RETHINKING LIGHTING FOR BROILER CHICKENS

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Light is an essential environmental component in poultry housing systems with important direct and indirect impacts on poultry production, profitability, and welfare. Broilers *(Figure 1)* are intensively reared worldwide in flocks confined to houses where food, water, and environmental conditions (including lighting) are provided for their basic physiological needs ***(Newberry, 1999)***. The ability of light to influence the production performance and wellbeing of poultry has long been an area of interest to researchers ***(Aldridge, 2019)***. However, considering bird evolutionary history from the original jungle fowl until today, the environmental conditions provided in modern production facilities are vastly different from that found by chickens in the wild ***(Sans et al., 2021)***. In nature, chickens are exposed to a variety of circumstances and environmental conditions which include day length, varying light intensities, and photoperiod ***(Newberry, 1999; Collias and Collias, 1996)***. Broiler chickens raised in a commercial setting are typically housed, for most of the flock's life, in a uniformly dim lighting environment because it improves productivity and feed conversion efficiency. Perhaps it's time we rethink that scenario.

VISION IS CRITICAL TO POULTRY

Figure 1. Broiler chicks in a commercial poultry house.

Vision is likely the dominant sense in domestic poultry. The evolution of vision was determined, in part, by the natural light available, which changes in color and intensity, particularly near sunrise and sunset. The photoreceptive pigments in the retina allow birds to perceive color and color changes in more detail than humans ***(Prescott and Wathes, 1999)***. If birds perceive natural and artificial light differently, this may influence their behavior. The use of low intensity light (< 10 lux) has been reported to have negative impacts on behavioral rhythms ***(Alvino et al., 2009)***, ocular development ***(Lauber et al., 1965)*** and foot pad health ***(Deep et al., 2010)***. Preference tests suggest that most broiler chickens make consistent and rational choices associated with environments that are associated with lower fear and stress responses. In addition, a recent report suggests that the optimal light environment for broiler production should provide varying light intensity ***(Aldridge, 2019)***.

One of the early papers that assessed the improved production of poultry by using artificial lighting came from ***Curtis (1920)***. Numerous subsequent studies have been conducted on the

effects of lighting on poultry production performance, with recent research focusing more on the effects on behavior and well-being ***(Raccoursier, 2016)***. Light has been an important management tool to regulate poultry production, health, and welfare since the beginning of intensive poultry production. Lighting *(Figure 2)* is a key component in poultry production and is likely the most critical factor because it controls physiological and behavioral processes in the bird ***(Manser, 1996)***. It is important to understand the origin of behavioral processes and whether these processes are related to visual ability. The large eyes of a chicken in relation to its body weight and brain size suggest that vision is a critical sense ***(Garamszegi et al., 2002; Prescott et al., 2003)***. Birds use visual cues for a variety of activities, such as awareness of other birds' intentions, status recognition, determining what is safe to eat and drink, and navigation ***(Collins et al., 2011)***.

Figure 2. Poultry house lighting is critical to flock performance.

Davis et al. (1999) found that the preference of broilers changed from 200 lux at 2 weeks for all behaviors to 6 lux for inactive behaviors and 200 lux for active behaviors at 6 weeks. Broilers ate more feed under 20 lux than 5 lux ***(Raccoursier, 2016)***. ***Raccoursier et al. (2019)*** found that in a choice system, broilers exhibited a preference to be present and consume feed under a light intensity of 20 lux compared to intensities of 5 and 10 lux. However, broilers also congregated in an area of low light intensity (1 and 2 lux) when not feeding or drinking. It was suggested that regulations requiring uniform light intensities for broiler chicken production might be reconsidered based on bird behavior allowing opportunity to retreat between bouts of eating and drinking to areas with low light intensity. ***Aldridge (2019)*** found that similar production performance (body weight, feed;gain) could be achieved using a gradient lighting system of higher light intensity (30 to 90 lux) than a lower (20 lux) uniform light intensity.

Birds have developed several adaptations to their visual system compared to mammals. For example, birds are tetrachromatic, which means they possess four types of cone photoreceptor cells compared to trichromatic animals, such as humans. Oil droplets in the cones filter light before it reaches the photopigments, providing birds with increased accuracy in color discrimination ***(Prescott and Wathes, 1999; Kelber, 2019)***. Birds also possess a different spectral sensitivity and therefore perceive color and intensity differently than humans, particularly in the blue color range which birds see brighter than humans ***(Lewis and Morris, 2000)***. This means that measuring light intensity in units of lux, the traditional unit used to assess illuminance under white light, may not be the best method when assessing light intensity of colored lighting in poultry settings because it is based on human spectral sensitivity ***(Franco et al., 2022)***. Where chickens are concerned, a more accurate assessment unit has been developed, referred to as clux (or chicken lux), that considers a bird's spectral sensitivity ***(Nuboer et al., 1992; Prescott et al, 2003; Kristensen et al., 2006)***.

WHAT DOES ALL THIS MEAN?

Figure 3. Is it time to rethink lighting for broilers?

It means we may need to rethink how we design broiler lighting in the future. Early results from gradient light trials indicate that a uniform light level throughout the house may not be ideal. Precision Livestock Farming (PLF) has become a hot topic recently and primarily refers to making decisions based on continuous real-time monitoring of birds. PLF techniques associated with lighting and other areas will change the way broilers are produced in the future. There's no reason to believe that the way we have designed and operated poultry lighting in the past has been optimal in terms of production or welfare.

Development of new lighting technologies such as the light-emitting diode (LED) have almost totally replaced incandescent lighting in poultry houses. LED technology continues to improve each year. The poultry industry has an opportunity to harness this improved technology and use it to improve the welfare of broiler chickens. This includes additional preferences along

with different types of artificial lighting programs, as well as assessing bird preference for a particular environment. This could include not only a gradient in light intensity for birds to choose from but also a gradient in light color. Many controllers currently have a sunrise/sunset feature to gradually ramp the light level up and down when lights come on and go off. Lighting systems that control light color may be an added welfare feature to mimic reddish hued light at sunrise and sunset vs. bluer hued light throughout the day.

Considering the higher visual perception capacities of birds compared to humans, exploring other light characteristics in addition to intensity seems an important next step. Future research should consider bird perception of light, not just the light perception of their human caretakers. However, we have to keep in mind that light affects behavior. Chickens are social creatures, so their preferences may be influenced by the choices a flock is making. In other words, they have a flock mentality and tend to behave as a social unit wherein they exhibit the same behavior at the same time. This is most noticeable when a few chicks in the broiler house will decide to start running and before long, it appears all the chicks in the house are in motion.

Figure 4. Runway and overhead lights in use with young chicks.

"RUNWAY" LIGHTING FOR BROILER PRODUCTION

Light color has been increasingly important for broiler production as we seek to improve the effects of lighting. Color is determined by the various output of light from the different wavelengths that make up the visible spectrum. For example, white light contains all wavelengths on the visible spectrum. Light color also differs in the color temperature or kelvin (K) rating. This is measured by the power emitted from different wavelengths within the spectrum, with 2,000K to 3,000K being warm, 3,100K to 4,500K being intermediate, and 4,600K to 6,000K being cool. A recent study showed broilers preferred a warmer (redder hued) light (2,700K) during the first and last hour during a 16-hour light period ***(Aldridge et al., 2019)***. Additionally, improved body weight was observed for those broilers provided a choice in comparison to those reared using 2,700K while broilers reared under 5,000K were intermediate.

Figure 5. Runway lights only with larger broilers.

Light intensity and uniformity are also being reconsidered by many poultry integrators today. Gradient lighting or what we will call "runway" lights *(see Figure 4 and Figure 5)* may be a superior form of lighting in broiler houses. Runway lights are sometimes called "feed line lights" because they may attach to the feed lines or may be built into the feed pans themselves rather than being attached to the ceiling. These gradient-style lights are bright (> 200 lux) at the feed lines but dim rapidly as the light spreads towards the drinker lines and the wall because the lights are close to the floor. This allows birds to exhibit some preference for light intensity. However, there are increasing reports that this nonuniform lighting pattern may not be as undesirable as once thought and may even be advantageous.

Aldridge et al. (2022) indicated there are multiple reports that light intensity both does and does not influence growth of broiler chickens. ***Prayitno et al. (1997)*** reported lighting intensity impacts behavioral aspects of broiler chickens. For instance, broiler chickens exhibit greater activity at 20 lux than 5 lux ***(Rault et al., 2017)*** or 50 lux vs. 5 lux ***(Blatchford et al., 2009)***. Light intensities less than 1 lux impair wellbeing (e.g., preening, footpad lesions, and behavioral rhythms) relative to intensities over 5 lux ***(Lien et al., 2008; Deep et al., 2011, 2013)***.

Recent reports indicate that the preference chickens have for light intensity changes as the flock ages. ***Raccoursier et al. (2019)*** reported that broilers disproportionately dispersed with greater numbers in areas at 20 lux, where feed and

water were available, and areas at 1 lux, without feed and water, versus areas at 5 lux, where feed and water were available. When provided a choice of light intensities of 6, 20, 60, and 200 lux, 2-week-old broiler chickens preferred bright light (200 lux) for all behaviors, while 6-week-old birds exhibited active behavior at 200 lux but preferred to rest and perch at 6 lux ***(Davis et al., 1999)***. ***Aldridge et al. (2022)*** reported superior feed efficiency when broilers had a choice between light intensities (5, 10, and 20 lux) versus a constant 20 lux. This indicates that uniform light may disadvantage broiler production. There was also improved performance (growth) when broiler chickens were provided a choice between two light spectrum color temperatures (2,700K and 5,000K) ***(Aldridge et al., 2021)***. While it is not clear what mechanism is responsible for improved performance when a choice of intensities or color temperatures were provided, it was speculated that provision of a different or "enriched" environment was the opposite of what might be considered a "barren" or uniform environment, and therefore, beneficial.

SUMMARY

Poultry house lighting impacts bird development. Light intensity, photoperiod, placement, and color temperature are all factors that influence growth. For many years, light has been viewed as something to maintain uniformly throughout the entire house. However, consumer demand for birds produced with optimum welfare considerations is now causing the poultry industry to reassess current lighting strategies and may indicate a potential lighting change on the horizon within the industry.

The optimal light intensities for broiler production and well-being have been studied for many years and continues. Growing broiler chickens exhibit preference for light intensities that change over time as the flock matures. Recent studies indicate that varying light intensity in commercial production houses may actually provide both optimized flock performance and increased welfare. Feed line or "runway" lighting designs provide an opportunity to rethink lighting programs and a better understanding of the influence that bird preference may play on the growth and wellbeing of broiler chickens. Flock performance and energy costs associated with gradient lighting will require further assessment but may be part of the future of poultry house lighting. Precision Livestock Farming will change how broilers are produced in the future, but there's no reason to believe we cannot provide an improved lighting environment in the near future.

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