The Influence of Light on Reproductive Performance in Female Broiler Breeders

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INTRODUCTION

The lighting of poultry is a potential area of confusion with producers, breeder companies, and industry people. Much of what we chose to do in our barns may be based on what has worked for us in the past, or on anecdotal evidence from others. Some of us have probably heard things like, "The 'Brand-X' bird does not perform well under flourescent lighting", or "It's way to bright in this barn". While some of this simply isn't true, some may be based on fact. As broiler breeder lighting research is almost non-existant, we must look to other poultry types for information. Until now, most breeder research focused on feed allocation and hatchability issues. The current interest in light management is a reaction to interest in the basic principles of light management being evident within primary breeding companies, integrated broiler companies and, in Canada, associations of hatching egg producers. Issues that have arisen include:

- What is the best light source?
- Is there a critical light intensity threshold?
- What is the best age to photostimulate?
- Does the rate of increases in day length make a difference?
- Does increasing day length after peak egg production improve egg production?
- How "black" should "black-out" be?
- Are there strain differences in the photo-sexual response?
- Is photo-refractoriness an issue with broiler breeders?
- Does photoperiod management need a higher priority in management programs?

One of the shortcomings of the literature on light management of poultry, is that almost without exception, this work has been reported based on research trials with egg-type chickens or with turkeys and much of this is 30 years old. In some instances valuable data concepts have been gleaned from egg-type hen research, particularly basic studies of the principles of the ovulatory cycle, and ovarian steroidogenesis. However, the body weight and reproductive performance of egg-type and meat-type hens differ markedly. It is assumed that the manner in which nutrients are partitioned in the body, and perception of environmental cues also differ to various degrees.

The following factors should be considered when developing a broiler breeder lighting program. The ideal lighting program should:

1. Encourage chicks to approach feed and water with vigor for the first few days of life.
2. Control activity and the incidence of aggressive acts during rearing.

3. Promote adequate activity levels for ensuring skeletal health and integrity.
4. Retard development of the reproductive system until an appropriate age.
5. Stimulate (cue) reproductive development in all birds in a flock at the appropriate time.
6. Create conditions for the high peak production with good persistency.
7. Stimulate proper timing of male compared to female sexual maturation.
8. Provide conditions that discourage birds from floor-laying.
9. Limit activity and aggressive acts while encouraging normal completed matings.
10. Limit incidence of broodiness.
11. Be cost effective.

THE OPTICAL SPECTRUM AND LIGHT TYPE

The use of light-tight breeder houses in the Canadian broiler breeder industry increases the importance of understanding the effects of light types on production and behavior. For example, any negative effects of a particular type of light would probably not be noticed in the curtain-walled houses of the southern United States because of exposure to full-spectrum daylight.

The “optical spectrum” of light energy includes three major categories, ultraviolet, visible and infrared. Visible range varies from 3700 to 7500 A, and is perceivable by the eye. This is the range utilized by photostimulation programs for poultry. These light sources are longer in wavelength than ultraviolet light, but shorter than infrared light. Some types of light, such as sodium vapour or mecury vapour, emit light in a fairly narrow range of wavelength. If maintenance of egg production requires exposure to a particular wavelength, the concern is that some light types are not supplying this wavelength, despite appearing just as bright as other light sources.

Fluorescent lighting is considered a good alternative to incandescent lighting because of its energy efficiency. Whereas light from fluorescent tubes is emitted almost exclusively in a visible form (due to a narrow wavelength range), incandescent lights emit almost all of their energy as invisible infrared radiation (longer wavelength detected as heat). Although some researchers have said that the use of a full-spectrum fluorescent is better than the cool-white version because of its inclusion of a greater portion of the optical spectrum, few effects on egg production efficiency have been reported for layers or broiler breeder females.

When incandescent lights are compared to fluorescent at intensities above 5 lx, birds under fluorescent lights have been reported to be more active. Despite light intensities being identical, the birds may perceive a higher intensity under fluorescent lights due to their spectral eye. It is thought that the poultry eye is more sensitive to particular light wavelengths than humans. They may perceive some of the UV light emitted by the fluorescents. We need to be clear on how differences in light type and intensity are perceived by the bird.

A potential concern with the use of fluorescent sources of lighting is the potential effect of "flicker." Fluorescent lights are typically modulated at a frequency of 120 Hz (100 Hz in Europe). Although this is actually discontinuous lighting, we see it as continuous because the highest flicker rate we can detect is 50 to 60 Hz. Chickens, however, can detect flicker up to 105 Hz under high intensity lighting. This becomes more important in worn out lights, as they do not modulate evenly and even humans can detect flicker. Whereas some feel that a fear response to the discontinuous fluorescent light may be occurring, other research has shown that the birds have similar behaviour under incandescent and fluorescent lights, and that they may prefer fluorescent lighting. One theory is that UV light may bring out patterns in the feathers, simplifying the formation of pecking order and thereby calming the birds. Research in this area demonstrates that egg production and growth performance are not consistently affected by light type.

PHOTO-REFRACTORINESS

A photo-refractory bird is one which is no longer able to stimulate adequate reproductive hormone production (FSH and LH) on long days. This leads to a gradual decline in egg production as the photo-refractoriness worsens. Early onset of photo-refractoriness, although more common in turkeys, is also known to occur in broiler breeder hens. There is some evidence to suggest that it may be more of a problem with higher-yielding breeders than with more maternal type lines. Photo-refractory birds will stop laying, and will not recommence lay until a process of reproductive involution, body weight loss, and exposure to short days for 10 to 12 weeks has occurred. These processes appear to reset the reproductive hormonal signalling system to normal levels. Work with turkeys has shown that the sensitivity to lighting changes varies within a population. Some birds are highly responsive to a negative light stimuli, while others have a more moderate, temporary response, or even no reaction at all. In breeders we see a similar range of responses to excess feed intake, demonstrating that each population is comprised of groups of birds differing in their biological responsiveness.

The same signals that stimulate the onset of lay are thought to trigger processes leading to photo-refractoriness. A major difference is that the daylength needed for photostimulation is shorter than that of photo-refractoriness. In the case of strains known to be more susceptible to photo-refractoriness, the use of marginally photostimulatory photoschedules (11 or 12 hours of daylight) may be beneficial, as they may limit the onset of photo-refractoriness. Work with egg strains at the University of Alberta has shown that high light intensity may accelerate the photo-refractory process. One form that we think that photorefractoriness may take place is that of early follicular atresia. This bird does not have enough reproductive hormone (gonadotrophic) support to sustain maintenance of the follicular hierarchy. Novel lighting programs, such as increasing daylength throughout the production cycle, have been found to disrupt photo-refractoriness in turkeys. Similar studies have been attempted in broiler breeders.

LIGHT INTENSITY

One of the basic rules of light intensity has been that the layer house should never be darker than the pullet house. Pullet houses have also traditionally been quite dim for ease of management. Beyond this, however, there are not a lot of hard and fast rules.

Early light intensity studies were performed almost without exception in floor pens and were limited to production effects. It was shown in layers that there was a proportional effect of intensity on rate of lay at levels below 5 lx (0.5 fc). This could be due to a delayed sexual maturity, or to less frequent eggs. Maximal rates of lay occurred at intensities of 5 lx and above. More recent studies have shown no differences in egg production with intensities down to 1.75 lx.

The key role of light intensity relates to the bird's perception of night and day. Poultry appear to need a minimum of a 10-fold difference in light intensity between night and day to properly distinguish them. As 0.4 lx is not thought to be distinguished from darkness, it seems reasonable to assume a minimum of 5 lx is needed to distinguish day from night as well as generating the maximum photoperiodic response.

As layer strains appear insensitive to many lighting effects, observed light intensity effects may be even more prominent in breeder stocks. Modern layer stocks are thought to be more tolerant of differences in light intensity, perhaps because of their higher propensity to produce eggs at all cost. This is not the case in broiler breeders, however, who are more sensitive to factors negatively affecting egg production. Early light intensity work in broiler breeders demonstrated no production differences using mean pen intensities of 60 to 250 lx.

'Mean light intensity' is an important phrase to draw attention to because it demonstrates the weakness of much of the early light intensity work in all bird types was variation due to light positioning. Layer studies with caging show deck effects of up to 50%. Using a single incandescent bulb to light an entire pen does not have a lot of precision. In floor pens, there can be a 100-fold difference in light intensity within a few meters of distance.

Recent work from the University of Alberta has utilized cage units with individual light sources for each cage to precisely control variability in light intensity. These trials gave attention to the carcass and ovarian morphology of the birds at sexual maturity, which can be valuable in explaining egg production differences and/or potential. Broiler breeder pullets photostimulated with 10 or 100 lx intensity in this system reached sexual maturity at a similar rate and with similar carcass traits. There was a trend towards a stronger photostimulation effect under 100 lx, as these birds came into production 2.5 d faster and with an extra 0.5 large follicles on the ovary. Even though these birds were expected to be more sensitive to differences in light intensity, the difference tested was not sufficient to evoke a response. Both 10 and 100 lx were adequate for normal sexual development.

A University of Alberta trial with antique and modern layers photostimulated with 1, 5, 50, or 500 lx demonstrated all light intensities to be sufficient to initiate sexual maturation, but that 1 lx was insufficient for normal ovary development in modern birds. At sexual maturity (first egg), the modern 1 lx birds had fewer ovarian follicles (Figure 1) than birds at higher light intensities, and their large follicles were smaller on average (which can impact egg size). Broiler breeder research at the University of Alberta has shown that a low number of large follicles, as seen in the 1-lx birds, would be expected to limit potential egg production. Follicle numbers in the antique strain were not affected by these light intensities, which means this is either a new phenomenon, or a strain-specific effect.

TABLE 2: Ovary and egg production traits of four layer strains exposed to one of four light intensities between photostimulation and 45 wk of age (Renema et al., 2001).

	Ovary Weight (g)	Large Yellow Follicles	Hen-day Production	Egg Sequence Length[1]	Total Eggs to 45 wk of age
Light Intensity					
1 lx	30.9 b	6.79 b	82.5% b	28.4 b	142 b
5 lx	32.5 ab	7.44 ab	85.9% a	43.6 ab	148 a
50 lx	36.1 a	8.34 a	86.9% a	53.5 a	150 a
500 lx	31.5 b	7.59 ab	85.2% ab	49.1 a	146 a

[1]Mean of all sequences.

In a subsequent trial, four layer strains were tested in a University of Alberta egg production trial using the 1, 5, 50, and 500 lx light intensities from photostimulation. Light intensity affected ovary development, as birds with the 1 lx light intensity had a lower ovary weight and large ovarian follicle number than the 50 lx birds at sexual maturity. A lower large follicle number in 1 lx birds at this time led to reduced hen-day production, sequence length, and total egg numbers by 45 wk of age (Table 2). The effects of light intensity were partly strain dependent, but light intensity less than 5 lx limited both ovary development and egg production.

Interestingly, a 500 lx light intensity limited egg production after peak production in brown egg strains. This light intensity caused birds to peak very quickly and very well, but production trailed off more quickly than with other light intensities. As the brown-egg strains tested would be most comparable to broiler breeders, this type of "burn-out" under higher light intensities may also be expected in broiler breeder stocks -- especially strains that come into lay very strongly and peak well. High light intensity appears to be accelerating the photo-refractory process in some strains. A photo-refractory bird is one which is no longer able to stimulate adequate reproductive hormone production under long days, thereby gradually shutting down egg production.

LIGHT INTENSITY IN BROILER BREEDERS

The objective of this trial was to examine the effects of a range of light intensity and two photoperiods on carcass and ovarian morphology and the timing of sexual maturity in Cobb 500 birds. Particular interest stems from the potential for under- or over-stimulation of ovary development by low and high light intensity, respectively, and in the modulating effect of daylength on the sexual maturation process. Providing inadequate light exposure may not stimulate sexual maturation as expected in all pullets in the flock. On the other hand, providing too much light may result in an earlier onset of photo refractoriness later in lay.

As with previous work with light intensity in egg laying stocks, we found an altered ovarian morphology in birds photostimulated with a very low light intensity (1 lx). The way these birds managed the large follicle hierarchy differed, with the higher light intensity birds tending to create more pairs of follicles. This increases the likelihood of multiple ovulations in these birds, and the production of unsettable eggs. The greatest effect of the light intensities used was on the rate of sexual maturation. A low, 1 lx light intensity delayed sexual maturation by about 5 days compared to the standard, midrange light intensity birds. A 1 lx light intensity was found to delay the onset of lay regardless of daylength, whereas 5 lx was sufficient for a normal sexual maturation interval only when the daylength was 16 hours. Although this was only a numerical difference at sexual maturity, it had long-term effects on the productivity and carcass parameters of the 5 lx groups. Importantly, the 500 lx treatment accelerated sexual maturation by about 3 days compared to standard light intensities. Previous work has indicated that light intensities above 5 lx are not any more or less stimulatory for the rate of sexual maturation. It had not been previously demonstrated in poultry that the rate of sexual maturation can be increased with high light intensity (500 lx). The reproductive control of broiler breeders may be distinctly different from that of egg laying stock in that their ovarian morphology and rate of sexual maturation is modulated both by very low and by high light intensities.

The egg production portion of this study demonstrated effects of both daylength and light intensity on laying traits, hormone status, and on carcass and reproductive characteristics. Not only did the 1 lx birds lose potential egg production at the onset of lay due to delays in sexual maturation, but they also underwent severe declines in egg production by 50 wk of age, when they were laying at an approximately 40% compared to 60% rate of lay in all higher light intensity treatments. This was far worse in the 16HR-1lx group, where egg production dropped beginning at 43 wk of age to a low of 20% production. Measures of reproductive tract parameters indicated significant reductions in the size and follicular capacity of 16HR-1lx birds compared to their 12HR-1lx counterparts.

The combined effects of both daylength and light intensity on the duration of the sexual maturation process indicate that there are likely multiple control mechanisms being affected by the treatments. High light intensities did not reveal significant negative effects on the productivity of the broiler breeders, although the experiment ended before these effects may have been more pronounced.

IMPLICATIONS FOR HATCHING EGG PRODUCERS

The primary implication of these results applies to light management in broiler breeder operations, particularly when high intensity lights, such as sodium vapor lights, are used. There may also be implications for producers using long daylengths (16 or more hours) as part of their breeder management program. As broiler breeder ovarian morphology has now been demonstrated to be sensitive to both low and high light intensities, the management of the light environment may become more critical. Dunn and Sharp (1990) indicate that the threshold daylight period for a photostimulatory response is approximately 10.5 hours. In the broiler stocks they tested, there was no advantage in the photostimulatory response (measured by LH release into the bloodstream) in using daylengths over 13 hours. This was not a production trial, however, and it is not clear if using marginally responsive daylengths, such as 11 hours, would also affect egg production.

High light intensities did not reveal significant negative effects on the productivity of the broiler breeders, although the experiment ended before these effects may have been more pronounced. However, as broiler breeder females showed sensitivity to long days under sub-optimal lighting conditions (1 lx) it does demonstrate that these birds may be more sensitive to lighting differences than table egg stocks are. It still may be that the use of bright high pressure sodium vapor lights and mercury vapor lights used in some breeder houses result in a "burn-out" situation which brings on photo-refractoriness, but, based on the scope of this study, light intensity may actually be less important that daylength in bringing about these effects. An advantage to producers with light-tight houses is that they can set the maximum daylength and minimum or maximum light intensity.

CONCLUSIONS

The newer broiler breeder genetic strains are becoming more specialized and appear to have more specific management methods associated with them. While some types of lighting may be of concern due to their narrow optical spectrum, most light types perform well in the breeder barn environment. Both low and high light intensity can be detrimental to egg production. Very low light intensity can limit ovary development, follicle production, and egg production, while high light intensity may cause birds to go photorefractory early, limiting late egg production. Management of these and newer genetic stocks should include an understanding or recognition of the potential effects of light intensity and daylength. Sensitivity of broiler breeder hens to lighting management issues will likely continue to grow as the birds become more specialized in their management due to their heavy genetic selection for growth traits.

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