Let there be light: Photoperiod management of dairy cattle

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Introduction

Photoperiod is the duration of light that an animal is exposed to in a day. It is often manipulated artificially to produce either long days, which are 16 to 18 hr of light and 6 to 8 hr of darkness, or short days, which is characterized by 8 hr of light and 16 hr of darkness. Photoperiod affects animal physiology in a number of ways, for example, growth, lactation and reproduction are all affected by light exposure in cattle. This paper provides a brief review of how photoperiod can be managed across the life cycle of a cow to improve performance and health.

Exposure to variable light and dark cycles alters the secretion of hormones, and ultimately it is those endocrine fluctuations that cause production responses. The first impact of light exposure is on secretion of the hormone melatonin, which is suppressed by light. In contrast, darkness is associated with a rapid and robust increase in the secretion of melatonin. Thus, cattle and other animals use the duration of elevated melatonin as a signal for physiological daylength.

The pattern of melatonin release drives changes in the secretion of other hormones. Two of the hormones critical to the discussion of photoperiodic responses in cattle are insulin-like growth factor-I (IGF-I) and prolactin (PRL) (Dahl et al, 2000). Increases in IGF-I are associated with increases in milk yield when cows are treated with bovine somatotropin, and there is evidence that IGF-I affects mammary cell function. PRL has numerous physiological actions, but most notable are the affects on mammary growth and the immune system. Under long day photoperiod, blood concentrations of IGF-I and PRL increase relative to short days. These hormonal shifts are the basis for changes in lactation, growth and health in cattle when housed in different photoperiods.

Long day effects on Lactation

During lactation, exposure to long days increases milk yield in cattle an average of 5 lbs of milk/day (Peters et al., 1978; Stanisiewski et al., 1985), and the increase is associated with an increase in IGF-I (Dahl et al., 1997; 2000). The boost in milk yield occurs regardless of stage of lactation or parity. Milk production increases gradually over 2 to 4 weeks and it drives an increase in feed intake of 2 to 3 lbs. of dry matter each day. There is generally no change in milk composition, although occasional reports of slight decreases in milkfat have appeared (Dahl and Petitclerc, 2003). Long days can also be
combined with other production enhancers, such as bST for additive effect (Miller et al., 2000).

Given the benefit of increasing the duration of light exposure in lactating cows, an obvious question is how to manage that photoperiod properly. The target light intensity for the 16 to 18 hrs of light is 15 to 20 footcandles. That level of illumination can be achieved with a variety of lamps, from fluorescent to metal halide to high-pressure sodium vapor lamps. However, lamps should be selected based on the mounting height available, which is dependent on the barn type. The most efficient lamp that can be mounted in your facility, based on ceiling or truss height, should be selected. It is important to note that these same considerations for lighting system design apply to photoperiod management for dry cows and growing heifers.

**Lighting effects in dry cows**

Photoperiod management also has significant effects on cows during the dry period. In contrast to lactating cows, however, exposure to short days offers the treatment that produces the greatest benefit to production and health. Specifically, dry cows housed under short days produce an average of 7 lbs milk/day relative to cows under long days when dry (Miller et al., 1999; Auchtung et al., 2005). This response is independent of photoperiod exposure after calving, in fact most studies have not provided any additional lighting during lactation.

Cows on short days experience a decrease in circulating PRL, but the expression of the receptor for PRL increases (Auchtung et al., 2003; 2004a). Therefore, the PRL signal is amplified and at the mammary gland this translates to an increase in mammary growth (Wall et al., 2005). Of perhaps greater interest to producers are the effects on health during the transition period in dry cows under short days. The altered PRL signaling affects immune cell function in a positive manner, and dry cows on short days had reduced somatic cell counts at calving compared with cows on long days (Auchtung et al. 2004b). In that same study cows on short days had fewer new quarter infections in early lactation. Thus, short days appear to improve mammary health in addition to the effect on production.

**Photoperiod for growing animals**

In addition to the effects described above for mature cows, heifers on long days from weaning to puberty grow at a faster rate than those on short days (Rius et al., 2005). Most of the growth increase is in height, and the long day heifers tend to be leaner than the heifers on short days. The long day heifers remained taller when height was followed through to calving. Because height is more strongly correlated to future production than weight, this early growth response should be an advantage. Indeed, when heifers exposed to long days during the prepubertal period were tracked through calving and into their first lactation, they produced over 1600 lbs. more milk than heifers that were raised on short days prepubertally (Rius and Dahl, 2006).
Heifers on long days also achieve puberty sooner than those on short days; typically a month or so earlier (Hansen, 1985). Like the effect on growth, this response should be an advantage as there is evidence that increasing the number of cycles before breeding results in higher conception rates. Thus, there is no biological disadvantage to the use of long days to speed heifer development.

An economic analysis has not been completed to examine the returns long day exposure of growing heifers. However, using a few careful assumptions it is possible to predict if such a management approach is reasonable. Given the milk yield response of approximately 16 cwt. in the first lactation of heifers grown under long days, a conservative estimate of an extra $200 in income in that first lactation can be made. The period between weaning and puberty is approximately 200 days for dairy heifers, so the cost of lighting would have to be greater than $1/heifer/day for a loss to be avoided. Therefore, it is likely that treatment with long days would be cost effective in many heifer growing situations.

Summary

The preceding evidence supports the concept that long day exposure improves milk production during lactation. Further, raising heifers under long days improves growth and ultimately first lactation milk yield. In contrast dry cows housed under short days have higher production and health in the subsequent lactation. The hormonal basis for these responses are linked to IGF-I during lactation and growth, and PRL during the dry period. Photoperiod management of dairy cattle is a simple technique that can be used to improve production efficiency and profitability across growth, lactation and the dry period.

References


