Prepubertal Growth Characteristics Associated with Calving Rates of Replacement Angus Heifers

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Story in Brief

Angus heifers (n = 88) were used during three years to determine the relationship between two sets of traits considered to be indicators of growth. Data were collected at weaning (7-8 mo), yearling (10-11 mo), and prebreeding (13-14 mo), and included body weight (BW), hip height (HH), hip width (HW), pelvic height (PH), pelvic width (PW), lactate dehydrogenase activity (LDH), longissimus muscle area (LMA) and backfat thickness (BKFAT). Measurements were grouped into two sets of traits; Set I included BW, HH, HW and LDH while Set II included PH, PW, LMA and BKFAT. Weight was correlated ($P < 0.01$) with all variables studied except LDH activity. At weaning, heifers with lower LDH activity had a larger pelvic height just prior to the breeding season. The first canonical correlations between Set I measurements at weaning or yearling and Set II measurements at prebreeding were greater than 0.8 ($P < 0.01$). Additional linear combinations of Set I traits at weaning and yearling were correlated ($r > 0.48$; $P < 0.01$) with linear combinations of Set II traits at prebreeding. These results suggest that the Set I measurements, as early as at weaning, could be used as indicators of Set II variables at prebreeding. The canonical coefficients of Set I traits were used to rank heifers as either above or below the mean. Ranking heifers based on Set I measurements at weaning resulted in a greater ($P < 0.01$) percentage of heifers calving as a 2-year old. Correlations between Set I and Set II traits suggest that external measurements coupled with LDH activity could be used in identifying replacement beef heifers that have larger pelvic dimensions at breeding and a greater frequency of calving as 2-year olds.

Introduction

Selection criteria of replacement heifers should include traits that will reflect how well heifers will consistently reproduce in the cow herd. Heifers conceiving and calving at a young age produce more pounds of total beef compared to contemporaries conceiving at a later age. Typically, beef heifers do not breed until they reach about 65% of their potential mature body weight. Attainment of puberty in the heifer is not modulated solely on body weight. Age, hip height, and other elements may be limiting factors, suggesting that selection of replacement heifers based solely on BW may be insufficient.

Body composition, specifically body fat, of postweaning heifers has been related to the attainment of puberty. Previously, we have shown that lactate dehydrogenase (LDH) was highly heritable, and useful as a predictor of subsequent body composition of finished cattle. Age-related differences of several serum constituents, including LDH at the time of puberty, have been reported. Those results suggest that LDH activity may be useful in selecting heifers that have early maturing reproductive systems.

Knowledge of the association among indicators of long bone maturation (skeletal measurements) and metabolic maturation (LDH) could allow for the ranking of heifers at an early age (i.e., weaning). Thus, our objective was to determine relationships between two sets of traits that are indicators of growth and body composition in the replacement beef heifer and subsequent calving rates for those heifers.

Experimental Procedures

Traits were determined on three groups (one group in each of three consecutive years) of purebred Angus replacement heifers (n = 88). Trait information was obtained at weaning (7 to 8 mo), yearling (10 to 11 mo) and prior to the breeding season (13 to 14 mo).

Data were collected for the following traits: body weight (BW), height and width at hips (HH and HW, respectively), pelvic height and width (PH and PW, respectively), longissimus muscle area (LMA) and backfat thickness (BKFAT). A sliding caliper, developed specifically to measure external body dimensions in beef cattle, was used to measure HH and HW. Measurements for PH and PW were taken per rectum using a Rice Pelvimeter (Lane Manufacturing, Denver, CO). Longissimus muscle area and BKFAT were determined by ultrasonic measurements. An individual technician conducted all ultrasound scans using real-time ultrasonography (Aloka 500 Vâ, Corometrics, Wallingford, CT, equipped with a 3.5-MHz, 17 cm transducer with superflab attachment). Measurements were taken between and parallel to the 12th and 13th ribs 4 inches from the dorsal midline. Ultrasonic images were captured on tape, and analyzed using the AniMorp software, version 1.4 (Woods Hole Educational Assoc., Woods Hole, MA)

Blood samples also were collected at each of the three measurement ages. Samples were allowed to clot and then centrifuged at 2,300 x g for 30 min. Serum was decanted and stored at –20° C until assayed. Total protein concentration was determined on serum samples using the Biuret method. Serum LDH activity was evaluated using a quantitative, colormetric assay (Sigma Diagnostics, St. Louis, MO) and was reported as I.U. of LDH activity per milligram of serum protein.

Heifers were maintained on common bermudagrass and tall fescue, overseeded with winter annuals of wheat, rye, and ryegrass. In addition, heifers were fed a supplement (1% BW/d) consisting of cracked corn and soybean meal.

Traits were assigned to one of two sets. The first group of traits (Set I) included BW, HH, HW and LDH. The second group of traits (Set II) included PH, PW, LMA and BKFAT. Assignment of traits to

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set was based on the desire to include indicators of skeletal size and body composition in each set. Relationships among these two sets of traits were examined by Pearson correlation and canonical correlation analyses.

The objective of the canonical correlation analysis was to find a linear combination of one group of variables (Set I) that had a maximal correlation with a linear combination of a second group of variables (Set II). That process continues until the number of pairs of canonical variables equals the number of variables in the smaller group. Two separate canonical analyses were examined on this data set.

Analysis I compared Set I traits at weaning with prebreeding Set II traits. Analysis II compared yearling Set I traits with Set II traits at prebreeding. Results are presented as correlations of the canonical variates (v1-3, and w1-3) with the original measured variables, along with estimated canonical correlations. Standardized canonical coefficients [(X – mean X)/(SD of X)] for first and second variates of analyses I and II were generated, X represents each trait of either Set I or Set II. Those coefficients were used to generate a score for each heifer. Heifers were then ranked as below or above the mean value for each score. Distribution of heifers calving as a 2-year old and categorized as above or below the mean value for each canonical variate was analyzed by Chi-square analysis.

Results and Discussion

Table 1 presents the means and standard deviations for heifer age and the traits determined. Those data indicate that the heifers had a modest postweaning growth rate (approximately 1.3 lb/day) and were representative of moderately-sized replacement Angus heifers. Table 2 presents the Pearson correlation coefficients between traits determined at either weaning or yearling with those same traits at prebreeding. The simple correlation coefficients were quite variable; however, there were negative ($P < 0.01$) coefficients between weaning or yearling LDH activity with PH and PW at prebreeding. Conversely, BW and HH at weaning or yearling were positively ($P < 0.01$) correlated with PH and PW at prebreeding, indicating taller heifers at weaning had larger pelvic areas prior to the breeding season. Hip width was correlated at all ages with body weight. These results suggest Set I traits at weaning could be useful in describing pelvic dimensions and to a lesser extent body composition at prebreeding.

Canonical correlation analyses of weaning (analysis I), and yearling (analysis II) Set I variables with Set II variables at prebreeding showed these two sets of variables to be highly correlated (Table 3). Both analyses I and II resulted in three significant and independent linear combinations of the two sets of variables. For analysis I, the largest canonical correlation was 0.81. That particular canonical variate had a high positive correlation with hip height and a high negative correlation with LDH of the set I variables, and had high positive correlations with set II variables PH and LMA. For analysis II, the canonical correlations ranged from 0.51 to 0.80. The first canonical variate had relatively high correlations with all of the traits determined except BKFAT. These data suggest that linear combinations could maintain external body dimensions, weight, and rib fat thickness while increasing pelvic area.

Table 4 presents the standardized canonical coefficients for the first and second variates for analyses I and II. Each heifer's score was classified as above or below the mean canonical score for all heifers. Table 5 presents the percentage of heifers calving for each ranking within analyses I and II. For analysis I, heifers with canonical scores below the mean v1 had a greater ($P < 0.06$) percentage of heifers calving as a 2-year old than those with scores above the mean. Conversely, for analysis I, heifers with canonical scores above the mean v2 had an increased ($P < 0.02$) calving rate when compared with those heifers with canonical scores below the mean. When Set II traits were used to develop canonical coefficients (w1 and w2) there were no differences ($P > 0.3$) in calving rates. Collectively, these results suggest that at weaning Set I traits (BW, HH, HW, LDH) could be used to segregate heifers into groups that would be more likely to calve as 2-year olds. Set II traits (PH, PW, LMA, BKFAT) at neither weaning nor yearling were useful in segregating heifers into calving groups.

Implications

Our results confirm the high correlation between internal and external measurements of heifer long-bone growth. Selection of replacement heifers using data from Set I traits (body weight, hip height, hip width, and lactate dehydrogenase activity) at weaning could be used to increase the percentage of heifers that calve as a 2-year old. Those traits were associated with increased pelvic area at breeding, which may decrease dystocia. While pelvic dimensions alone will not prevent dystocia, heifers with larger pelvic openings should have fewer problems in calf delivery.

Table 1. Means and standard deviations (SD) for weaning, yearling and prebreeding traits of Angus heifers

Trait[a]	Weaning (SD)	Yearling (SD)	Prebreeding (SD)
Age (d)	245 (19.6)	341 (23.6)	416 (19.1)
BW (lb)	397 (57.5)	526 (75.6)	626 (80.1)
HH (in)	39.7 (2.37)	42.9 (2.74)	44.4 (2.97)
HW (in)	12.8 (1.32)	13.4 (1.00)	14.7 (1.05)
PH (in)	3.80 (0.788)	4.30 (0.718)	5.01 (0.514)
PW (in)	3.44 (0.432)	4.07 (0.389)	4.25 (0.454)
LMA (in^2)	4.22 (0.725)	4.97 (0.727)	5.92 (0.929)
BKFAT (in)	0.12 (0.042)	0.13 (0.039)	0.17 (0.041)
LDH (IU/mg protein)	603 (266)	768 (321)	719 (264)

[a]Traits are age of heifer at time of measurement, body weight (BW), hip height (HH), hip width (HW), pelvic height (PH), pelvic width (PW), ultrasonic longissimus muscle area (LMA) and backfat thickness (BKFAT) between the 12th and 13th ribs, and serum lactate dehydrogenase (LDH) activity.

Table 2. Pearson correlation coefficients of body measurements at weaning or yearling with those at prebreeding of Angus heifers

		Prebreeding							
Measurement[a]	Date of measurement	WT	HH	HW	PH	PW	LMA	BKFAT	LDH
BW	Weaning	0.77**	0.67**	0.74**	0.47**	0.53**	0.46**	0.22*	-0.25*
	Yearling	0.88**	0.74**	0.81**	0.53**	0.59**	0.49**	0.25*	-0.32**
HH	Weaning	0.68**	0.75**	0.55**	0.53**	0.40**	0.46**	-0.07	0.06
	Yearling	0.78**	0.87**	0.68**	0.66**	0.56**	0.46**	0.04	-0.13
HW	Weaning	0.49**	0.28*	0.77**	-0.22	0.14	-0.01	0.19	-0.71**
	Yearling	0.76**	0.67**	0.65**	0.57**	0.50**	0.55**	0.13	-0.02
PH	Weaning	0.12	0.48**	0.11	0.48**	0.57**	0.08	0.14	-0.25*
	Yearling	0.13	0.40**	0.06	0.68**	0.66**	0.23*	0.05	-0.06
PW	Weaning	0.39**	0.27**	0.33**	0.08	-0.01	0.28**	0.05	0.17
	Yearling	0.47**	0.24*	0.41**	0.21*	0.14	0.42**	0.11	0.17
LMA	Weaning	0.63**	0.42**	0.56**	0.21	0.23*	0.59**	0.18	-0.05
	Yearling	0.74**	0.48**	0.61**	0.31**	0.29**	0.70**	0.26*	-0.04
BKFAT	Weaning	0.18	-0.10	0.39**	-0.14	0.12	-0.06	0.54**	-0.46**
	Yearling	0.25*	-0.14	0.39**	-0.12	0.10	0.06	0.60**	-0.30**
LDH	Weaning	0.17	-0.20*	0.34**	-0.58**	-0.39**	-0.17	-0.01	-0.25*
	Yearling	-0.02	-0.29**	-0.16	-0.28**	-0.59**	0.13	-0.03	0.68**

[a]BW = Body weight, HH = hip height, HW = hip width, PH = pelvic height, PW = pelvic width, LMA = longissimus muscle, BKFAT = backfat thickness,and LDH = lactate dehydrogenase.
*P < 0.05; **P < 0.01.

Table 3. Results of canonical correlation analyses of measurements at weaning and yearling with measurements at prebreeding of Angus heifers (Analyses I and II)

Measurement	Correlations with canonical variates (Analysis I)			Correlations with canonical variates (Analysis II)		
Set I[a]	v_1	V_2	v_3	v_1	v_2	V3
Body weight	0.41	-0.08	0.90	0.80	0.25	0.51
Hip height	0.70	0.51	0.34	0.90	0.28	-0.08
Hip width	-0.21	-0.13	0.87	0.79	0.46	0.19
Lactate dehydrogenase	-0.80	0.20	0.55	-0.55	0.79	-0.27
Set II[b]	w_1	W_2	w_3	w_1	w_2	w3
Pelvic height	0.94	0.12	-0.06	0.89	0.13	-0.27
Pelvic width	0.37	0.49	0.77	0.88	-0.37	0.27
Longissimus muscle	0.76	-0.33	0.21	0.49	0.82	0.24
Backfat thickness	0.07	-0.76	0.53	0.06	0.17	0.72
Canonical correlation	0.81**	0.48**	0.38+	0.80**	0.57**	0.51**

[a]Set I measurements were taken at weaning for Analysis I and at yearling for Analysis II.
[b]Set II measurements were taken prior to breeding for both analyses.
+P < 0.1; **P < 0.01

Table 4. Standardized canonical coefficients[a] for first and second variates for analyses I and II

Measurement	Analysis I		Analysis II	
Set I	v_1	v_2	v_1	v_2
Body weight	0.4791	-0.0563	-0.3123	0.4877
Hip height	0.3015	1.1334	0.6853	0.0383
Hip width	-0.1788	-1.1904	0.4931	0.1641
Lactate dehydrogenase	-0.6898	1.2813	-0.4345	1.0074
Set II	w_1	w_2	w_1	w_2
Pelvic height	0.7432	0.0512	0.4504	0.2096
Pelvic width	-0.0057	0.6199	0.5686	-0.6876
Longissimus muscle	0.4102	-0.2981	0.2114	0.8617
Backfat thickness	-0.0650	-0.7776	-0.1115	0.0521

[a]Individual canonical variable scores may be calculated for Set I and Set II by multiplying appropriate standardized canonical coefficient by standardized observation [i.e. (X - mean X)/(SD of X)] and summing over all traits for Set I or Set II, respectively.

Table 5. Results of Chi-square analyses for calving status versus high or low ranking of standardized canonical variates

			Calved[a]		
Analysis	Ranking[b]	N[c]	N	Percent	Chi-square statistic[d]
I	High v_1	35	16	46	
	Low v_1	24	17	71	3.64
I	High v_2	26	19	73	
	Low v_2	33	14	42	5.54
II	High v_1	52	35	67	
	Low v_1	36	19	53	1.89
II	High v_2	34	20	59	
	Low v_2	54	28	52	0.41
I	High w_1	33	17	52	
	Low w_1	26	16	62	0.59
I	High w_2	29	17	59	
	Low w_2	30	16	53	0.17
II	High w_1	51	33	65	
	Low w_1	37	21	57	0.57
II	High w_2	45	30	67	
	Low w_2	43	24	56	1.09

[a]Represents the number of heifers, and the percentage of heifers within that ranking that calved as a two-year old.
[b]Variates were ranked as high if they were above zero and as low if they were below zero; i.e. above or below the mean for the standardized canonical variable score.
[c]Number of heifers within that ranking and analysis.
[d]Chi-square analysis of calving (yes vs. no) and ranking (high vs. low) within canonical variate analysis. Significant Chi-square statistics were 3.64 (P = 0.06) and 5.54 (P = 0.02).