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Post-weaning nutritional programming of ovarian development in beef heifers[1]

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SUMMARY

The nutritional management of replacement females from weaning to breeding is critical to lifetime productivity. Traditionally, cereal grains have been used to develop replacement heifers to attain puberty and enter the breeding system at a younger age. However, overfeeding heifers decreases number of calves weaned, while peri-pubertal caloric restriction increased primordial follicle numbers in the developing ovary. The number of primordial follicles a female has can determine her overall fertility; females with a greater amount of follicles have greater reproductive lifespans. In this study, two groups of heifers were developed to prebreeding status. One group received a control diet (228 kcal ME/BW $kg^{0.75}$) while the other received a restricted diet (157 kcal ME/BW $kg^{0.75}$) for 84 days, and were then stepped up to receive a diet containing 277 kcal ME/BW $kg^{0.75}$. Both groups were evaluated at three different time points for number of primordial follicles. Heifers on the restricted diet had more primordial follicles than control heifers at 13 mo of age. In summary, heifer input costs could be decreased without negatively effecting overall fertility and perhaps improve fertility.

INTRODUCTION

It has been well established that the main factor influencing production efficiency of a cow/calf operation is reproductive efficiency (Short et al., 1990). In a heifer production system, it is important that a replacement female weans enough calves to pay for her development costs (Mathews and Short, 2001). Therefore, the objective to developing high quality replacement females is for them to conceive early in the breeding season as well as to maximize pregnancy rates within a 45-d breeding period (Eborn et al., 2013).

Management practices implemented during heifer development impose lasting economic impacts. Traditional approaches to post-weaning development of replacement heifers have included increasing the availability of cereal grains allowing replacement heifers to attain puberty and enter the production system at a younger age. However, overfeeding heifers has been reported to decrease the number of calves weaned in the first parity and increase calving difficulty (Pinney et al., 1961). Martin et al (2008) reported that heifers developed to lighter

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than traditional targets body weights (55%) were not detrimentally affected in profitability or future productivity. Additional data suggests that altering growth patterns, resulting in compensatory growth periods, in weaned heifers can alter the interval of time a cow is retained in the herd as well as offer producers the opportunity to decrease feed costs (Clanton et al., 1983; Lynch et al., 1997; Freetly et al., 2001). In addition, heifers developed on a stair-step nutritional management scheme have been reported to have greater productivity, along with a greater abundance of primordial follicles compared to their cohorts (Freetly et al., 2014). We hypothesized that limiting the caloric intake during the peri-pubertal period positively influences the ovarian reserve in beef heifers, contributing to increased reproductive longevity. The objective of the present study was to investigate the timing of changes in follicle populations in the ovary throughout the dietary treatments.

MATERIALS AND METHODS

All experiments were approved by the USDA Meat Animal Research Center Institutional Animal Care and Use Committee. Thirty crossbred heifers (MARC II, ¼ Angus, ¼ Hereford, ¼ Pinzgauer, ¼ Red Poll) of similar age and size born to cows $\geq$ 4 years of age were used in the study. Following weaning, heifers were moved to the USMARC feedlot in early November and trained to use Calan headgates. Heifers were fed a diet consisting of 30% alfalfa hay, 69.8% corn silage, and 0.2% salt (DM basis). At eight months of age (December), six heifers were ovariectomized under local anesthesia and ovaries were collected through flank laparotomy (Youngquist et al., 1995). This first group of heifers served as the untreated controls to determine base-line changes in the ovarian reserve prior to dietary treatments.

The remaining 24 heifers were divided into two treatment groups (n=12 heifers/diet). Heifers in the Control group were offered 228 kcal ME/BW $kg^{0.75}$ over the entire feeding period. Heifers were weighed every three weeks and feed intakes were adjusted for body weights. Orts were taken weekly such that they corresponded with weigh dates. Beginning at 256 days of age, Stair-Step heifers received adequate diet to provide 157 kcal ME/BW $kg^{0.75}$ for 84 days. Following the 84-d restriction, heifers were stepped up to receive a diet containing 277 kcal ME/BW $kg^{0.75}$ over a 15-d period and were held at this feeding level until late May. Ovaries were collected at 11 mo of age (n=6/diet), at the time when the intake for the Stair-Step heifers was increased; and at 14 mo of age (n=6/diet), after the increase in intake when the heifers would normally enter their first breeding season. Histological evaluations of primordial, primary, secondary and antral follicles were analyzed using MIXED procedure of SAS (9.2 SAS Inst. Inc., Cary, NC). At each time point, the numbers of primordial, primary, secondary, or antral follicles per section were analyzed with dietary treatment (Control or Stair-Step) as a fixed effect and animal as a random effect.

RESULTS AND DISCUSSION

There was no difference (P=0.13) in BW between treatments at 8-, 11-, or 13 mo of age. There was no effect of treatment on primordial follicles between Control and Stair-Step diets at 8 mo (P=0.41) and 11 mo (P=0.75). However, Stair-Step heifers had more primordial follicles (P=0.04) than Control heifers at 13 mo. Similar findings in the difference in follicle numbers were reported previously in heifers at 13 mo of age (Freetly et al., 2014). There was no effect of treatment on primary follicles (P=0.94) at 8 mo or 13 mo (P=0.80). However, Control heifers had a greater number of primary follicles (P=0.03) at 11 mo of age. The difference in number of

primordial and primary follicles indicates that non-caloric restricted heifers have increased activation of primordial follicles or that restricted heifers have reduced activation of follicles. There was no difference in secondary follicles between treatments at 8 mo (*P*=0.30), 11 mo (*P*=0.48) and 13 mo (*P*=0.25). There was also no effect of treatment on antral follicles between Control and Stair-Step heifers at 8 mo (*P*=0.27), 11 mo (*P*=0.75) and 13 mo (*P*=0.84). In summary, our results indicate that the ovarian reserve can be positively affected when exposing heifers to a single-phase Stair-Step program and possibly influence reproductive lifespans.

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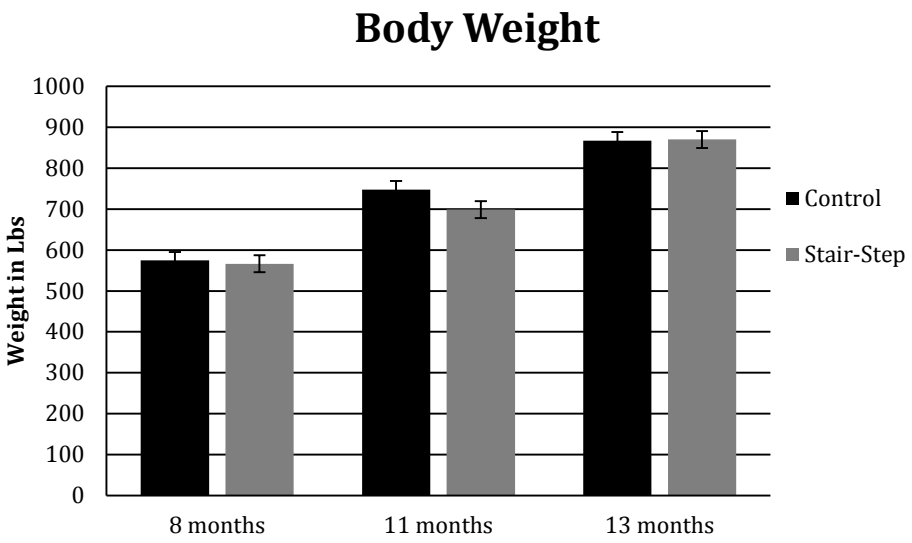

Figure 1. Body weight between Control and Stair-Step heifers at 8 mo, 11 mo, and 13 mo. There was no difference in body weight between treatment groups or time points.

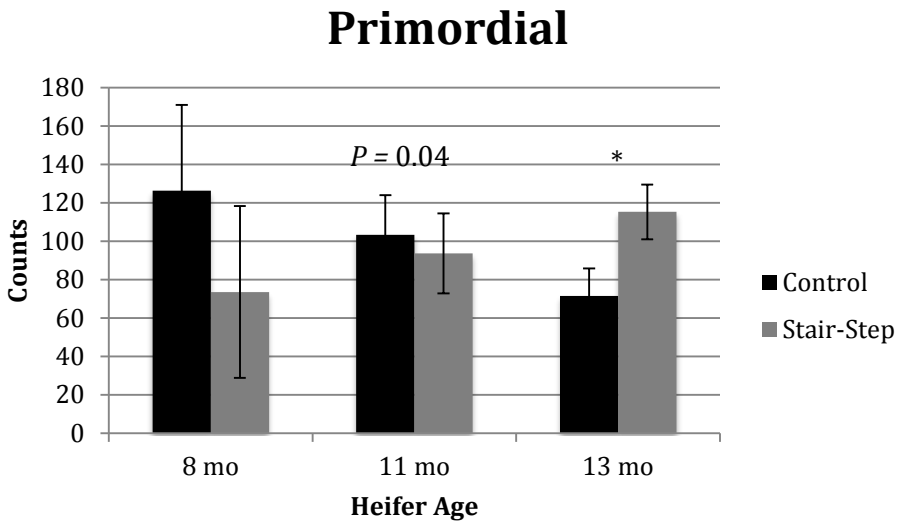

Figure 2. Primordial follicle counts between Control and Stair-Step heifers at 8 mo, 11 mo, and 13 mo ($P < 0.05$). Stair-Step heifers had a greater number of primordial follicles at 13 mo of age compared to Control heifers.

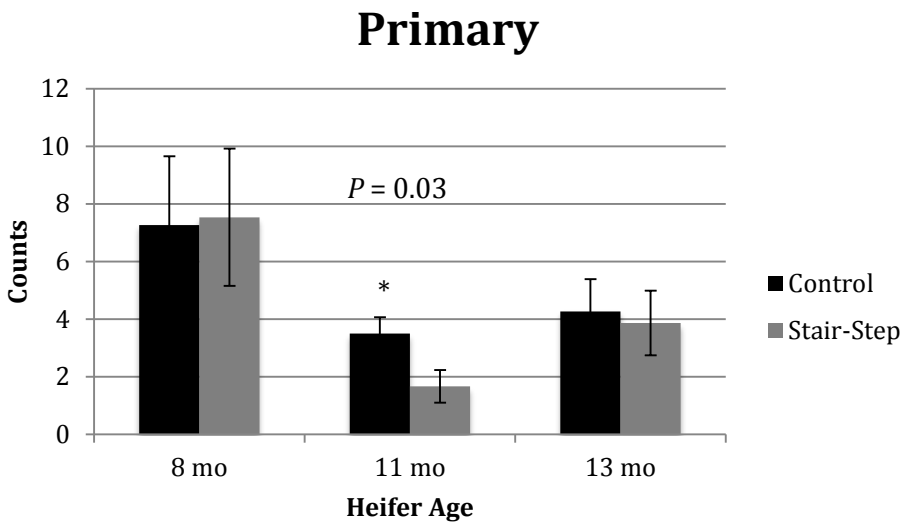

Figure 3. Primary follicle counts between Control and Stair-Step heifers at 8 mo, 11 mo, and 13 mo ($P < 0.05$). Control heifers had a greater number of primary follicles at 11 mo compared to Stair-Step heifers.