Photoperiod Management of Dairy Cattle

Geoffrey E. Dahl[3]
Department of Animal Sciences, University of Illinois

Introduction

Environmental factors influence reproduction and other productive functions in many domestic species. For example, the negative impact of heat stress is familiar to many dairy producers. For many years, poultry producers have manipulated light to enhance layer and broiler productivity (20). Management of lighting in dairy housing has recently received interest as a method to improve production. As with any management approach, there are certain guidelines that require consideration for successful implementation. The purpose of this paper is to describe the response, outline its physiologic basis, present options for implementation, and evaluate the financial impact of successful photoperiod management in dairy production.

Photoperiod is the duration of light an animal is exposed to within a 24 hr period. Animals use photoperiod to track the length of the day; in this context "daylength" is the number of hours of light. A long day is considered continuous exposure to 16-18 hr of light along with a 6-8 hr period of darkness. Experimentally, a short day is 8 hr of light and 16 hr of darkness, though under normal field conditions anything less than 12 hr of light will yield a short day response. Photoperiod is of interest to dairy producers because at least 9 published research studies show that milk production is increased in cows exposed to long days (LDPP) relative to those on natural photoperiod (Summarized in Figure 1; 2, 7, 8, 10, 12, 13, 14, 17, 18). Photoperiod also affects growth and reproduction in younger cattle (19), and recent evidence suggests that lighting affects immune function (1).

Photoperiod Physiology

Exposure to light suppresses secretion of the hormone melatonin in cows as in other species. Thus, as the length of photoperiod increases, there is a reduced duration that melatonin is at high concentrations in the blood. The pattern of melatonin influences secretion of other hormones, particularly prolactin (PRL) and insulin-like growth factor-I (IGF-I). It is believed that the changes in IGF-I are important to the increase in milk yield observed in lactating cows on long days (6, 7). In contrast, the changes in PRL observed in response to photoperiod may be the mechanism for the effects of photoperiod on dry cows that will be discussed below.

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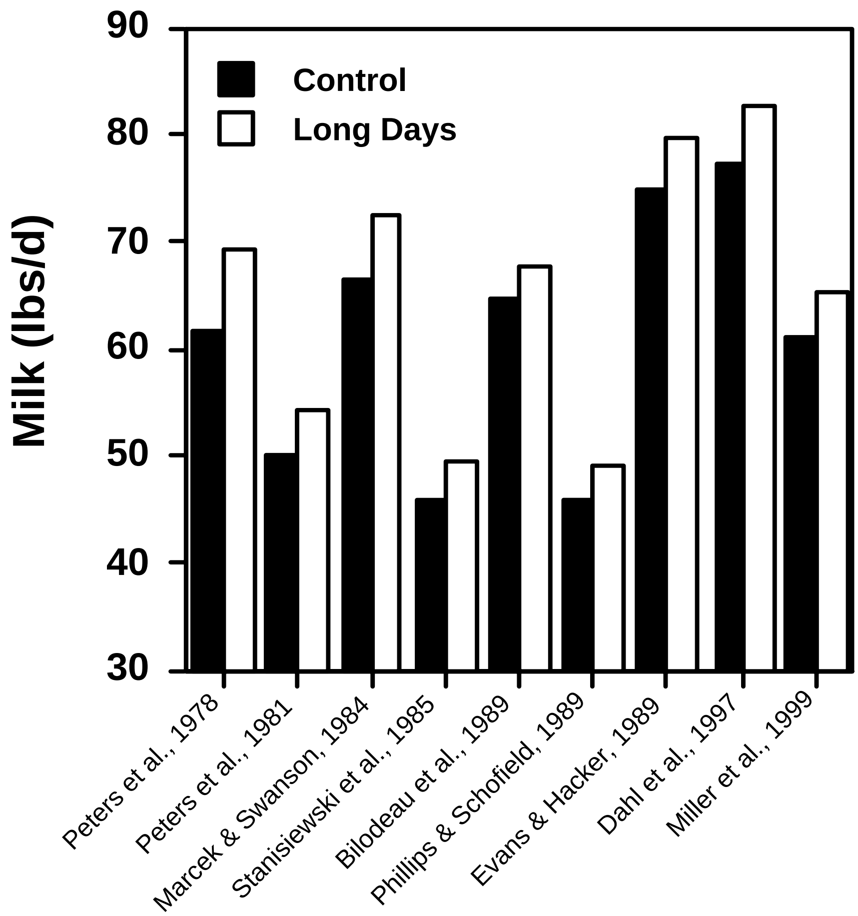

Figure 1. Summary of nine studies reporting the effect of long day photoperiod on milk yield in lactating cows.

How does an understanding of the physiologic basis of the response affect the implementation of photoperiod management? A common misconception about the basis for the response is that lights can be placed only over the feedbunk in a freestall. But, cows do not respond to photoperiod by eating more and then producing more milk. Rather, cows experience a physiologic stimulus to produce more milk and then dry matter intake increases to support the greater milk yield. Because cows spend the majority of their time lying in stalls rather than at the bunk eating (4, 5), putting lights only over the feed alley is severely limiting the exposure to extra lighting.

Cow Responses to Light

As with most management interventions, there is a range in response to LDPP. However, a typical response is 5 lbs/cow/day. Note that the response does not become apparent right away; it usually takes 4 weeks to observe a change relative to normal daily variation in milk production. A metric for producers to use to gauge the response in their cows is the "150 day" or "management level milk" value from DHI records. This allows for comparison of a herd's response to lighting if all other factors are held constant.

After review of all the published data on the lactational response to LDPP, it is clear that long days stimulate milk production across production levels. For example, cows in the experiment with the lowest average yield of 45 lbs/day had increased milk production to a similar extent as cows in the experiment that averaged 77 lbs/day (Figure 1). In addition, the response appears to be fixed, in the range of 4 to 6 lbs per day. With regard to milk components, there is no effect of photoperiod on milk lactose, protein, or solids. Slight variance in fat has been observed, with an increase in one experiment and a decrease in another. In general, there is no effect on fat or other components. Remember that milkfat yield will increase in response to longer photoperiod, even if there is a slight reduction in milkfat percentage. Similarly, yields of other components will increase as milk yield increases.

As with any stimulation of milk production, LDPP treatment will pull an increase in dry matter intake (DMI), but in response to higher milk production rather than the opposite. In other words, cows don't eat more and then produce more milk. Rather, they produce more milk and consume more feed to meet the increased demand for energy to make that milk. Given a typical 5 lb/d response to LDPP, a 2 lb/d increase in DMI should be planned for to support the higher milk yield.

Implementing Photoperiod Management

The initial step in adoption of photoperiod management is evaluation of the light presently available in the barn and other areas of housing (e.g. holding pens, outdoor feedbunks). Light is measured in footcandles (FC) or lux (lx), with 1 FC = 10.8 lx. To observe a production response in lactating cows, an intensity of 15 FC at 3 feet from the floor of the stall is recommended. Responses have been observed at intensities as low as 10 FC, but the extra 5 FC gives a buffer for dirty lamps, burned out bulbs, etc. It is critical that the dispersion of light over an area should be as uniform as possible. Appropriate dispersion can be achieved with correct mounting height and distance. Lamps are sold with a recommended range of mounting height, and a rule of thumb for placement of lamps is a mounting distance that is 1.5 times the mounting height (3). Mounting height is measured from the bottom of the lamp to a level 3 feet from the floor of the stall.

Light intensity can be measured using a light meter, which can be obtained from electrical suppliers or photographic shops; they are usually priced between $75 – 125. Light meters are simple to operate and are portable. Regardless of lighting design recommendations, all lighting systems should be tested with a light meter. Because photoperiod *management* requires light intensity to be monitored, a light meter will continue to be used after the initial installation.

What type of lighting is recommended? Responses to long days have been observed in cows exposed to fluorescent, metal halide, and high pressure sodium (HPS) lighting. The choice of lighting type should be made according to efficiency and the mounting height most appropriate to the barn. For example, in tie-stall and stanchion barns the relatively low ceilings allow use of fluorescent lights only (mounting height of 8-10 ft). In freestalls, lights can often be mounted at heights of 12 to 16 ft, thus, metal halide or high pressure sodium lamps are appropriate. One caution to the use of HPS is that many people do not respond well to the yellow light output from those lamps. Therefore, worker acceptability should be considered in lamp choices.

One question that is often asked is "How dark is "dark"?". There is limited data available on the lower limit of light that a cow can detect. However, it appears that cows can not detect light at less than 5 FC. It should be noted that cows may experience a shift in their ability to perceive light depending on the difference in intensity of the light relative to dark.

Many times, producers want to leave a "night light" on in the barn to ensure that cows find feed and water during darkness. This is not necessary, and may detract from the response. Cows are able to find both feed and water in the dark. It is important to remember that at least a 6 hr period of darkness is required, and "night lighting" may interfere with that. Low intensity red lighting (7.5W bulbs at 20-30 ft intervals; mounted 10 ft from the floor) has been used successfully for observation and movement of cows during dark periods.

One critical feature of the long day response in lactating cows is that it is not linear. That is, providing more light relative to natural daylength is good, but leaving lights on continuously is not better. As stated previously, animals use the pattern of melatonin to track daylength. In the absence of any darkness, there is no cue for relative daylength, and it appears that cows default to a short day response. Indeed, cows on continuous lighting do not produce more milk than cows on a natural photoperiod (10), likely because the hormonal shifts associated with higher milk production do not occur.

Photoperiod and other Management Practices

Although no controlled studies have been conducted to verify that cows milked 3X will respond to long days, a number of producers have combined these two approaches with success. Remember to keep a 6 hr uninterrupted period of darkness between two of the three milkings. This may require coordination of milking schedules and darkness in different sections or barns. Again, the management level milk value from DHIA records can be used to evaluate photoperiodic responses after implementation.

Long day lighting can also be combined with bST for an additive response. In an experiment reported from the University of Maryland, cows were treated with bST, long days or the combination and milk yield was compared to natural photoperiod control cows (12). Long days alone increased milk by about 5 lbs/d, bST increased milk by 10 lbs/d, and the cows receiving both produced an average of 15 lbs/d more than the control cows. In addition, cows on LDPP and bST increased dry matter intakes sooner than cows receiving bST under natural photoperiod.

In contrast to lactating cows, recent experiments from the US and Canada indicate that a short day photoperiod is most appropriate for dry cows. Cows on SDPP when dry produced 7 lbs/day more than cows on LDPP when dry (11, 15, 16). We suspect that the short days "reset" the cow's ability to respond to LDPP in the subsequent lactation. This means that dry cows should not remain under the same lighting as lactating cows. In most situations, pasture or other facilities removed from the barn housing lactating cows will be exposed to less than 12 hours of lighting each day, and that may be enough of a decrease in photoperiod to elicit the response.

Although cows are not considered seasonal breeders, there are some subtle effects of photoperiod on the reproductive axis (reviewed in 9). Exposure to LDPP hastens puberty in heifers. In lactating cows, no direct effect of photoperiod has been observed, but seasonal effects associated with differences in photoperiod occur. Notably, cows calving in the winter, when days are short, have a longer delay in return to estrous cyclicity relative to cows that calve in summer, when days are long.

Table 1. Milk price sensitivity to photoperiod management for a typical 80 cow tie-stall barn.

Milk Price[a]	$14.00	$13.00	$12.00	$11.00	$10.00	$9.00
Milk Response[b]	5	5	5	5	5	5
Milk Income[c]	$0.70	$0.65	$0.60	$0.55	$0.50	$0.45
Feed[d]	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11
Electricity[f]	$0.18	$0.18	$0.18	$0.18	$0.18	$0.18
Total Cost	$0.29	$0.29	$0.29	$0.29	$0.29	$0.29
Net Profit	$0.41	$0.36	$0.31	$0.26	$0.21	$0.16
Profit/Mo	$984.00	$864.00	$744.00	$624.00	$504.00	$384.00
Annual Profit[g]	$9,840.00	$8,640.00	$7,440.00	$6,240.00	$5,040.00	$3,840.00

[a]Mailbox price per cwt.
[b]Average response in lb per cow each day.
[c]Per cow each day.
[d]Assume 1.8 lb increase in dry matter to support 5 lb increase in milk.
[e]Electricity to power supplemental lighting 16 hr/day.
[f]Assumes response only 10 month each year.

Economic Returns from Photoperiod Management

Even in times of low milk prices, photoperiod management offers an attractive return on investment to dairy managers. Table 1 and 2 present examples of the milk price sensitivity with adoption of photoperiod management in two different types of housing options. Although LDPP is profitable on farms of every size, certain economies of scale factor in on larger farms and increase the profitability.

Table 2. Milk price sensitivity to photoperiod management for a typical 250 cow free-stall barn.

Milk Price[a]	$14.00	$13.00	$12.00	$11.00	$10.00	$9.00
Milk Response[b]	5	5	5	5	5	5
Milk Income[c]	$0.70	$0.65	$0.60	$0.55	$0.50	$0.45
Feed[d]	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11
Electricity[e]	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04
Total Cost	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15
Net Profit	$0.55	$0.50	$0.45	$0.40	$0.35	$0.30
Profit/Mo	$4,125.00	$3,750.00	$3,375.00	$3,000.00	$2,625.00	$2,250.00
Annual Profit[f]	$41,250.00	$37,500.00	$33,750.00	$30,000.00	$26,250.00	$22,500.00

[a]Mailbox price per cwt.
[b]Average response per cow each day.
[c]Per cow each day.
[d]Assume 1.8 lb increase in dry matter to support 5 lb increase in milk.
[e]Electricity to power supplemental lighting 8 hr/day.
[f]Assumes response only 10 month each year.

Summary

Photoperiod manipulation is another management technique that dairy producers can use to improve production efficiency and profitability. A website is available at *http://il-traill.outreach.uiuc.edu/photoperiod.* This site contains more information on photoperiod, worksheets to assist producers in lighting design and cost analysis, expected economic returns, and other contact information.

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