Effect of Photoperiod on Feed Intake and Animal Performance

Geoffrey E. Dahl[1]
Department of Animal Sciences
University of Illinois

Abstract

Exposure to extended periods of light is a commonly implemented management practice to improve overall yield and production efficiency in lactating dairy cattle, and recent studies support additional benefits of a reduced photoperiod during the dry period. Whereas the observation of greater milk yield indicates some effect of photoperiod manipulation at the mammary gland, support for the increase in milk must be provided also, suggesting involvement of other factors in the response. Feed intake increases with photoperiod manipulation, although the effect of light varies with the physiological state, i.e. lactating vs. dry. One consistency, however, is that increases in dry matter intake **(DMI)** are most consistently associated with lighting shifts that increase milk yield.

Introduction

Numerous studies across multiple locations support the concept that lactating cows exposed to 16 to 18 hours of light each day (i.e. long day photoperiod or **LDPP**) have greater milk yield relative to cows on a typical light schedule of natural photoperiod plus some additional light to accommodate milking on a 12:12 hour schedule (reviewed in Dahl et al., 2000). The increase in milk output appears to be a fixed response, with an average milk yield response of about 5.1 lb/day across production levels that range from less than 44 lb/day to over 88 lb/day (Dahl and Petitclerc, 2003). Exposure to LDPP can be effectively combined with other management approaches, such as bovine somatotrophin, to increase yield (Miller et al., 1999).

In contrast to the impact of LDPP on lactating cows, there is now substantial evidence that dry cows exposed to a reduced photoperiod (i.e. short days or **SDPP**) produce more milk in the subsequent lactation than contemporaries exposed to LDPP or even natural light conditions (Miller et al., 2000; Dahl and Petiticlerc, 2003; Auchtung et al., 2005), and those studies are buttressed by analysis of seasonal environmental influences of heat and light that indicate a negative effect of long days during the dry period on performance in the next lactation (Aharoni et al., 1999, 2000).

Photoperiod manipulation, therefore, is a useful tool to improve the lactational performance of cows, yet the physiological mechanisms that drive the response of dry versus lactating cows appears to differ. In addition, the impact of photoperiod on dry matter intake varies according to the physiological state of the cow. The remainder of this paper considers the difference between those mechanisms and their associated effects on intake.

Comparison of Physiological Responses to Photoperiod

One of the most consistent responses to photoperiod across species is a substantial increase

[1]Contact at: 230 Animal Sciences Laboratory, MC-630, 1207 W. Gregory Dr., Urbana, IL 61801, (217) 244-3152, FAX: (217) 333-7088, Email: gdahl@uiuc.edu

in circulating concentrations of prolactin **(PRL)**, and that response is well documented in cattle (Dahl et. al, 2000). In cattle, this increase in circulating PRL occurs regardless of gender, age, or stage of lactation, with the only exception being that at very low ambient temperatures, no increase in PRL occurs (Peters et al., 1981). Recently, we have noted an inverse relationship between PRL-receptor **(PRL-r)** mRNA expression and circulating PRL in cattle on different photoperiods, with SDPP animals expressing higher PRL-r relative to those on LDPP (Auchtung et al., 2003). This inverse relationship between PRL and PRL-r results from the shift in PRL secretion in response to photoperiod manipulation (Auchtung and Dahl, 2004). Higher PRL-r mRNA expression is associated with greater mammary growth during the dry period and improvements in immune function, both of which likely contribute to the higher milk yield in the subsequent lactation (Auchtung et al., 2004, 2005; Wall et al., 2005).

The effect of LDPP in lactating cows is not likely to result from the changes in PRL characteristically observed for at least two reasons. First, the previously mentioned failure of cows to respond with increases in PRL under cold ambient temperatures did not prevent the milk yield response to LDPP during lactation (Peters et al., 1981). Second, administration of exogenous PRL does not improve milk yield relative to placebo (Plaut et al., 1987). Although circulating growth hormone concentrations are unaffected by photoperiod manipulation in cattle, exposure to LDPP increases insulin-like growth factor-I in heifers, steers, and lactating cows (Spicer et al., 1994; Dahl et al., 1997; Kendall et al., 2003). Thus, an increase in IGF-I rather than PRL is more likely to be the endocrine mechanism of greater milk yield in lactating cows.

Photoperiodic Effects on Dry Matter Intake

Despite the differing mechanisms proposed for the responses, the milk yield increases observed following photoperiod manipulation during lactation, or the dry period, must be supported by additional energy partitioning to the mammary gland. Lactating cows exposed to LDPP have higher DMI compared with those without extended light exposure (Dahl et al., 2000; Dahl and Petitclerc, 2003). The increase in DMI does not appear to drive the higher yield of milk, however, as it lags the milk response (Dahl et al., 2000). As milk yield increases, the demand for energy to support that increment in milk stimulates intake, and producers should plan for an additional 2.2 lb/day of DMI in cows exposed to LDPP during lactation.

In contrast to lactating cows, dry cows on SDPP consume more feed than those on LDPP. The DMI increases an average of 2.2 lb/day in dry cows on SDPP, although this response is most apparent in the early to middle portion of the dry period. Because milk yield is not a factor, it follows that this response is directly associated with the reduced light exposure. We have not observed any carryover effect on intake in the next lactation, although the length of time that we typically track that response (i.e. 42 days) is likely insufficient to observe a response with the number of animals in our studies.

One possible explanation for altered intake of cows on different photoperiods is that of feeding time. That is, does light exposure influence the amount of time that cows spend feeding? Studies in heifers and some of our own work in dry cows suggest that shifts in total feeding time do not account for differences in intake (Zinn et al., 1986; Karvetski et al., 2006). However, there may be altered distribution of feeding bouts throughout the day on different photoperiods. For example, dry cows on LDPP spend more time feeding directly after feed is offered relative to those on SDPP that distributed feeding bouts more evenly throughout the day (Karvetski et al., 2006). That observation may be useful in barn design and feeding area management, because the peak utilization of the feedbunk would differ between groups.

Implementing Photoperiod Management

Light exposure is easily manipulated during lactation as it requires extending the amount of light beyond the typical natural exposure. Light intensity of 150 to 200 lux is necessary to produce the response, and placement of the lamps should ensure that all areas of the barn achieve that illumination level, not just the feedbunk. A consistent duration of 16 to 18 hrs of light is needed, and it is critical that a continuous 6 to 8 hour period of darkness occur to sustain the response. That is, continuous light exposure should be avoided in lactating cows.

For dry cows, limiting light exposure to 8 hours/day can be achieved using well-ventilated, enclosed barns. Cows can be outside and exposed to natural daylight for up to 8 hours, but should be in darkness for the remaining 16 hours/day. Low intensity red lighting, such as that from 7 to 15 W incandescent bulbs, can be used for observation during dark periods in both lactating and dry cows, as dim illumination in the red range is not perceived as light by cows. More information on lighting design and approaches is available at: http://www.traill.uiuc.edu/photoperiod/.

Conclusions

In summary, photoperiod manipulation during lactation and the dry period offers an effective, non-invasive approach to stimulate milk yield and performance. Light exposure alters DMI directly and indirectly depending on the stage of the lactation cycle. Photoperiod management is easily integrated into most types of confinement dairy production systems and can be combined with other stimulators of yield.

References

Aharoni, Y., A. Brosh, and E. Ezra. 1999. Effects of heat load and photoperiod on milk yield and composition in three dairy herds in Israel. Animal Sci. 69:37-47.

Aharoni, Y., A. Brosh, and E. Ezra. 2000. Short Communication: Prepartum photoperiod effect on milk yield and composition in dairy cows. J. Dairy Sci. 83:2779-2781.

Auchtung, T.L., and G.E. Dahl. 2004. Prolactin mediates photoperiodic immune enhancement: Effects of administration of exogenous prolactin on circulating concentrations, receptor expression, and immune function in steers. Biol. Reprod. 71:1913-1918.

Auchtung, T.L., P.E. Kendall, J. Salak-Johnson, T.B. McFadden, and G.E. Dahl. 2003. Photoperiod and bromocriptine treatment effects on expression of prolactin receptor mRNA in bovine liver, mammary gland and peripheral blood lymphocytes. J. Endocrinol. 179:347-356.

Auchtung, T.L., A.G. Rius, P.E. Kendall, T.B. McFadden, and G.E. Dahl. 2005. Effects of photoperiod during the dry period on prolactin, prolactin receptor and milk production of dairy cows. J. Dairy Sci. 88: 121-127.

Auchtung, T.L., J.L. Salak-Johnson, D.E. Morin, C.C. Mallard, and G.E. Dahl. 2004. Effects of photoperiod during the dry period on cellular immune function of dairy cows. J. Dairy Sci. 87:3683-3689.

Dahl, G.E., B.A. Buchanan, and H.A. Tucker. 2000. Photoperiodic effects on dairy cattle: A review. J. Dairy Sci. 83:885-893.

Dahl, G.E., T.H. Elsasser, A.V. Capuco, R.A. Erdman, and R.R. Peters. 1997. Effects of long daily photoperiod on milk yield and circulating insulin-like growth factor-1 (IGF-1). J. Dairy Sci. 80:2784-2789.

Dahl, G.E., and D. Petitclerc. 2003. Management of photoperiod in the dairy herd for improved production and health. J. Anim. Sci. 81(Suppl. 3):11-17.

Karvetski, K.E., J.M. Velasco, E.D.Reid, J.L. Salak-Johnson, and G.E. Dahl. 2006. Behavioral time budget of dry cows: photoperiod alters distribution of maintenance behaviors. J. Anim. Sci. 84(Suppl. 1):In Press.

Kendall, P.E., T.L. Auchtung, K.S. Swanson, R.P. Radcliff, M.C. Lucy, J.K. Drackley, and G.E. Dahl. 2003. Effect of photoperiod on hepatic growth hormone receptor 1A expression in steer calves. J. Anim. Sci. 81:1440-1446.

Miller, A.R.E., L.W. Douglass, R.A. Erdman, and G.E. Dahl. 2000. Effects of photoperiodic manipulation during the dry period of dairy cows. J. Dairy Sci. 83:962-967.

Miller, A.R.E., E.P. Stanisiewski, R.A. Erdman, L.W. Douglass, and G.E. Dahl. 1999. Effects of long daily photoperiod and bovine somatotropin (Trobest®) on milk yield in cattle. J. Dairy Sci. 82:1716-1722.

Peters, R.R., L.T. Chapin, R.S. Emery, and H.A. Tucker. 1981. Milk yield, feed intake, prolactin growth hormone, and glucocorticoid response of cows to supplemental light. J. Dairy Sci. 64:1671-1678.

Plaut, K., D.E. Bauman, N. Agergaard, and R.M. Akers. 1987. Effect of exogenous prolactin administration on lactational performance of dairy cows. Domest. Anim. Endocrinol. 4:279-290.

Spicer, L.J., B.A. Buchanan, L.T. Chapin, and H.A. Tucker. 1994. Effect of 4 months of exposure to various durations of light on serum insulin-like growth factor-1 (IGF-1) in prepubertal Holstein heifers. J. Anim. Sci. 72(Suppl. 1):178. (Abstr.)

Wall, E.H., T.L. Auchtung, G.E. Dahl, S.E. Ellis, and T.B. McFadden. 2005. Exposure to short day photoperiod enhances mammary growth during the dry period of dairy cows. J. Dairy Sci. 88:1994-2003.

Zinn, S.A., L.T. Chapin, and H.A. Tucker. 1986. Response of body weight and clearance and secretion rates of growth hormone to photoperiod in Holstein heifers. J. Anim. Sci. 62:1273-1278.