Effects of Nutritional Environment on Percentage of Mature Weight at which Crossbred Heifers of Varying Proportion of Brahman Breeding Attain Puberty

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ABSTRACT

Crossbred heifers (n=181) produced from mating *Bos indicus* × *Bos taurus* cows to Simmental, Senepol, Braford and Simbrah bulls and Angus cows to Brahman bulls were used to determine if restricting postweaning gain for the first 3 mo after weaning followed by rapid gain for the second 3-mo-period (Restricted-Rapid) would affect attainment of puberty as compared to heifers fed for a constant gain (Constant) from weaning to breeding. Both nutritional groups were fed to reach 65% of there estimated mature weight (EMW) by the start of their yearling breeding season. Percent of estimated mature weight (EMW) at which puberty was reached was not affected by nutritional management (62.7 vs 62.9% for Constant and Restricted-Rapid fed heifers, respectively), but was affected ($P < .0057$) by breed of sire (Simmental, 59.8%; Senepol, 61.7%; Braford, 63.2%; Simbrah, 64.2%; and Brahman, 65.3%). Age at puberty was affected by nutritional management ($P < .0027$) and sire breed ($P < .0001$). Average age and weight at puberty were by nutritional management, Constant 403 d, 776 lb and Restricted-Rapid 429 d, 774 lb; and by breed of sire, Simmental 362 d, 763 lb; Senepol 417 d, 763 lb; Braford 425 d, 765 lb; Simbrah 430 d, 813 lb; and Brahman 448 d, 772 lb. There was no difference in pregnancy percentage or average calving date by nutritional management or sire breed, although the Constant heifers tended ($P < .1294$) to calve earlier.

INTRODUCTION

Breeding heifers as yearlings is a common practice in the central and northern United States (Short et al., 1990). Several researchers have shown heifers bred as yearlings are more productive in their lifetime than heifers bred as 2-yr-olds (Lee et al., 1982, Morris, 1980, Nunez-Dominquez et al., 1985). The practice of breeding heifers as yearlings is not as common in the Gulf Coast Region of the United States, where the genotype of the cattle includes increased *Bos indicus* breeding. Cattle which contain *Bos indicus* breeding reach puberty later in life than cattle of *Bos taurus* breeding. Also, the nutritional quality and quantity of the forage may limit growth during the postweaning growth phase, when it is most critical for early attainment of puberty. This experiment was designed to determine the effects of postweaning nutritional management and sire breed on age, weight and percentage of mature weight at puberty and on pregnancy percentage in yearling beef heifers.

MATERIALS AND METHODS

Breed composition

Heifers (n=181) used in this study were produced at the University of Florida Beef Research Unit, Gainesville, from the mating of Braford, Simbrah, Senepol, and Simmental bulls to F_1 Brahman x Angus, F_1 Romano Red x Angus, 1/2 Brahman:1/4 Angus:1/4 Brown Swiss, and 1/2 Romano Red:1/4 Angus:1/4 Brown Swiss cows, and from the mating of Brahman bulls to Angus cows. Heifers were born beginning in the last week in December and continuing until the second week of March in each of the three years and were weaned the first week of September each year.

Nutritional regimen

Heifers were started on the feed trial approximately 2 to 4 wk after weaning, and were sequentially assigned by breed of sire into two nutritional regimens; Constant (C) = fed to achieve 65% of their estimated mature body weight (EMW) by gaining at a constant rate from

weaning to the beginning of the breeding season, and Restricted-Rapid (RR) = fed to gain .67 lb/d for the first phase of the trial (84 d in each yr) (Period 1) and then fed a higher energy level to attain 65% of their EMW by the beginning of the breeding season (Period 2) (98, 77 and 84 d in yrs 1, 2 and 3, respectively). Hip height measurement was taken on the heifers at an average age of 8 mo, and this value was used to determine frame score of each heifer (BIF, 1986). By using this frame score value the EMW was calculated from the table constructed by Fox et al. (1988).

Years 1 and 2

Heifers were placed into 10 drylots for the postweaning feed trial. Each breed by nutritional regimen group was assigned a pen and group fed approximately 21 lb silage and 1.5 lb protein pellet (52% CP) per head per day. The silage was either corn silage or sorghum silage depending on the availability within and across the 2 yr. Corn grain was top dressed on the silage-protein pellet mixture, on a pen basis, at levels necessary to reach the target gains for the pen.

Year 3

In year 3, heifers were placed in confinement and fed using the Calan individual feeding system. Weighback was recorded three times per week and total feed consumption was recorded. The amounts of silage and corn were manipulated on an individual basis to achieve the desired average daily gain.

On December 6, 1988, January 4, 1990 and December 12, 1991, in years 1,2 and 3, respectively, the energy level of the RR group was changed from low to high, to allow heifers in the RR group to gain the necessary weight during the remainder of the trial so as to reach 65% of their EMW at the beginning of the breeding season (end of Period 2).

Body condition measurements

Heifers were subjectively scored for body condition on a nine point system, and subcutaneous fat at the 12th and 13th rib interface (FOE) was measured using real-time ultrasound at the start of the trial, when the diets were changed for the RR group, and at the start of the breeding season.

Puberty determination

Heifers were weighed and jugular blood samples were drawn at 14-d intervals in yr 1 and 2 and at 7-d intervals in yr 3 for progesterone (P_4) analysis. The heifers were palpated for reproductive status and ovarian structures and given a uterine score when the diet for the RR group was changed, at the end of the feed trial, and at the end of the breeding season (about June 1). Heifers were classified as puberal when the serum sample contained 1 ng/ml or greater of P_4, and (or) when the heifer had a uterine score of 4 and a palpable corpus luteum. Additionally, some heifers did not produce elevated P_4 values but were palpated pregnant. Date of puberty for these females was determined by subtracting 285 d from date of calving. Weight at puberty was extrapolated from the two closest weights. Percentage of mature weight at puberty was determined for each heifer by dividing her weight at puberty by her EMW.

Breeding procedures

At the conclusion of the feed trial the heifers were grouped together and allowed to graze pasture consisting primarily of pensacola bahiagrass (*Psapalum notatum*), with some white clover (*Trifolium ripens*) available till late spring. The heifers were also supplemented with corn silage when the availability of forage was low in the pastures, up to the start of the breeding season.

All heifers were implanted with Syncro-mate B®(CEVA Laboratories, Inc Overland Park, KS) during the second or third week in March. After a 9-d interval the implants were removed and the heifers were bred by artificial insemination on standing heat if it occurred within 48 h, otherwise they were inseminated 52 h after implant removal. Any heifer that showed a standing heat was bred by AI through the last week in April in each year. At the conclusion of the AI breeding period, half of the heifers of each sire-breed group were put with a Limousin bull and the other half with a Brangus bull for the remainder of the breeding season (about 40 d). Heifers were palpated and bled at the end of the breeding season to determine early pregnancy and puberty status. Any heifer not classified as puberal at the end of the breeding season was bled monthly until about the first week of September, when palpation for pregnancy diagnosis was performed. Any nonpregnant heifer that was classified as puberal was culled. One Braford-sired heifer had not reached puberty as of August 30, 1989, in year 1 of the experiment, and was assigned a puberty date of October 30, 1989. Additionally, three heifers in year 2 (one Braford-sired, one Simbrah-sired, and one F_1 Brahman-Angus) had not reached puberty at the conclusion of the experiment, and were slaughtered to

examine the reproductive tracts. Reproductive tracts of the three heifers were classified as normal and prepuberal, and to avoid biasing the results of the above three breeds, the heifers were assigned an age at puberty 60 days after the slaughter date.

Statistical analysis

Data were analyzed by least squares, fixed model procedures analysis of variance using Statistical Analysis Systems (SAS, 1982). Heifer response traits analyzed were weight gains, body condition score, real time ultrasound FOE, age and weight at puberty, percent of estimated mature weight at puberty, and pregnancy status. Main effects of nutritional regimen, breed of sire and breed group of dam, year and all two-way interactions were included in the mathematical model as independent variables. Breed group of dam was not significant and was removed from the model. Age of the heifer was included in the model as a covariate in all analyses where age adjustments were necessary. Because of differences in time of initiation of trials across the three years, age was used as a covariate for all variables except for age and weight at puberty.

RESULTS AND DISCUSSION

Nutritional management

Nutritional management affected age at puberty with the C group heifers reaching puberty about 26 d earlier than the RR group females. This difference may have contributed to the tendency ($P < .1294$) for the C group heifers to calve earlier in the calving season. Previous work has shown heifers which breed earlier and calve earlier in the calving season will remain in the herd longer and be more profitable (Lesmeister et al., 1973). The observed differences in age at puberty and in calving date may have been due to the fact that RR-fed heifers had lower average daily gains during the postweaning period (Table 2), and thus, these heifers were older when they attained 65% of EMW. There was no difference in the percentage of heifers that had attained puberty at the start of the breeding season by nutritional management. However, during the breeding season a greater percentage of heifers in the C group attained puberty than the RR group heifers, and there was a strong tendency ($P = .0763$) for a difference in the percentage of puberal heifers at the end of the breeding season (93.2 vs 85.4% for C and RR heifers, respectively). A goal when breeding heifers as yearlings is to get as many as possible pregnant in the first third of the breeding season, because it is known that heifers usually have a longer postpartum anestrous period as lactating 2-yr-olds. There was no difference in pregnancy percentages by nutritional management. However, when the calving dates of the heifers that bred during the 60 d breeding season are compared across nutritional management treatments, 67% of the C females calved in the first half of the calving period compared to only 53% of the RR heifers. This indicates that a greater percentage of the C heifers should rebreed as lactating 2-yr-olds.

There was no difference ($P > .82$) in weight or percentage of EMW at puberty by nutritional management. These data support the theory that the attainment of puberty is to some extent based on a genetically controlled percentage of mature weight and not solely on a set weight or chronological age. Most previous research indicates that heifers needed to reach a certain "critical" weight before puberty is attained (Day et al., 1985; Short and Adams, 1988; Ferrell, 1982). This study suggests that it is not necessarily a specific weight, but rather a specific percentage of mature weight. The most commonly reported value is 65% of mature weight for puberty to be attained. In this study, heifers were fed to attain 65% of their EMW by the start of the breeding season. The heifers actually only reached about 63% of their EMW at the start of the breeding season, but on average the heifers reached puberty before they reached the 65% target. At the start of the breeding season only about one-third of the heifers in each nutritional management group were puberal. By comparing the percentage of heifers that were cycling at the start of and then at the end of the breeding season it can be seen that a majority of the heifers in each nutritional group reached puberty during the breeding season. This may be due to at least two factors other than chronological age and increased weight; 1) synchronization by Syncro-mate B®; 2) the male-female interaction when bulls were placed with the heifers.

Sire breed

Sire breed affected age and percentage of EMW at puberty as well as the percentage of heifers that were cycling at the start of the breeding season. There was also a tendency for weight at puberty to be influenced by sire group. The Simmental-sired heifers (¾*Bos taurus*:¼*Bos indicus*) were the youngest by far at puberty at less than one year (362 d) while the Brahman × Angus

F_1 (½*Bos taurus*:½*Bos indicus*) heifers were the oldest at about 14.5 mo (448 d). Theses results agree with Ferrell (1982) and Laster et al. (1979), who reported that breeds selected for high milk production, such as the Simmental, should reach puberty earlier in life than breeds of the same mature size selected primarily for beef production. The approximately 2.5 mo difference in age at puberty for the Simmental-sired compared to the F_1 heifers has major implications when attempting to breed heifers as yearlings. Heifers that reach puberty by one year of age will have two or more estrous cycles prior to the beginning of the breeding season. Previous work indicates that more fertile heats occur after the second heat, and so pregnancy rates may be decreased in heifers that reach puberty late and have only one or two heats during the breeding season, (Byerly et al., 1987). As observed in this study, the heifers which reach puberty earlier breed and calve earlier compared to those that reach puberty later.

There was a difference in the percentage of heifers cycling at the start of the breeding season, with a greater percentage of the Simmental-sired heifers (70.2%) being puberal compared to the Senepol-, Braford- and Simbrah-sired heifers where only about 31 to 38% of heifers were puberal, and the F_1 heifers where only 8.2% were puberal at the start of the breeding season. No statistical difference in calving date was observed, but as expected the Simmental-sired heifers calved very early in the calving period.

Only a tendency (P = .0675) for weight at puberty by sire breed was observed with all sire breed groups reaching puberty around 760 to 770 lb, except for the Simbrah-sired heifers, which averaged 813 lb at puberty. The percentage of EMW at puberty differed by sire breed with the Simmental-sired heifers reaching puberty at 59.8%, the Senepol- 61.7%, Braford- 63.2%, Simbrah- 64.2% and the F_1 females at 65.3%. The percentage of EMW at which puberty was reached increased as the percentage of *Bos indicus* breeding increased. The Simmental- and Senepol-sired heifers (25% *Bos indicus*) reached puberty at a lower percentage of EMW than did the Braford- and Simbrah-sired heifers, (about 44% *Bos indicus*) and the Brahman × AngusF_1 (50% *Bos indicus*).

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TABLE 1. NUMBERS OF HEIFERS BY NUTRITIONAL MANAGEMENT, SIRE BREED AND YEAR

	Nutritional management								
	Constant				Restricted-rapid				
	Year				Year				
Sire Breed	88	89	90	3 Yr Total	88	89	90	3 Yr Total	Total
Simmental	5	4	5	14	5	3	3	11	25
Senepol	7	9	4	20	6	9	5	20	40
Braford	7	8	5	20	8	7	5	20	40
Simbrah	8	6	6	20	7	6	7	20	40
Brahman	7	6	4	17	7	6	6	19	36
Total	34	33	24	91	33	31	26	90	181

TABLE 2. LEAST SQUARES MEANS ± STANDARD ERROR FOR REPRODUCTIVE AND GROWTH CHARACTERISTICS BY NUTRITIONAL MANAGEMENT

	Nutritional management		
Item	Constant	Restricted-Rapid	P
Number	91	90	
Age at puberty, d	403 ± 7	429 ± 7	.0027
Weight at puberty, lb	776 ± 9	774 ± 9	.8290
% EMW[a] at puberty	62.7 ± .7	62.9 ± .7	.8462
% EMW at start of breeding season	63.4 ± .5	62.6 ± .5	.3019
% EMW at end of breeding season	69.0 ± .5	68.0 ± 5	.1653
ADG birth to puberty, lb/d	1.76 ± .02	1.68 ± .02	.0035
ADG birth to weaning, lb/d	1.98 ± .02	1.98 ± .02	.6477
ADG weaning to puberty, lb/d	1.43 ± .02	1.26 ± .02	.0001
% Puberal at start of breading season	35.1 ±.05	36.7 ± .05	.9134
% Puberal at end of breeding season	93.2 ± .03	85.4 ± .04	.0763
Pregnancy, %	75.8 ± .05	70.0 ± .05	.3949
Average calving date[b]	31 ± 3	37 ± 3	.1294
EMW, lb	1237 ± 7	1232 ± 7	.5055

[a]Estimated mature weight determined as outlined in materials and methods
[b]Average calving date was determined by setting the day the first heifer that calved as day 1 in each year

TABLE 3. LEAST SQUARES MEANS ± STANDARD ERRORS FOR REPRODUCTIVE AND GROWTH CHARACTERISTICS BY SIRE BREED

Item	Sire Breed					
	Simmental	**Senepol**	**Braford**	**Simbrah**	**Brahman**	**P**
Percentage Brahman (*Bos indicus*)	**25**	**25**	**44**	**44**	**50**	**--**
Number	25	40	40	40	36	
Age at puberty, d	362 ± 13[a]	417 ± 11[b]	425 ± 11[bc]	430 ± 11[bc]	448 ± 11[c]	.0001
Weight at puberty, lb	763 ± 18	763 ± 13	765 ± 13	813 ± 13	772 ± 15	.0675
% EMW at puberty	59.8 ± 1.2[a]	61.7 ± 1.0[ab]	63.2 ± 1.0[bc]	64.2 ± 1.0[c]	65.3 ± 1.0[c]	.0057
%EMW at start of breeding season	63.4 ± 1.0	62.0 ± .8	62.9 ± .8	63.4± .8	63.6 ± .8	.3492
% EMW at end of breeding season	69.8 ± .9	66.7 ± .8	68.3 ± .7	68.4± .7	69.3 ± .7	.0671
ADG birth to puberty, lb/d	1.90 ± .04[c]	1.48 ± .02[a]	1.65 ± .02[a]	1.74 ± .02[b]	1.61 ± .02[a]	.0001
ADG birth to weaning, lb/d	2.14 ± .04[c]	1.96 ± .04[ab]	1.92 ± .02[a]	2.03 ± .02[bc]	1.87 ± .04[a]	.0001
ADG weaning to puberty, lb/d	1.46 ± .07	1.28 ± .04	1.34 ± .04	1.32 ± .04	1.03 ± .04	.1581
% Puberal at start of breading season	70.2 ± .07[c]	30.8 ± .07[b]	38.1 ± .07[b]	32.2 ± .07[b]	8.2 ± .07[a]	.0001
% Puberal at end of breeding season	99.8 ± .07	88.2 ± .05	86.4 ± .05	88.0 ± .05	84.1 ± .06	.4257
Pregnancy, %	91.5 ± .09	72.4 ± .07	68.6 ± .07	64.6 ± .07	67.5 ± .07	.1673
Average calving date[e]	26 ± 5	38 ± 4	33 ± 4	39 ± 4	35 ± 4	.1877
EMW, lb	1276 ± 11[d]	1237 ± 9[c]	1210 ± 9[b]	1265 ± 9[d]	1182 ± 9[a]	.0001

[abcd] Numbers within rows with different superscripts differ, P < .05

[e] Average calving date was determined by setting day the first heifer that calved as day 1 in each