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Supplemental Lighting Stimulates Growth and Lactation in Cattle

Abstract. *Sixteen hours of light daily (114 to 207 lux) increased weight gains and milk yield 10 to 15 percent in Holstein cattle in comparison with cattle exposed to natural-length photoperiods (39 to 93 lux) of 9 to 12 hours. The weight gain was accomplished without increased consumption of feed. Manipulation of supplemental light may thus cause dramatic increases in food supplies from animals.*

In dairy cattle, 16 hours of light daily increase concentrations of serum prolactin (1), an anabolic hormone (2) associated with lactational production (3). We now report that 16 hours of supplemental lighting stimulated body growth and milk yields of dairy cattle 10 to 15 percent in comparison with natural-length photoperiods of 9 to 12 hours.

Twenty Holstein heifers, 3 to 6.5 months of age at the start of this experiment, were divided according to age and genetic potential for milk yield into two equal groups. Each group was housed unrestrained within separate pens inside a barn, and no supplemental heat was provided. Between 18 November 1975 and 9 March 1976, one group (control) received an average of 9.8 hours of indirect sunlight daily through northern windows (natural photoperiod) (4). The second group received the natural photoperiods plus supplemental cool-white fluorescent light between 0600 and 2200 hours (16 hours total light daily). The ration fed daily to each heifer consisted of 2.3 kg of 14 percent protein pelleted concentrate, with alfalfa hay and water freely available. Girth at the level of the heart (heart girth) was measured weekly on each animal with a tape measure to quantify growth. In the control group, heart girth increased from 114 to 139 cm during the 16-week experiment (Fig. 1A). In comparison, the heart girth of heifers receiving 16 hours of light increased from 112 to 141 cm. The difference in the total heart girth gain (24.8 ± 1.1 versus 28.7 ± 1.1 cm) between the two groups of heifers was significant (t-test, $P < .02$).

The ability of 16 hours of supplemental lighting to stimulate growth was confirmed in another similarly designed experiment (5) conducted between 6 October 1976 and 2 March 1977, except that body weight was quantified instead of heart girth. Weights were measured on one day each week for 22 weeks. Animals were deprived of water for 16 hours before being weighed. Average body weights in control heifers increased from 160 kg at week 1 to 274 kg at week 22, while heifers given supplemental lighting increased from 159 to 285 kg (Fig. 1B). Thus, average daily weight gains of Holstein heifers exposed to natural-length photoperiods ($N = 14$) or supplemental lighting ($N = 14$) were 0.78 ± 0.02 and 0.86 ± 0.02 kg (t-test, $P < .05$), respectively. All concentrates fed were consumed completely each day. Daily feed intakes of alfalfa hay by heifers exposed to 16-hour and natural photoperiods averaged 4.6 ± 0.7 and 4.7 ± 0.5 kg, respectively. Thus, supplemental light during the fall and winter in Michigan increased growth rates 10 to 15 percent without requiring additional feed. The increased growth was of similar magnitude to that achieved by steers receiving diethylstilbestrol (6).

A third experiment, designed similarly to the second, was conducted between 1 May and 13 August 1976, when the natural photoperiod ranged between 13.6 and 15.3 hours of light. Daily weight gains of 13 Holstein heifers receiving natural-length photoperiods averaged 0.89 kg, not significantly different from that (0.90 kg) of 13 heifers receiving 16 hours of supplemental fluorescent light.

To determine if photoperiod affected milk yields, we exposed 46 lactating Hol-

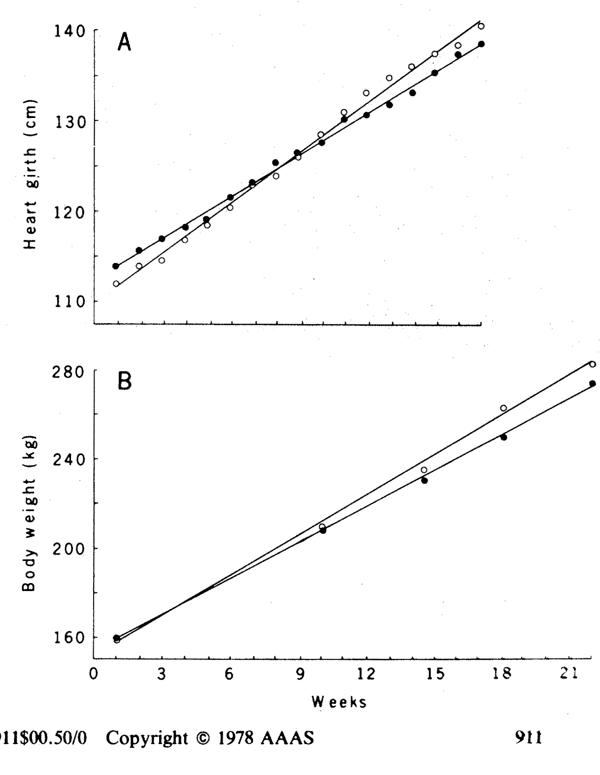

Fig. 1. Growth response of Holstein heifers to 16-hour (○) or natural (●) photoperiods in East Lansing, Michigan. (A) Heart girth, 10 heifers per treatment, 18 November 1975 to 9 March 1976. (B) Body weight, 14 heifers per treatment, 6 October 1976 to 2 March 1977.

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stein cows to natural-length photoperiods, and we supplemented the natural photoperiod of a second group of 46 similar cows with fluorescent light between 0500 and 2100 hours daily, beginning with animals undergoing parturition after 15 September 1976 (*7*). Cows were assigned to treatment groups on the basis of order of parturition. That is, as parturitions occurred after 15 September, cows were alternately assigned to treatment groups. Each group of cows was housed unrestrained in an unheated freestall barn (*8*) with free access to water. Cattle were milked twice daily at 0500 and 1630 hours. Cows were fed as a group. On the average, each cow was fed 17 kg of a 16 percent protein complete mixed ration (*9*) twice daily plus 1.8 kg alfalfa hay daily. If cows produced more than 36.4 kg of milk per day, they also received 3.6 kg of shelled corn plus soybean oil meal (4 : 1) daily for each 4.5 kg of additional milk produced.

Cows exposed to natural-length photoperiods produced an average of 30.5 ± 0.4 kg of milk daily for the first 60 days of the experiment, whereas cows receiving 16 hours of supplemental light produced 33.5 ± 0.4 kg (analysis of variance, $P < .002$) (Fig. 2). At 10 days postpartum, cows that received 16 hours of supplemental light produced 1.7 kg more milk daily than cows exposed to natural-length photoperiods, and at 20 days this difference increased to 3.1 kg. This difference in milk production was maintained for 100 days postpartum. The percentage of fat in the milk was unaffected by photoperiod length. During lactations before this experiment, average daily milk yield of cows receiving natural-length and 16-hour photoperiods were not significantly different, averaging 23.9 ± 0.62 and 24.7 ± 0.77 kg/day, respectively (*10*). Thus, the supplemental lighting–induced increase in milk yield could not be attributed to biased assignment of cows to treatment.

On day 100, postpartum treatments of the two groups were reversed (average date of crossover was 21 January). Daily milk yields between days 60 and 100 (before crossover) averaged 28.0 and 31.4 kg for cows given natural-length ($N = 18$) and 16-hour ($N = 18$) photoperiods, respectively ($P < .01$) (Fig. 2). Between days 101 and 140 postpartum (after crossover) milk yields averaged 27.7 and 26.8 kg for cows on natural-

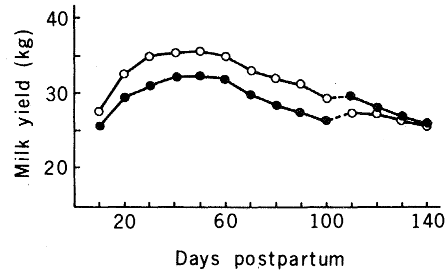

Fig. 2. Milk production of Holstein cows exposed to 16-hour (○) or natural-length (●) photoperiods between 15 September 1976 and 28 March 1977 in Owosso, Michigan. There were 46 cows per treatment between days 0 and 60; between days 61 and 140 there were 18 cows per treatment. At day 100, cows receiving 16 hours of supplemental lighting were switched to natural-length photoperiods and cows receiving natural-length photoperiods were switched to 16 hours of light.

length and 16-hour photoperiods (analysis of variance, $P > .05$) (Fig. 2). Thus, switching cows to 16 hours of supplemental lighting after 100 days of natural-length photoperiods appeared to retard the decline in milk yield with advancing lactation. But a 16-hour supplementation of light was not a sufficient stimulus to cause these cows to produce more milk between days 101 and 140 than cows initially given 16-hour photoperiods for the first 100 days postpartum.

It has been known for many years that the optimal daily photoperiod necessary to maximize egg production in poultry is 14 to 16 hours of light (*11*). Lambs grew 21 to 66 percent faster when subjected to 16-hour as compared with 8-hour light periods (*12*), and feed efficiency was increased. These data, coupled with the results of our study, suggest that manipulation of photoperiods may cause dramatic increases in food supplies from animal sources.

The mechanism whereby 16 hours of light stimulate growth and lactation is not known, but it is probably not a result solely of increased serum prolactin concentrations. The basis for this hypothesis is that the increases in serum prolactin in cattle normally observed after administration of thyrotropin-releasing hormone or 16 hours of light are blocked when ambient temperatures are below 5°C (*13*). In our experiments, the cattle were subjected to many consecutive days when ambient temperatures were below 5°C, yet neither growth rate nor daily milk yields were affected. Furthermore, we cannot exclude the possibility that the greater intensity of light provided to the cattle subjected to 16 hours of light was associated with the increased growth and lactation. Additional studies will be needed to determine the mechanism of action and the optimal illumination scheme for growth and lactation.

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5. Rations were similar to that of experiment 1. Heifers were paired across treatments according to initial body weight at the start of the experiment and genetic potential for milk production. Age of heifers at the start of the experiment ranged from 2 to 10 months. Feed intake was measured twice weekly.
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9. Complete mixed ration fed twice daily to each cow consisted of 7.3 kg of shelled corn, 9.72 kg of soybean oil meal, 2.6 kg of chopped alfalfa hay, 6.4 kg of corn silage, plus calcium, phosphorus, and trace mineralized salt.
10. Data were adjusted for differences in age at parturition and season to a mature equivalent basis [H. D. Norman, P. D. Miller, B. T. McDaniel, F. N. Dickinson, C. R. Henderson. *USDA-DHIA Factors for Standardizing 305-Day Lactation Records for Age and Month of Calving* (Rep. No. ARS-NE-40, U.S. Department of Agriculture, Washington, D.C., 1974)].
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