16 How Does Photostimulation Age Alter the Interaction Between Body Size and a Bonus Feeding Program During Sexual Maturation?

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Background

At the time of photostimulation, we would like to see all of the pullets having sufficient size and carcass stores to respond to a photostimulatory cue as a uniform group, reach sexual maturity within 21 to 35 days, and not decrease egg production later in life due to 'burn-out' from being brought into production too early. However, poor uniformity in body size at photostimulation creates a variability in response to the photostimulatory cue. Poor uniformity results in many birds coming into production too light or too heavy and over a wide time period.

Extra feed can highly stimulate large yellow follicle development. Broiler breeders are thought to be most responsive (or 'estrogenic') in the weeks immediately following photostimulation (2 to 4 weeks after photostimulation). Excess feeding during this period may be the most detrimental for ideal ovary development. As the condition of the ovary at sexual maturity has direct implications for potential egg production, it is critical to manage the pullets with the precision required to generate an ideal ovary.

The ovary of a small bird will develop differently than that of a large bird. When broiler breeder pullets are photostimulated, both body weight and feeding level will modulate the response of the hypothalamus, pituitary, and ovary to the photostimulatory cue. As a result, the individual birds can be exposed to very different reproductive hormone environments. Overfeeding broiler breeder females during sexual maturation increases Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH), and can accelerate sexual maturation (Renema *et al.,* 1999). It can also increase ovarian large yellow follicle numbers (Hocking, 1993) and reduce settable egg production.

The smallest birds in the pullet flock ultimately lay fewer eggs because they are still actively growing at photostimulation, which delays their onset of lay. Delaying photostimulation may have no negative effect on egg numbers because the hens will often have a higher rate of lay (Robinson *et al.,* 1996). A better understanding of the balance between body size, feeding level, and photostimulation age would be beneficial for the improved mangement of breeders.

Renema, R,A, F E Robinson, M Newcombe, and R I McKay. 1999. Poultry Science 78:619-628.

Hocking, P M. 1993. British Poultry Science 34:793-801.

Robinson , F E, T A Wautier, R T Hardin, N A Robinson, J L Wilson, M Newcombe, and R I McKay. 1996. Canadian Journal of Animal Science 76:275-282.

Our Objectives

- To define and separate the effects of feeding level and photostimulation age on ovary development of broiler breeder hens. This can provide information on the sensitivity of ovary development and egg production potential to management decisions during this critical management phase.
- To identify which pullet body size is most sensitive to increased feed allocations and if this relationship changes with photostimulation age.

Our Approach

We began by selecting three groups of birds from a pullet flock that were near the breeder-recommended standard body weight (STD), and those approximately either 18% lighter (LOW), or heavier (HIGH) at 18 weeks of age. These body weight groups were based on natural flock variation. The birds were individually caged, and these three body size groups were maintained on parallel growth curves in order to maintain the previous growth rates (Figure 1). The pullets were photostimulated at either 19 or 22 weeks of age, and given a Control (standard feed allocation) or Bonus diet (Control allocation + 30 g) from the time of photostimulation. (Figure 2). The bonus feeding treatment represented a 30 g increase in feed allocation between photostimulation at 19 or 22 weeks and sexual maturity. The base feed allocation was intended to cover all basic growth and metabolic requirements at a given age. The 30 g of extra feed provided by the Bonus regimen therefore represented a similar amount of excess nutrient allocation throughout the study.

Carcass Morphology Measurements

We processed each bird once it reached sexual maturity. Body weight, breast muscle, abdominal fat pad (the major fat depot), liver, ovary and oviduct weights were recorded. The individual weights of large yellow ovarian follicles (> 10 mm in diameter) were recorded to help investigate treatment effects on the follicular hierarchy. The large yellow follicles were sorted by size, and follicles within one gram of each other were considered in a multiple follicle set. The percentage of large yellow follicles in a multiple follicle arrangement was measured.

How do you feed groups differing in weight?

There is a wide range in body weight within a flock due to differences in genetic potential, feed access, and drive to eat. Birds that are small or large to begin with will remain that way because of the differences in their feed intake and growth efficiency. With individually caged birds in an experimental setting, we adjust for this by maintaining the body size treatment groups on parallel growth curves. This maintains the target growth rate while respecting pre-existing size differences. If we fed them all the same amount, the LOW birds would be overfed, while the HIGH birds would be underfed, and the information we gather would not be applicable to what actually happens in a barn setting.

Figure 1
Body weights of broiler breeder pullets at the 19 and 22 week photostimulation ages

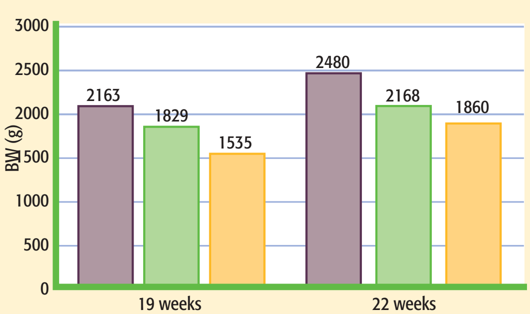
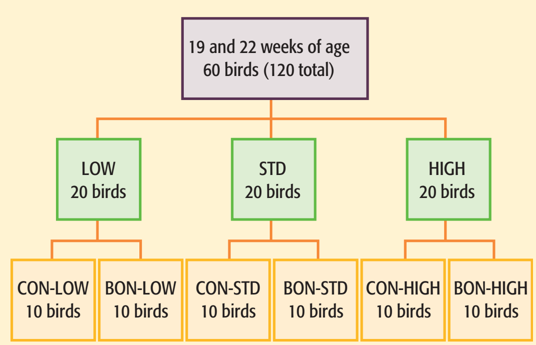


Figure 2
Experimental design



Why measure multiple follicle sets?

The ideal large yellow follicle hierarchy is a single set of follicles that can be sorted by size. On any given day, only one follicle can reach a mature state, and be ovulated. When two or more follicles are the same size, the likelihood of a multiple ovulation day is high. As it takes 24 hours or more to make an egg, this leads to the production of eggs with poor quality, or no shells, and double-yolked eggs – none of which are settable eggs.

Reproductive Hormone Analysis

We took blood samples at photostimulation (Day 0), one day later (to measure the immediate hormonal response to photostimulation), and then at 7 day intervals until each bird began lay. Plasma estradiol-17β, follicle stimulating hormone (FSH), and luteinizing hormone (LH) profiles were used to examine the relationship between photostimulation age, body size, feeding level, and reproduction. Both LH and FSH are released by the pituitary and stimulate ovary development. Estrogen is produced by the developing follicles on the ovary, and stimulates the formation of secondary sexual characteristics and processes supporting egg production. The liver dramatically increases its fat production to support yolk formation. We measured the change in the blood plasma fat level between photostimulation and the onset of lay by extracting and weighing the plasma fat.

Our Results

Growth and Carcass Traits

It took our birds 11 more days to reach sexual maturity, on average, when they were photostimulated at 19 instead of 22 weeks of age. The natural range in body weight found in the pullet flock also affected the timing of maturation, with LOW birds entering lay 11 days behind the STD and HIGH birds, on average. By photostimulating the birds later, the range in the duration of the sexual maturation process among the body size groups was reduced from 16.4 days to 9.5 days, on average (Figure 3). Clearly, delaying the photostimulation age improved the uniformity of response to the photostimulatory cue.

The use of a Bonus feeding regimen from photostimulation accelerated the sexual maturation process by 5.6 days compared to that of the target-fed Control regimen birds. However, it also increased hen body weight by 230 g (8.4%) compared to Control-fed birds. The Bonus regimen was adding only 30 g extra feed each day, but the birds grew by 30 grams per day compared to only 19 grams per day in the Control birds. Like the effects of body size, the impact of the Bonus feeding regimen diminished with the later photostimulation age (Figure 4).

The increased body weight of the Bonus compared to Control birds at sexual maturity was partly due to increased fleshing, although there was no difference in muscle mass when it was compared as a percentage of body weight. This was not the case for fat deposition, however, as the liver fat and abdominal fat pad of Bonus birds made up a higher

Figure 3
Interval between photostimulation and sexual maturity in pullets varying in body size at photostimulation

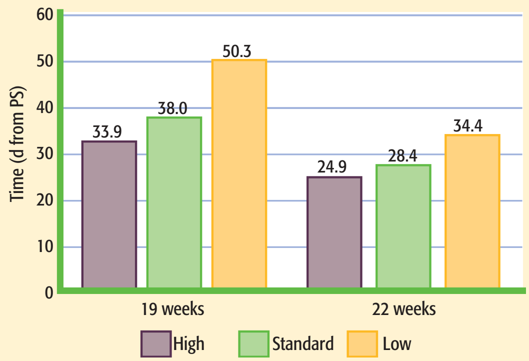
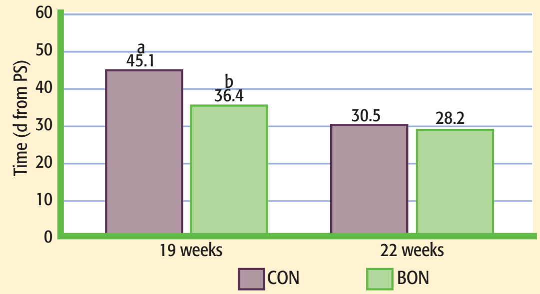


Figure 4
Interval between photostimulation and sexual maturity in pullets fed a control (CON) or bonus (BON) diet from photostimulation



proportion of the body weight than in the Control birds. The Bonus feeding regimen made the birds fatter.

The HIGH birds were particularly affected by these increases in the size of the fat depots. We can see this in the change in the blood plasma fat concentration between photostimulation and sexual maturity. This trait is a good indicator of how much extra fat may be present for the purposes of storage. In the HIGH birds, the change in plasma fat in Bonus birds was double that of Control birds, while there was no difference in LOW birds (Figure 5). The smaller birds were predisposed to divert the extra nutrients into growth in frame size and muscle mass, while the larger birds had already achieved a more mature conformation, and diverted more of the extra nutrients into storage as fat. Delaying the photostimulation age allowed the smaller birds to reach a more mature state, eliminating the significant differences in the measures of fatness between HIGH and LOW birds.

Ovary Development and Reproductive Hormones

Both the initial body size of the pullet and the feeding level from photostimulation affected ovarian large yellow follicle development. The HIGH, STD, and LOW birds generated 8.4, 7.8, and 7.1 large yellow follicles at sexual maturity, respectively. The use of the Bonus feeding regimen triggered the development of an additional large yellow follicle at this time. The birds with the higher follicle numbers had a greater percentage of them paired with another follicle in size. This results in the bird maintaining more than one complete hierarchy of large yellow follicles on the ovary, and contributes to multiple ovulation, resulting in

Statistical Analysis

The experimental design was a 2 × 2 × 3 factorial design, with photostimulation age, feeding regimen, and body size as the main effects. The statistical analyses were conducted using the General Linear Models Procedures of SAS® for Personal Computers (SAS Institute, Inc. 1996). The results were presented primarily as the main effects. When a main effect or an interaction of main effects was determined to be of significant importance, the treatment means were separated using the PDIFF test of SAS. A probability of $P < 0.05$ was used as the standard measure of statistical significance.

SAS Institute, 1996. The SAS® System for Windows. Release 6.12. Cary, N.C.

Figure 5

Change in plasma fat concentration between photostimulation (19 or 22 weeks of age) and sexual maturity.

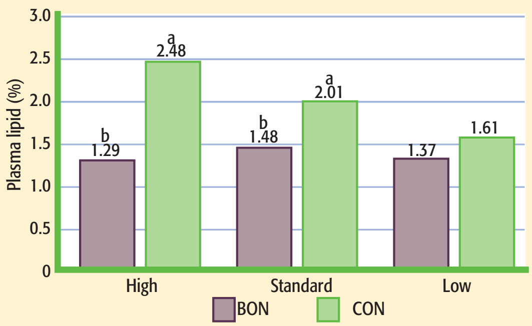
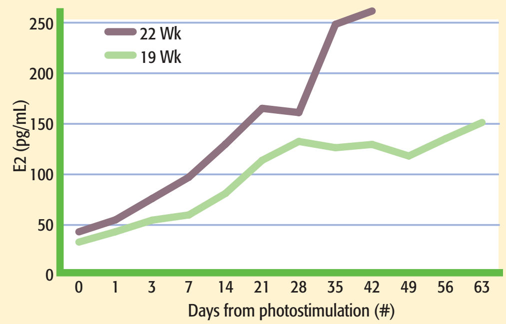


Figure 6

Plasma estradiol-17β concentration between photostimulation and sexual maturity.



Why does the number of follicles matter?

The formation of as little as one additional large yellow follicle results in egg production being reduced by 10 eggs (Robinson et al., 1998a, 1998b). These differences can be genetic strain-sensitive, however, as we have seen no impact from a more aggressive feeding treatment on the chick production of one strain, yet it was reduced by 18 chicks in a high breast yield strain (Chapter 29).

the production of unsettable eggs. The effect of body size on this trait was most striking in birds photostimulated at 19 weeks of age, where 57% of the large yellow follicles from HIGH birds were in a paired arrangement compared to 28% in LOW birds.

The reproductive hormones, LH, FSH, and estradiol-17β are the primary hormones acting to bring the bird out of a juvenile state. In unphotostimulated birds, the initial plasma estradiol-17β and LH concentrations both significantly increased between 19 and 22 weeks of age, telling us that some early reproductive development was spontaneously occurring during this period. This meant that when we used the later photostimulation age, the ovarian production of estradiol-17β increased at a faster rate (Figure 6). More of the birds are able to respond to the photostimulatory cue.

The Bonus feeding regimen generated higher plasma LH and FSH profiles than in the Control-fed birds within 7 days of photostimulation. An increased release of these hormones is known to accelerate the sexual maturation process. The resulting stimulation of estradiol-17β production by the ovary was also affected by feeding program. Plasma estradiol-17β concentrations doubled in the first 7 days after photostimulation, and were significantly higher in Bonus compared to Control birds by 21 days after photostimulation. Body size was also a factor with HIGH birds having greater estradiol-17β concentrations than STD or LOW birds in the first few days after photostimulation. These results show how the sexual maturation process in Bonus-fed birds and the larger body sizes went more quickly.

The slower sexual maturation of the LOW birds when using the 19 weeks photostimulation age could be explained by examining their reproductive hormone profiles. The rise in all of the reproductive hormones measured was delayed by 7 to 14 days in the LOW birds compared to that of the larger groups, corresponding with their 11 day delay in reaching the onset of lay.

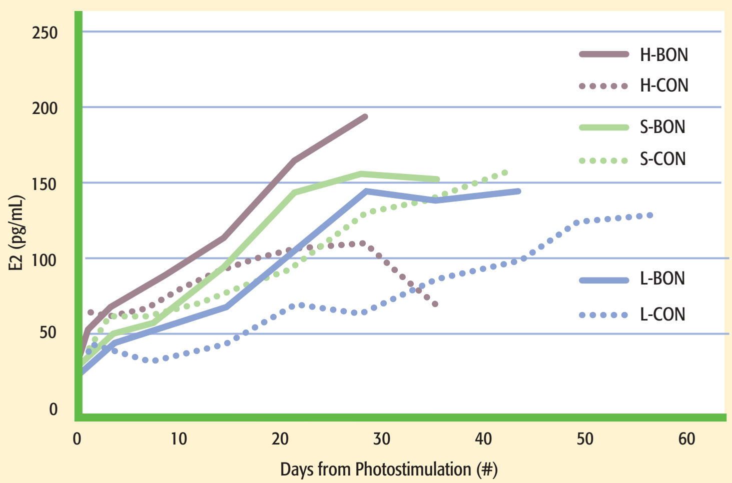
However, the use of the Bonus feeding regimen completely changed the reproductive hormone profiles, making them indistinguishable from those of the larger body size groups (Figure 7). Giving the birds extra feed made them behave like a larger bird – complete with an earlier onset of lay. The metabolic and reproductive hormone environments were changed enough to convince the bird it had the resources to support a reproductive effort. Reproduction requires adequate resources or body conditioning to occur, and is one of the first things to suffer if the supply of resources changes in the hen's future. The drawback to allocating extra feed to the LOW birds is that they will get fatter, and possibly produce too many large yellow follicles on the ovary. However, as these birds tend to be more lean than the bigger birds, and produce fewer large yellow follicles, this may not be a serious drawback for the LOW birds. The use of the 22 weeks photostimulation age eliminated the lag time in the changes to the reproductive hormone profiles of the LOW birds compared to the larger body sizes.

Robinson, F E, R A Renema, L Bouvier, J J R Feddes, J L Wilson, M Newcombe, and R I McKay. 1998a. Canadian Journal of Animal Science 78:603-613.

Robinson, F E, R A Renema, L Bouvier, J J R Feddes, J L Wilson, M Newcombe, and R I McKay. 1998b. Canadian Journal of Animal Science 78:615-623.

Figure 7

Interaction of Body size with Feeding regimen for plasma estradiol-17β concentration between photostimulation and sexual maturity.



Sorting birds to improve body weight uniformity

Sorting the pullet flock to fix problems with body weight uniformity before they can affect egg production can be a viable management tool. A possible method is to sort the smaller birds into a separate area of the barn, but continue with the same feed. The reduced competition with the larger birds will improve their feed intake. Some supplemental feeding can also be beneficial, but care must be taken to not overfeed them too much at ages above 14 weeks. If the sorting is done early (during the 3 to 10 weeks of age period), a major breeder recommends grading the bottom 30% of the females into a separate pen and full-feeding them until the weight recovers.

For more detailed information on this project, see:

Renema, R A, F E Robinson, and J A Proudman. 2000. Photostimulation age, body weight and bonus feeding effects on sexual maturation in female broiler breeders. Poultry Science 79(Suppl. 1):63.

Taken as a package, the Bonus feeding of broiler breeders is not for every bird in the flock. Whereas the reproductive hormone profiles of LOW birds can be normalized to that of the larger birds, the HIGH birds cannot tolerate the extra feed. The HIGH birds have already grown at a faster rate and have more fat stores than LOW birds due to a combination of feeding behavior and genetic potential. They are already prepared to respond to a photostimulatory cue at a near maximal rate at 19 weeks of age. The Bonus feeding regimen caused these birds to get fatter and begin to lose some control of the ovarian hierarchy and follicle formation. A Bonus feeding program may be useful if the pullets are being sorted by weight, and an early photostimulation age is needed. Otherwise the best results will be achieved by using later photostimulation ages, when the pullets can respond more uniformly.

What Does It Mean?

- The sexual maturation process is significantly affected by both initial body size and by feeding level from photostimulation.
- The plasma reproductive hormone profiles were modified by feeding level – with the LOW body size birds being the most responsive. The larger, HIGH body sized birds diverted much of the extra nutrients into fat.
- A pullet flock will not respond in a uniform fashion to excess feed. When poor body weight uniformity is an issue, the potential productivity of the target weight and larger birds should not be put at risk while attempting to increase the weight of the smaller birds.
- Photostimulating pullets at 22 compared to 19 weeks of age improves the uniformity of response and reduces potentially detrimental effects of overfeeding and body weight variation on carcass and ovary morphology.