LIGHT MANAGEMENT FOR POULTRY

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Light is an important aspect of an animal's environment. Avian species as well as mammalian species respond to light energy in a variety of ways, including growth and reproductive performance. The value of regulating the photoperiod of poultry and livestock to stimulate reproduction has been recognized for many years and is used regularly by commercial poultry and livestock farmers. For chickens there are three major functions of light: 1. to facilitate sight, 2. to stimulate internal cycles due to day-length changes, and 3. to initiate hormone release. Providing light for chickens has become a little more complex during the last 15 years than just screwing in a bulb and flicking on a switch. Now there are a wide variety of lighting programs and devices available to poultry producers, each with its own characteristics and applicability to rearing chickens. However, before we get to the details, I have found that most people are slightly confused about what light is and what aspects of it are important to rearing poultry. I would therefore like to elaborate on this just a little.

WHAT IS LIGHT?

Visible light is just a tiny portion of the total electromagnetic spectrum, which includes radio waves, microwaves, x-rays and gamma rays. The light environment can be classified in three ways, ***wavelength, intensity and duration***. Each of these aspects will be discussed relative to rearing poultry.

WAVELENGTH OR COLOR OF LIGHT

Research has shown that the color of light can have many different effects on behavior, growth and reproduction in poultry. Birds sense light through their eyes (retinal photoreceptors) and through photosensitive cells in the brain (extra-retinal photoreceptors). Since long wavelengths of light (towards red end of the spectrum) penetrate the skin and skull more efficiently than short wavelengths, it has been observed that growth and behavior are linked to retinal photoreception (and shorter wavelengths) whereas the reproduction has been linked to extra-retinal photoreceptors. From these observations it has been reported that **blue** light has a calming effect on birds, hovever, **red** has been used to reduce cannibalism and feather picking. It has also been shown that **blue-green light stimulates growth** in chickens (Cho, et al. 2008; Olanreqaju, et al. 2016)) while **orange-red stimulates reproduction**. Birds have pigmented oil droplets on their cone cells that correspond to peak sensitivities of 415 nm, violet; 460 nm, blue; 510 nm, green; and 560 nm, yellow for young birds with a peak at 580 nm, orange for adults. Recently, it has been shown that the lens of birds is transparent to light in the UVA range (320-400 nm). However, they probably see brightness of color different than humans. These facts are important to remember when selecting a light source for illuminating poultry.

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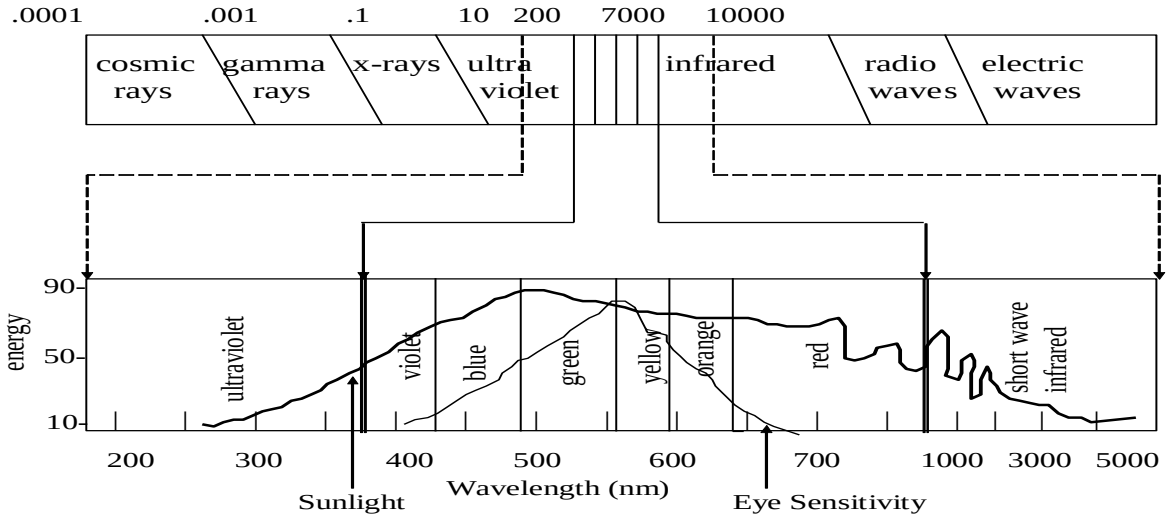
The lighting industry uses four methods to describe light color but only one really applies to selecting lighting for poultry, *chromaticity*. Chromaticity is the measure of a light source's warmth (warm light) or coolness (cool light) expressed in degrees Kelvin. The scale runs from 2000 to 7000K. Chromaticity values of 4000K and higher are considered cool (mostly blue light), those around 3500K or 3600K are called "balanced" or "neutral" and those of about 3000K or lower are considered warm (more red light). A color temperature designation is truly accurate only for an incandescent lamp because it produces a continuous spectrum. LED, Fluorescent and HID (high-intensity discharge; HP Sodium, Low pressure sodium, and Metal Halide lamps) lamps are said to have a "correlated" (apparent) color temperature and are thus always described using the term *correlated color temperature* (CCT) (Knisley, 1990).

ELECTROMAGNETIC SPECTRUM



WHAT KIND OF LAMPS ARE AVAILABLE TO POULTRY PRODUCERS?

Incandescent, LED, Fluorescent, Metal Halide and High-Pressure Sodium lamps are currently being used in poultry production facilities for laying hens, breeder flocks and growing meat birds. The ***incandescent*** bulb is the current standard by which others are compared, relative to poultry production.

Incandescent bulbs produce light by passing an electric current through a tungsten filament, heating it to incandescence. These lamps provide light energy over the entire visible spectrum, however much of the electrical energy is converted to heat energy as infrared. They have a light efficiency of about 8 - 24 lumens per watt and a rated life of about 750-2000 hours. A tungsten-halogen incandescent lamp will last about 3000 hours with an efficiency of about 20 lumens per watt.

Fluorescent lamps produce light by the passage of an electric current through a low-pressure vapor or gas contained within a glass tube. The ultraviolet radiation given off by the mercury-vapor arc stream produced along the length of the tube is absorbed by the phosphor material coating the inside of the glass tube, causing it to fluoresce at wavelengths that are seen as visible light. The wavelengths emitted depend upon the phosphors used in coating the tube. Most CF lamps use a special triphosphor coating, resulting in light emitted in discrete

wavelengths from each of the primary colors, red-orange, green and blue, giving an appearance of balanced white light. There are several styles of the CF lamps, including twin, quad and spiral tubes. They come in 5, 7, 9, 13, 16, 22, and 28 watt sizes with efficiencies of 50 to 69 lumens per watt and rated lifetimes of greater than 10,000 hours. Recent research has demonstrated that some may last more than 20,000 hours under poultry house conditions. However, these lamps will decrease their light output by about 20 - 30% over their lifetime, (Darre and Rock, 1995) and this must be considered upon initial installation. All fluorescent lamps require a ballast. The CF lamps have been used successfully in all types of poultry operations, including caged layers, (Darre, 1986) breeder flocks, growing broilers (Andrews and Zimmerman, 1990; Scheideler, 1990), growing pullets and turkeys. Research by Widowski, et al., (1992) indicated a preference for CF lamps over incandescent lamps by Leghorn layers.

High Pressure Sodium (HPS) lamps discharge an electric arc through a concentrated sodium vapor producing energy across the entire visible spectrum, but with the highest intensity in the yellow, orange and red regions. These are considered warm lights at about 2100K color temperature. They run at about 51-132 lumens per watt and come in wattages ranging from 35 to 1000. They have the longest rated life of all the lamps discussed, at about 24,000 hours. All HPS lamps require a ballast. These lamps require a warm up time to full illumination of between 5 and 15 minutes, which means that after a power outage, backup lighting may be necessary until full illumination has been achieved again. These lamps have been used successfully in poultry facilities, mostly in breeder houses and turkey facilities, with peaked roofs so that light distribution is more easily controlled (Andrews and Zimmerman, 1990).

Metal Halide (MH) lamps have ratings from 32 to 1500 watts and come in three different outer bulb finishes, clear, phosphor coated and diffuse. The MH lamps emit light across the entire visible spectrum, but are considered a cool light, having a lot of blue. They have efficiencies of about 80 to 100 lumens per watt and are rated at about 10,000 to 20,000 hours of life. MH lamps require a ballast also. Because these lamps must be mounted in a specific orientation (vertical or horizontal) they are not used much in the chicken house, but have been used in warehouse areas and egg handling rooms, where ceilings are high and efficient, bright lighting is required. These lamps also have a warm up period of between 5 and 15 minutes to achieve full illumination.

Cold Cathode Flourescent Light (CCFL) is a tubular light that works by passing an electrical current through a gas or vapor, much like neon lighting. Cold cathode lights can come in many sizes and colors, and there are many advantages over neon and fluorescent lighting.

The first advantage is that cold cathode lights do not get hot. Another is that a cold cathode light is up to five times brighter than neon lighting, and it has one of the longest lives of any lighting fixture at about 50,000 hours. Unlike incandescent bulbs, the longevity of one of these lights is not shortened by the repeated action of turning it off and on. Cathode Lighting Systems offers several different systems for varying applications, with light outputs up to 709 lumens per linear foot (2340 lumens per meter). Dozens of pastel and neon colors are available, as well as a wide array of high-color-rendering white hues. Lastly, they are dimmable using current incandescent lamp dimmers. The disadvantage is their initial expense. There are also CCFL designed to replace long life incandescent lamps and lamps that are used in dimming applications. These CCFL lamps are virtually the same size and shape as the incandescent lamps they were designed to replace. They include an integrated miniature electronic ballast, fully dimmable to less than 5% .

Light Emitting Diodes (LED) have been used for many applications where long life and reliability are required. Most run on low voltage (3.6 – 24 volts) and when put into an array,

they can produce high light output in either a focused or wide angle beam. The LED lamps and arrays are becoming less expensive all the time. They are illuminated solely by the movement of electrons in a semiconductor material, and they last just as long as a standard transistor. Alternating current (AC) driven lamps are also available.

Table 1. **Lighting Source Comparison**

	Inc.	CF	MH	HPS	CCFL	LED
Initial Cost	Low	Moderate	High	High	High	Moderate
Operating Cost	High	Moderate	Low	Low	Very low	Very low
Efficiency*	8-24	50-69	80-100	51-132	150 +	60-150+
Rated Life (hrs)	500-2000	10,000+	15,000+	24,000+	25,000+	60,000+
Color Temp (K)	2500K	2700K-Var	3700- 4000K	2100K	Var	Var

* Efficiency is measured as the rated lumens per watt.

HOW BRIGHT AND HOW LONG?

Now that the physical aspects of the lamps have been discussed, it is time to turn our attention to *intensity* and *duration.*

LIGHTING LAYERS and BREEDERS

Intensity: In natural light (window) housing the natural light is supplemented with 1.5 - 5.0 fc for the period when supplemental lighting is used. It has been found that birds exposed to very dim lights, say 3 hrs at.02 -.03 fc) prior to exposure to bright lights, say 8 hrs at .5 fc or more, might perceive this as sunrise and daylight and shift their biological clock as if exposed to 11 hours of normal light. However, the reverse, dim following bright, does not shift their perception. It appears that the threshold intensity for photostimulation is about .15 fc. However maximal egg production has been achieved at intensities between .5 and 1 fc.

The next important aspect is **duration** of light stimulation. Two rules exist for this.

1. **Never Increase** the duration or intensity of light during the **growing period**.

2. **Never Decrease** the duration or intensity of light during the **production period.**

Duration depends upon the age of the chicken and type of housing you use. Chicks can be exposed to 21-23 hrs of continuous light at one and two days of age and then reduced to 15 or 16 hrs of light until the birds are three weeks of age. (Chicks have a very low fear response during their first three days of life and can be exposed to many environmental stimuli, such as new housing, light and dark, etc. without much adverse effect.) At three weeks of age, reduce the hours of light to 10-12 hours or as dictated by natural day length. In summer for open housing use decreasing hours of light up to six weeks of age and then hold constant to avoid delays in maturity. When target body weights are achieved start your stimulatory lighting program. Jump to 13 hours and then add 15-30 min per week until 16 hrs of light is reached. Light stimulation should continue until peak production is achieved.

However, according to Lewis *et al.* (1992) the sensitivity of the young pullet to an increase in photoperiod varies with age and is at a maximum between 9 and 12 weeks of age and thus

increasing the photoperiod at or soon after 18 weeks has little effect on age at 50% lay. Therefore, the use of step-down - step-up lighting programs should be timed to bring the birds into lay at the age you wish, either early lay or late lay, starting the program between 9 and 12 weeks. With early lay you will get more, smaller eggs and with late lay you will get fewer, larger eggs, but the total egg mass at the end of lay will not be much different.

LIGHTING THE BROILER

Intensity: With blackout housing broilers can be exposed to 1 to 5 fc from day one to day three and then placed on .5 to 1 fc to processing. In natural light housing (window or curtain houses) the natural light is supplemented with .5 - 2.5 fc for the period when supplemental lighting is used. Broilers kept at 20 lux (2 fc) compared to 5 lux (.5 fc) were found to be more active, and had slightly slower growth (Rault, et al. 2017).

Duration depends upon the age of the chicken and type of housing you use. Broiler chicks can be exposed to 20-23 hrs of continuous light at one and two days of age and then reduced to 18 - 20 hrs of light until processed. Recent research has shown that darkness is just as important to the health and growth of birds as is light. During the dark phase, melatonin, a hormone released by the pineal gland, is released. Melatonin has been associated with immune function and disease resistance. Birds provided with sufficient dark periods have fewer health related problems, including sudden death, spiking mortality and leg problems..

WHERE SHOULD THE LAMPS BE PLACED IN MY BUILDING?

The distribution of light within your poultry facility will depend upon placement of the lamps. The lamps should be placed so that the maximum illumination value is spread over the largest area. This all depends upon the physical dimensions and equipment in your building.

In both breeder/layer and broiler facilities, it is best to place the lamps such that the darkest areas have at least .5 -.75 fc of light. The number of feet between lamps will depend upon the size of the lamp and the physical surroundings of the building, such as walls, posts, ceiling reflectivity, etc. Just remember, your goal is to achieve ***even*** lighting throughout your building, at the desired brightness level for your birds.

One last point, all the lamps described above, except the incandescent, will lose up to 20% of their original light output during their rated life, and must be considered in lamp placement (Darre and Rock, 1995). For example, if you desire no less than .5 fc at the darkest point and you use a CF lamp, at the end of the lamp life, or when dirty you may only have .4 fc or less. (If a lamp is rated at 100 lumens, it will have only 80 lumens toward the end of the lamp life.) Incandescent lamps will loose some but less of their original illumination value.

Dirty lamps will also decrease light output, by as much as 15 to 20%, therefore it is important to clean the lamps off at least once per week.

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