Kang et al., 2020). Fewer studies have examined the effect of natural light on performance, welfare, health and behavior. However, de Jong and Gunnink (2019) reported no difference in welfare indicators (lameness, footpad dermatitis, hock burn, cleanliness and injuries) between birds on a commercial farm provided natural light/enrichments and a control with no enrichments or natural light. De Oliveira Sans et al. (2021) reported that broilers preferred a natural light treatment (280 to 900 lux (26 to 84 fc)) to an artificial lighting only treatment (22 to 44 lux (2 to 4 fc) after 18 days of age. Bailie et al. (2012) reported that broilers grown in a commercial house and provided natural light (average of 85.2 lux (8 fc) showed increased activity and leg health when compared to broilers grown under artificial lighting only (average of 11.4 lux (1.05 fc)). Lower light intensities have been shown to reduce activity, cannibalism and scratching, whereas higher levels promote increased activity (Cherry and Barwick, 1962;

Newberry et al., 1988; Kristensen et al., 2006; Rault et al., 2016), which may explain some of the differences seen in studies on natural light.

An area receiving increased attention in recent years has been the uncontrolled ingress of natural light through tunnel exhaust fans, sidewall inlets and other house components which increases the temporal and spatial variability of light intensity (Miragliotta et al., 2006; Purswell and Olanrewaju, 2017; Linhoss et al., 2020). Linhoss et al. (2020) reported that light intensity at the fan end of a broiler house reached a peak of 440 lux (41 fc) and remained at over 100 lux (9.2 fc) for an entire day. Purswell and Olanrewaju (2017) reported significantly higher feed conversion ratio and feed consumption for birds raised in a variable light treatment, designed to mimic the huge variation in light intensity through tunnel fans, when compared to birds raised under a constant prescribed light intensity (2.5 lux (0.2 fc)). Linhoss et al. (2022) reported light intensity values as high as 6,000 lux (557 fc) in a curtain-sided natural light broiler house compared to a traditional artificial lighting system, over 600 times higher than levels generally accepted by the broiler industry today.

Gradient lighting

There is increasing evidence that indicates focusing on determining a single uniform light intensity and color (Figure 1) to be applied evenly across time (age) and space (the rearing environment) may have been misguided (Aldridge, 2019). With the poultry industry's increased focus on animal welfare, gradient lighting programs (Figure 2) that provide bright light levels near the feed lines and much lower light levels near the walls and allow broilers to "choose" their preferred light level are attracting much greater attention. Broiler chickens have shown a preference for higher intensity light when they are performing active behaviors (such as eating) but prefer dimmer areas when resting (Newberry et al., 1985; Berk, 1995; Raccoursier et al., 2019; Kang et al., 2020). Light intensity has been shown to affect the activity of birds, but most studies have focused on constant and uniform light intensities to determine their effect on welfare and performance (Kang et al., 2023). However, Blatchford et al. (2012) reported a strong effect of contrasting light intensities on the behavior and health of broilers and suggested that high contrast in light intensity was associated with strong daily rhythms of behavior.

Vision is likely the dominant sense in domestic poultry, and the evolution of vision was determined, at least in part, by the natural light available (Prescott et al., 2003), with its gradient combination of direct sunlight and shadows, in the jungles of Southeast Asia where the ancestors of today's broilers originated. However, broiler chickens in commercial management settings today are typically housed in dim lighting because it is presumed to improve productivity and

Figure 1. Uniform light levels have been a poultry industry standard for years.

Figure 2. Gradient lighting for broilers is attracting much attention today.

feed conversion efficiency, as well as reduce overall activity and injurious pecking episodes (Prescott and Wathes, 1999; Alvino et al., 2009). If birds perceive different light intensities in different ways, this may influence their behavior. Manser (1996) suggested that light intensities between 5 and 22 lux (0.5 to 2 foot-candles (fc)), currently used for broilers and turkeys, may contribute to a decrease of their engaging in exploratory behavior and social interactions and high prevalence of leg abnormalities, mortality, eye abnormalities, breast blisters in growing birds and fearfulness. Therefore, the potential for the enrichment of the perceived environment and, consequently, for improving bird welfare through gradient lighting seems to warrant additional investigation.

Numerous reports indicate that chickens have preferences for specific light intensities. When provided a choice of light intensities of 6, 20, 60 and 200 lux (0.5, 1.85, 5.5 and 19 fc) in a choice system, two-week-old broilers preferred bright light (200 lux (19 fc)) for all behaviors (Davis et al., 1999). However, by six weeks of age, broiler chickens exhibited active behaviors under 200 lux (19 fc) but resting and perching behaviors under 6 lux (0.5 fc) (Davis et al., 1999). Raccoursier et al. (2019) reported that broiler chickens given a lighting choice were found disproportionately dispersed with greater numbers in areas at 20 lux (1.85 fc) where feed and water were available and to poorly lit (~1 lux (0.1 fc)) areas with neither feed nor water compared to areas with feed and water and lit at 5 lux (0.5 fc). Kang et al. (2023) reported that a variable light intensity program increased volunteer natural behaviors and physical activity. Performance data, including increased daily weight gain and a lowered feed conversion ratio and results of brain welfare indicator gene expression, indicated the beneficial effect of a variable light intensity lighting program on performance and welfare. These studies tend to suggest that a uniform light intensity that the industry has utilized for years may not be the best option for broiler chickens. That message is not being lost on lighting manufacturers, as there are now multiple gradient lighting options available on the market and others in the testing phase.

Summary

Lighting programs in the broiler industry continue to evolve and are far from being an exact science. Responses to shifting consumer demands for alternative rearing programs and improved welfare conditions have resulted in a re-evaluation of lighting programs by the commercial

broiler industry in recent years. A variety of lighting programs are currently in use or being studied across the broiler industry. These range from going back to walls and windows that allow use of natural light to the most recent concept of gradient or variable intensity lighting that allows birds to "choose" the level of light they desire throughout the grow-out. This often means higher intensity lighting near the feeders and drinkers where activity levels are high and a much lower light level near the walls for resting where the activity level is lower. Despite our knowledge of the importance of light to broiler chickens, the industry continues to search for the ideal lighting program that can provide the production performance, growth, health and welfare benefits we desire. That search challenges lighting manufacturers to continually develop new state-of-the-art lighting options that can meet the needs of a changing poultry industry. Continued collaboration between lighting manufacturers and the poultry industry is critical to address lighting challenges and to allow for the continuing improvement of broiler lighting practices.

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