OVARIAN AND ENDOCRINE CHANGES BEFORE THE ONSET OF NUTRITIONALLY INDUCED ANOVULATION IN BEEF HEIFERS

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Story in Brief

To determine endocrine and ovarian changes preceding nutritionally induced cessation of ovarian cycles, three heifers were fed a diet to maintain body condition, while six heifers were fed a restricted diet to lose 1% of their body weight per week. During the experimental period, estrous cycles of all heifers were synchronized with $PGF_2\alpha$ to a length of 16 days. Ultrasonography of the ovaries was performed and blood samples were collected from day 8 of the estrous cycle (day 0 = estrus) until ovulation (day 1 of the subsequent cycle) to determine growth rate of the ovulatory follicle, follicle size at ovulation, maximum corpus luteum size and concentrations of progesterone, estradiol, glucose, nonesterified fatty acids and urea nitrogen in plasma. During the last two cycles before the cessation of ovarian cycles, the rate of growth and the size of the follicle at ovulation were reduced in nutritionally restricted heifers compared with the maintenance heifers. The maximum size of the corpus luteum and concentrations of progesterone and estradiol were also less in restricted than maintenance heifers during the last two cycles before anovulation. In addition, reduced nutrient intake resulted in decreased concentrations of glucose and increased concentrations nonesterified fatty acids. Urea nitrogen concentrations in plasma were not affected by dietary restriction. These results indicate that follicular growth and luteal function are reduced and energy metabolism is altered before the cessation of ovarian cycles in nutritionally restricted beef heifers.

(Key Words: Beef Heifers, Nutrition, Ovaries, Anestrus.)

Introduction

Nutritional management is one major factor that controls reproduction. The mechanism by which nutrition influences reproduction in cattle has not been well established, but the effects of body weight and body condition on reproductive performance have been documented. Cows bred while losing weight and body condition have decreased pregnancy rates compared to cows maintaining weight and body condition (Richards et al., 1986). Reduced

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nutrient intake results in decreased luteal activity and cessation of ovarian cycles in part due to insufficient gonadotropin stimulation (Richards et al., 1989). Cows fed diets limited in energy develop subfunctional CL during the transition from cyclicity to anestrus (Schrick et al., 1992). Moreover, dietary energy restriction alters follicular growth in postpartum cows and cyclic heifers (Murphy et al., 1991). The present study was designed to investigate effects of dietary energy restriction on endocrine and metabolic responses during the last two cycles before cessation of ovarian cycles in beef heifers.

Materials and Methods

Nine cyclic Angus x Hereford heifers with a body condition score (BCS) of 5.5 $\pm$ .2 and weight of 370 $\pm$ 10 kg were used. Three heifers were fed to maintain BCS (M group), while six heifers were fed a restricted diet to lose 1% of their body weight per week (R). Body weights were recorded every 16 days to determine weight changes for maintenance and restricted heifers. At the initiation of the study, estrous cycles of all heifers were synchronized with two injections of $PGF_2\alpha$ (Lutalyse, 25 mg; Upjohn Co.) at an 11 day interval. Starting on day 13 of the induced cycle, heifers were given $PGF_2\alpha$, and every 16 days thereafter to synchronize cycles to 16 days. After heifers lost approximately 12% of their initial body weight and until they became anovulatory, transrectal ultrasonography was performed daily to monitor the ovaries from day 8 of the cycle until ovulation (day 1 of the subsequent cycle). Size of the ovulatory follicle (mm), growth rate of the ovulatory follicle (mm/day) and maximum corpus luteum (CL) size were measured. Blood samples were collected from day 8 until ovulation and plasma was stored at -20^{o}C until analyzed. Progesterone and estradiol-17β were quantified by radioimmunoassay. Glucose, non-esterified fatty acids and plasma urea nitrogen were assayed by colorimetric procedures. Differences between treatment means for size of the ovulatory follicle, growth rate of the ovulatory follicle and maximum CL size were determined by split-plot analysis of variance with treatment (M or R) in the main plot and cycle (-2 or -1 before anovulation) in the split plot. Treatment effects were tested using animal within treatment as the error term and cycle and treatment x cycle effects were tested using the residual as the error term. Differences between treatment means for progesterone, estradiol, glucose, nonesterified fatty acids and plasma urea nitrogen concentrations were determined by split-split-plot analysis of variance with treatment in the main plot, cycle in the split plot and day of cycle (8 through ovulation) in the split-split plot. Cycle and treatment x cycle effects were tested using animal within treatment x cycle as the error term and day, treatment x day, cycle x day and treatment x cycle x day were tested using the residual as the error term.

Results

Reduced nutrient intake in R heifers resulted in loss of body weight and cessation of estrous cycles at 33.5 ± 4.2 wk after initiation of feed restriction. Average daily gain and average daily loss were .35 kg/d and -.40 kg/d for M and R heifers, respectively (Figure 1). Heifers became anovulatory after losing 23 ± 1.5 % of their initial body weight and at a BCS of 3.9 ± .2.

The ovulatory follicle emerged on day 9 or 10 of the estrous cycle and was identified at a diameter of ≥4 mm. Maintenance heifers had larger ($P<.0001$) ovulatory follicles (14.8 ± .5 mm) than R heifers (11.0 ± .9 mm) during the last two cycles before anovulation. Growth rate of the ovulatory follicle was greater ($P<.0001$) for M (1.4 ± .1 mm/d) than R heifers (.87 ± .1 mm/d).

In both M and R heifers, CL were at maximal size on day 13 of the cycle. A treatment x cycle interaction ($P<.001$) influenced maximum CL size. Maintenance heifers had greater maximum CL size (19.6 ± .6 and 20.2 ± 1 mm for cycle -2 and -1, respectively) than R heifers (15.3 ± .3 and 14.2 ± .7 mm for cycle -2 and -1, respectively). A treatment x day of cycle interaction ($P<.0001$), influenced progesterone concentrations during the last two cycles prior to anovulation. Progesterone concentrations in M heifers were greater during days 8 to 13 of the cycle than in R heifers (Figure 2). A treatment x cycle x day of cycle effect occurred for estradiol concentrations ($P<.0001$). Maintenance heifers had greater estradiol concentrations than R heifers in both cycles -2 and -1, however the preovulatory surge in R heifers occurred only in cycle -2 and not in cycle -1 (Figure 3).

Concentrations of glucose were less ($P<.005$) in R heifers than M heifers (Figure 4). There was a treatment x cycle interaction ($P<.1$) for concentrations of nonesterified fatty acids. Restricted heifers had greater concentrations of nonesterified fatty acids than maintenance heifers in both cyles -2 and -1 (Figure 5). Concentrations of urea nitrogen in plasma were not significantly influenced by treatment, indicating that restricted heifers had not utilized muscle to meet energy demands.

Discussion

The loss of both BCS and body weight illustrates that restricted heifers were nutritionally stressed and metabolizing body reserves to meet energy demands. Because NEFA were elevated in restricted heifers, the weight loss that occurred in these heifers was likely associated with a decrease in adipose tissue due to lipolysis. The alteration in body energy metabolism in restricted heifers was further indicated by a decrease in peripheral glucose concentrations. The reduced growth and steroidogenic capability of the corpus luteum and the ovulatory follicle during the last two cycles before anovulation indicates that the transition from cyclicity to anestrus is not abrupt but gradual. Although the mechanism by which nutrient intake and body energy reserves regulate the hypothalamo-pituitary-ovarian function is unknown, our results indicate that metabolic signals can act either on the hypothalamo-pituitary axis reducing gonadotrophin secretion or/and at the ovaries altering gonadotrophin responsiveness and steroidogenic ability. In summary, growth of the ovulatory follicle, maximum CL size and concentrations of progesterone and estradiol are reduced and energy metabolism is altered during the last two cycles before nutritionally inducedanovulation.

Literature Cited

Murphy, M.G. et al. 1991. J.Reprod. Fert. 92:333.
Richards, M.W. et al. 1986. J.Anim. Sci. 62:300.
Richards, M.W. et al. 1989. J.Anim. Sci. 67:1520.
Schrick, F.N. et al. 1992. Domest. Anim. Endocrinol. 9:187.

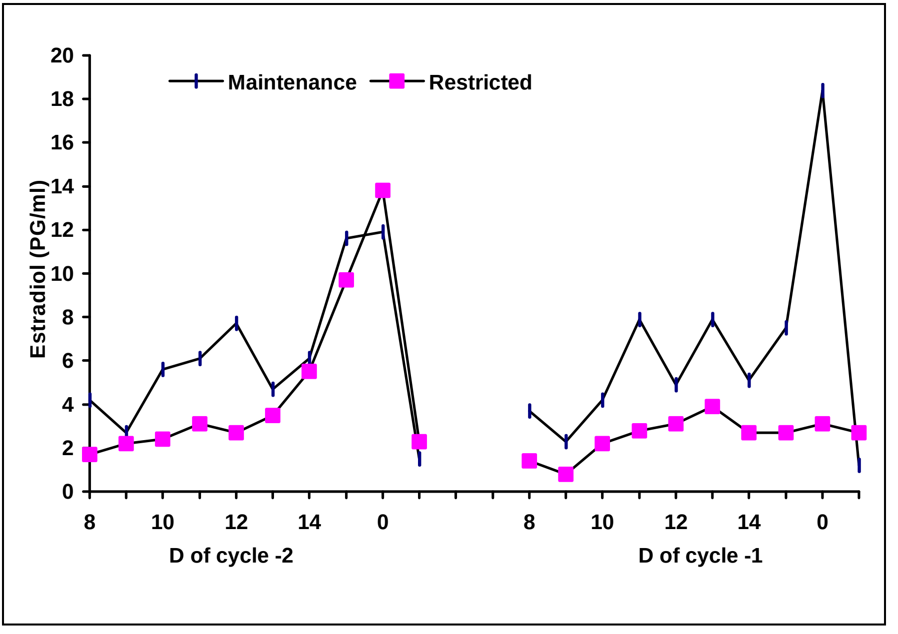

Figure 1. **Body weight changes of maintenance and restricted heifers during the experimental period (arrow = point of anovulation).**

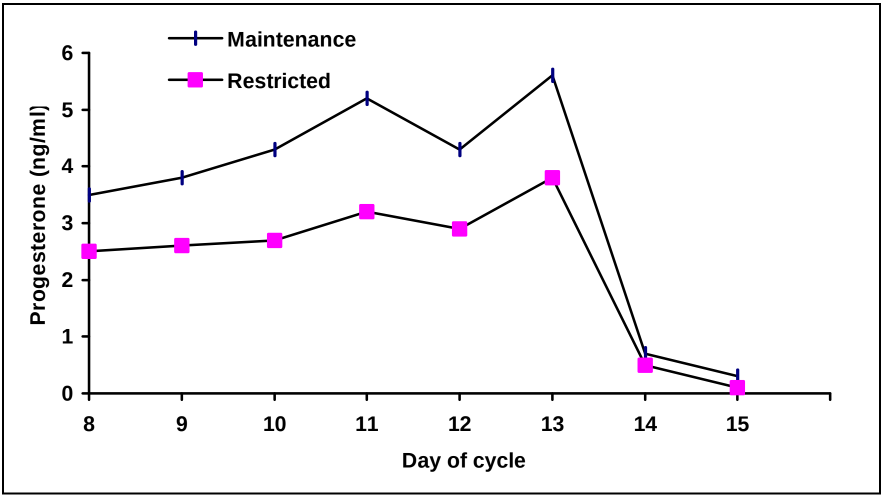

Figure 2. **Concentration of progesterone (ng/ml) during the last two cycles before anovulation in maintenance and restricted heifers (treatment x day interaction, P<.0001).**

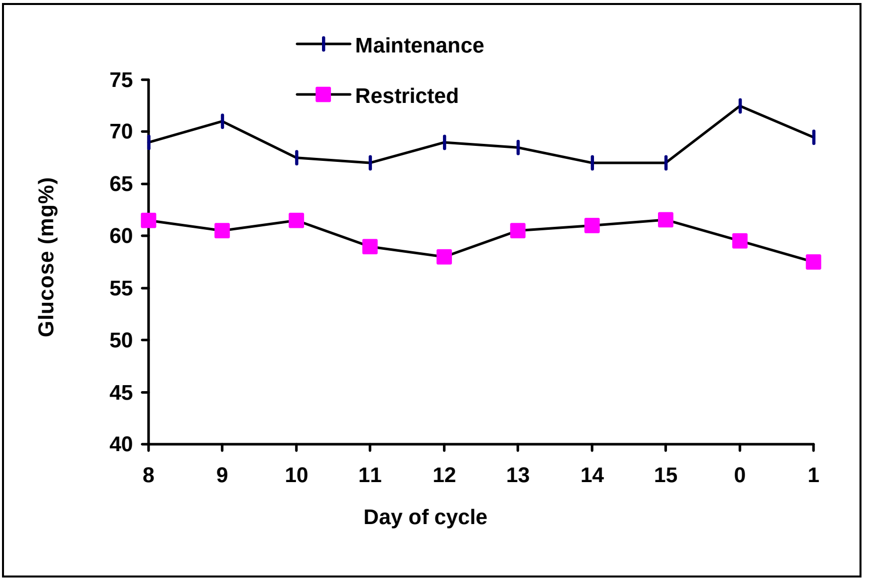

Figure 3. **Concentrations ofestradiol (pg/ml) during the last two cycles before anovulation in maintenance and restricted heifers (treatment x cycle x day interaction, P<.001).**

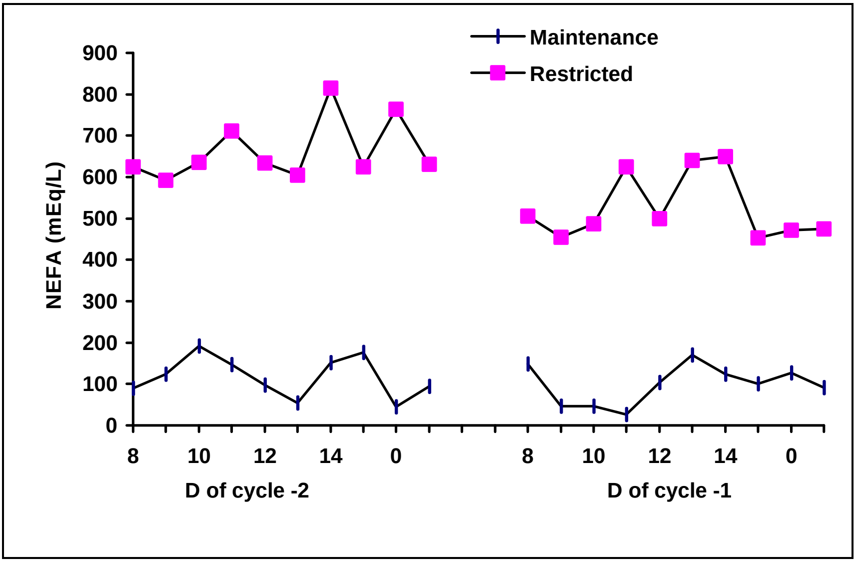

Figure 4. Concentrations of glucose (mg %) during the last two cycles before anovulation in maintenance and restricted heifers (treatment effect, P<.005).

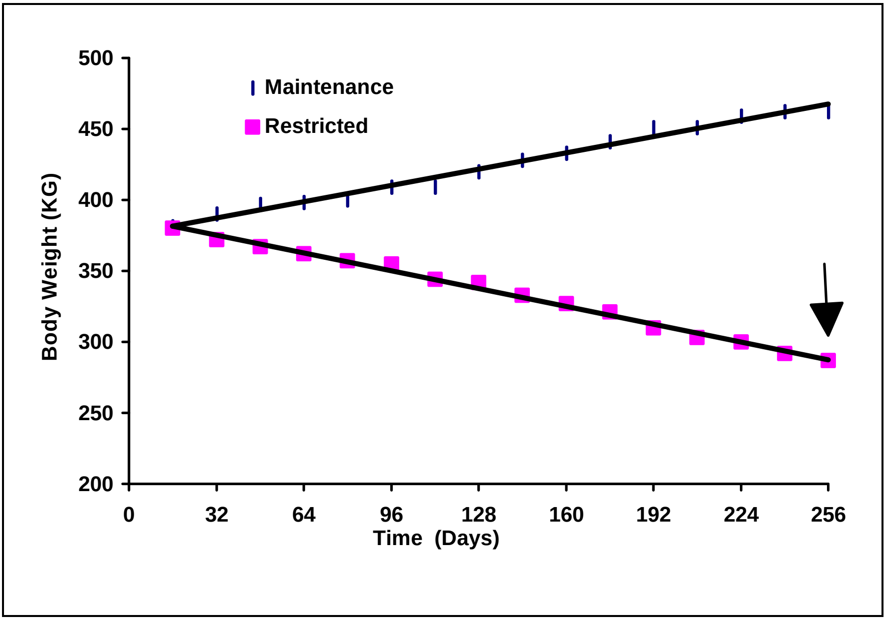

Figure 5. Concentrations ofnonesterified fatty acids (mEq/L) during the last two cycles beforeanovulation in maintenance and restricted heifers (treatment x cycle interaction, P<.1).