The Search For A Combination Of Carcass And Productivity Traits In Brahman Cattle

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Introduction

The Brahman breed is important to the cow-calf industry throughout the southern U.S. The breed's tolerance to heat, diseases including internal and external parasites, and to the low quality forage resources have established the dominance of the Brahman as the breed of choice for adaptation to warm climates. Crossbreeding research has documented the maternal superiority of crossbred Brahman cows in many environments and production situations. However, following the report of Crouse et al. (1989) a persistent criticism of Brahman crossbred cattle has been that Brahman crossbred cattle have lower carcass quality grades and more variable tenderness than many other breed types. This has resulted in significant discounts in the market place for Brahman-type calves. If within breed selection could improve carcass traits such as marbling score, USDA quality grade, and(or) tenderness, cow-calf producers would be able to address industry concerns for these traits and continue to benefit from the excellent performance of crossbred Brahman cows without receiving discounts for calves at marketing. Thus, the potential for improvement of beef traits in the Brahman breed needed to be adequately assessed. The objectives of this study were to use progeny testing to estimate the heritabilities for carcass and tenderness traits in the Brahman breed and to predict breeding values for these traits in Brahman bulls.

Materials And Methods

At the Subtropical Agricultural Research Station (STARS) located near Brooksville, FL, feedlot and carcass data of Brahman calves (n = 504, including 258 heifers and 246 steers) sired by 22 Brahman bulls were collected over 5 years (1996 through 2000). Beginning in 1994, Brahman cows were separated into breeding herds of approximately 30 to 50 and each group was exposed to a single Brahman sire. Five or six registered Brahman sires were used each year; most were loaned to STARS by purebred producers. In each year after the first, one bull that sired calves in the previous year was again used to facilitate comparison of data across years. The average number of progeny per sire was 22.9, and ranged from seven for a sire used in the 1996 breeding season (this bull was injured early in the breeding season) to 50 for a sire with calves born in 1998 and 1999.

The breeding season began on March 20 of each year and lasted 105 days. Calves were born from late December through late April or early May of each year. Shortly after birth, calves were weighed and tagged, and bull calves were castrated. Calves were weaned in September of each year at approximately 7 months of age. After a 2 to 3 week postweaning conditioning period, calves were sorted into feedlot pens by gender and weight. Calves were started on a diet that consisted of 55% corn, 25% cottonseed hulls and(or) ground hay, 15% supplement (that contained melengestrol acetate for heifers, and monensin, vitamin A, and microminerals for all calves), and 5% molasses. They were gradually changed to the final diet over approximately 28 days. The final diet consisted of 72.5% corn, 15% cottonseed hulls and (or) ground hay, 7.5% supplement, and 5% molasses. Steer and heifer calves were implanted with Synovex-S and Synovex-H, respectively, both at 0 and 112 days of feeding. After approximately 140 days of feeding, external fat cover was estimated monthly using real-time ultrasound. When the median backfat of the animals in a pen was 0.4 inches, full and shrunk weights were obtained on consecutive days, hip height was measured, and the entire pen was slaughtered at Central Packing Co. in Center Hill, FL. Approximately 18 hours after slaughter, carcasses were graded for USDA quality and yield factors. A strip loin was removed from each carcass and was cut into 1.0 in steaks that were vacuum-packaged, aged for 7, 14, or 21 days, and then frozen. At a later date steaks were thawed and cooked prior to analysis for Warner-Bratzler shear (a mechanical method of testing tenderness) and sensory panel (day 14). The traits evaluated and their unadjusted means and standard deviations are shown in Table 1.

The statistical models used to analyze the traits of this study included contemporary group as a fixed effect and animal as a random effect. A contemporary group was a pen of calves of the same gender that were slaughtered on the same date. There were 44 contemporary groups for all traits in the study, with an average of 11.45 calves per group. Age in days at slaughter was included as a continuous variable in all analyses. Restricted maximum likelihood procedures of MTDFREML were used to estimate heritabilities and to calculate predicted breeding values and standard errors of prediction. Accuracies of predicted breeding values were calculated using BIF guidelines.

Results And Discussion

Estimated heritabilities for traits are presented in Table 1. Heritability represents the proportion of the total phenotypic variation due to additive genetics, and so has a theoretical range from 0 to 1 (absolutely none to total genetic control). Higher estimates of heritability generally indicate that trait improvement by selection is possible. However, lower estimates do not exclude improvement by selection, but may be indicative of a longer, more difficult process. Most published estimates of heritability for a variety of traits in cattle range from 0.1 to 0.7.

The estimated heritabilities for carcass traits were moderate to large (Table 1), and indicate that effective selection programs for any of these traits could be implemented. Estimates were consistent with most other published estimates from other breeds or breed types of cattle. The moderate estimates of heritability for marbling score (0.44) and USDA quality grade (0.47) observed in this study are especially important. Apparent genetic differences in marbling score within the Brahman breed recently have been reported in Australia (Gazzola et al., 1998), where a Brahman sire was identified whose steer progeny (out of Brahman, Belmont Red, British, and Brahman-British cross cows) had significantly higher marbling scores than steers sired by other Brahman bulls. The estimates of heritability for marbling score and USDA quality grade of this study and similar results in crossbred Brahman and *Bos taurus* steers (O'Connor et al., 1997), and the results of Gazzola et al. (1998) provide a basis of support for sire selection within the breed for improvement of these traits.

Estimates of heritability for traits related to tenderness and palatability were less than 0.15, indicating that there is substantial non-additive genetic and environmental influences on phenotypic variation in these types of traits in Brahman cattle. Most estimates in the literature for similar traits were near 0.3 (e.g., Koots et al., 1994), including those involving Brahman straightbreds and crossbreds (Crews and Franke, 1998; Elzo et al., 1998), but there are many estimates from the literature that were similarly low (Van Vleck et al., 1992; Gregory et al., 1995; Wulf et al., 1996).

The low estimate of heritability for calpastatin activity was consistent with that (0.15) reported for *Bos indicus*-influenced American composites (O'Connor et al., 1997), but much lower than the high estimate (0.65) of Shackelford et al. (1994). The higher levels of postmortem calpastatin activity in Brahman cattle inhibit the enzymes responsible for tenderization (muscle cell degradation) to a greater extent than that in *Bos taurus* cattle. Although selection based on calpastatin activity seemed promising based on results of Shackelford et al. (1994) and on the substantial differences in calpastatin activity for Brahman as compared to *Bos taurus* beef (Pringle et al., 1997, 1999), it now appears that selection for tenderness or shear force values directly would be at least as (possibly more) effective. It is important to note that other than aging, no post-slaughter treatments were implemented for improvement of quality or tenderness in the present study.

Predicted breeding values (PBV) for the analyzed traits are presented in Tables 2 through 5 for each of the 22 sires (coded). They are presented in units of the trait (lb, in, etc.) along with their standard error of prediction and accuracy. For a given trait, the PBV is an estimate of twice the average amount a large number of progeny would be expected to deviate from the population average for this trait. This is similar to the familiar Expected Progeny Differences (EPDs); an EPD represents an estimate of one-half of the breeding value for a given trait. Predicted breeding values have comparative rather than absolute value. For example, the day 14 shear force PBVs for sires 3 and 6 were –1.77 and 0.96 lb, respectively. This means that we would expect a large number of sire 3's progeny to have an average day 14 shear force that is 1.365 lb less (more tender) than the average day 14 shear force for a large number of progeny from sire 6:

Sire 6	$0.96 \times ½$	= 0.48
Sire 3	$-1.77 \times ½$	= –0.885
Difference		= 1.365 lb

Predicted breeding values are never estimated perfectly, but those with higher accuracies are expected to be more reliable. Even though sire 3 has the best PBV for day 14 shear force of the sires evaluated, he could produce progeny with any (within the biological limits of the trait) day 14 shear force value, including poor values, because of the degree of uncertainty still associated with our estimate of his breeding value.

As another example, the PBVs for marbling score and USDA quality grade for sire 13 were 84.80 and 61.07, respectively, and for sire 10 were –39.52 and –32.43. This means that we would expect a large number of sire 13's progeny to have an average marbling score 62.2 units higher than, and an average USDA quality grade 46.7 units higher than the averages of a large number of progeny from sire 10. Also notice that for sire 13, the PBV for ribeye area was nearly the largest (0.65 in^2), however, the PBV for day 14 shear force for this bull was unfortunately, higher than most (0.44 lb). Thus, this information provides additional tools for breeders to use at their discretion in the selection for carcass and production traits.

Implications

Caution is necessary when interpreting results because of the relatively small data set. However, results from this study indicate that moderate to high levels of heritability were observed for feedlot production and carcass traits in Brahman cattle. The moderate estimates of heritability observed for marbling score and USDA quality grade indicate that these traits would be responsive to selection in the Brahman breed. Estimates of heritability for tenderness traits were lower and indicate that improvement in these traits by selection would likely be slow, and should be complemented by use of post slaughter technologies to enhance tenderness. Predicted breeding values for the sires used in this study could be used as a tool to guide selection for enhanced production, carcass quality, and tenderness in Brahman cattle.

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Table 1. Unadjusted means ($\bar{x}$), standard deviations (SD), and estimates of heritability (h^2) for feedlot, carcass, and tenderness traits of Brahman cattle.

Trait	N	$\bar{x}$	SD	h^2
Average daily gain, lb	504	2.43	0.38	0.64
Hip height, in	504	53.10	2.61	0.67
Slaughter wt , lb	504	977.98	122.80	0.47
Shrink, %	504	3.37	1.34	0.26
Adj. fat thickness, in	504	0.53	0.15	0.63
Hot carcass wt, lb	503	624.76	83.38	0.55
Dressing percentage	503	63.85	2.27	0.77
Loin muscle area, in^2	504	11.25	1.20	0.44
KPH fat, %	504	2.29	0.67	0.46
Yield grade	503	3.08	0.56	0.71
Marbling score[a]	504	323.75	57.19	0.44
Quality grade[b]	504	525.95	42.87	0.47
Shear force, d-7, lb	503	12.3	4.26	0.14
Shear force, d-14, lb	502	11.62	3.75	0.14
Shear force, d-21, lb	504	10.63	3.55	0.06
Panel tenderness[c]	503	4.93	0.72	0.11
Calpastatin activity, mg/g	490	2.69	1.17	0.07

[a]200 to 299 = Traces; 300 to 399 = Slight; 400 to 499 = Small.
[b]400 to 499 = Standard; 500 to 599 = Select; 600 to 699 = Choice.
[c]Panel tenderness measured on a scale from 1 to 8: 1 = extremely tough, 4 = slightly tough, 5 = slightly tender, 8 = extremely tender.

Table 2. Predicted breeding values (PBV), standard errors of prediction (SE), and accuracies (Acc) for feedlot average daily gain (ADG), hip height at slaughter, slaughter weight, and percentage shrink.

	ADG, lb			Hip height, in			Slaughter wt, lb			Shrink, %		
Sire	PBV	SE	Acc	PBV	SE	Acc	PBV	SE	Acc	PBV	SE	Acc
1	–0.15	0.15	0.38	–0.86	0.85	0.36	–32.68	34.37	0.29	0.67	0.43	0.21
2	–0.19	0.15	0.38	0.45	0.82	0.38	–47.15	33.14	0.32	–0.73	0.42	0.22
3	0.00	0.13	0.47	1.54	0.67	0.50	6.03	27.45	0.43	0.06	0.37	0.32
4	0.22	0.15	0.38	1.00	0.77	0.42	45.92	31.31	0.36	0.25	0.40	0.26
5	0.04	0.15	0.38	–1.54	0.83	0.38	10.87	33.22	0.32	–0.16	0.42	0.22
6	0.08	0.15	0.38	–1.03	0.84	0.37	6.76	33.93	0.30	0.14	0.43	0.21
7	–0.31	0.11	0.56	–0.99	0.63	0.53	–61.99	26.01	0.46	0.76	0.35	0.35
8	0.35	0.13	0.47	1.47	0.74	0.45	65.93	30.05	0.38	–0.09	0.39	0.28
9	0.06	0.13	0.47	1.44	0.74	0.44	34.66	30.25	0.38	–0.37	0.39	0.28
10	–0.14	0.15	0.38	0.59	0.75	0.43	–21.44	30.78	0.37	–0.10	0.40	0.26
11	–0.06	0.18	0.29	0.33	0.92	0.31	–8.92	36.84	0.24	–0.06	0.46	0.15
12	0.02	0.15	0.38	–0.60	0.76	0.43	–2.99	31.31	0.36	–0.32	0.41	0.24
13	0.16	0.11	0.56	0.52	0.61	0.54	24.55	25.02	0.48	0.02	0.34	0.37
14	–0.08	0.13	0.47	0.72	0.73	0.45	–9.50	29.85	0.39	–0.21	0.39	0.28
15	0.34	0.13	0.47	1.01	0.73	0.45	58.15	29.87	0.39	0.10	0.39	0.28
16	–0.07	0.11	0.56	–0.23	0.60	0.55	–16.80	24.27	0.50	–0.14	0.32	0.41
17	0.04	0.13	0.47	–1.96	0.70	0.47	–2.23	28.79	0.41	–0.10	0.38	0.30
18	–0.10	0.15	0.38	–0.15	0.78	0.41	–5.58	31.99	0.34	0.54	0.42	0.22
19	–0.18	0.13	0.47	0.41	0.75	0.43	–37.40	30.31	0.38	–0.04	0.39	0.28
20	–0.24	0.13	0.47	–0.50	0.74	0.44	–38.51	29.72	0.39	–0.04	0.38	0.30
21	–0.04	0.13	0.47	–0.05	0.74	0.44	–11.08	29.83	0.39	–0.35	0.38	0.30
22	0.23	0.15	0.38	–0.58	0.77	0.42	39.25	31.00	0.36	0.30	0.40	0.26

Table 3. Predicted breeding values (PBV), standard errors of prediction (SE), and accuracies (Acc) for fat thickness, hot carcass weight, dressing percentage, and ribeye area.

	Fat thickness, in			Hot carcass wt, lb			Dressing %			Ribeye area, in^2		
Sire	PBV	SE	Acc	PBV	SE	Acc	PBV	SE	Acc	PBV	SE	Acc
1	0.11	0.07	0.35	–15.22	24.43	0.31	1.12	0.98	0.39	0.28	0.46	0.28
2	–0.10	0.07	0.38	–43.09	23.50	0.34	–1.23	0.94	0.41	–1.18	0.44	0.31
3	–0.16	0.06	0.50	–14.18	19.22	0.46	–1.94	0.76	0.53	0.06	0.37	0.42
4	0.05	0.07	0.42	52.98	22.11	0.38	2.04	0.88	0.45	0.69	0.42	0.34
5	–0.03	0.07	0.38	–2.22	23.59	0.34	–1.12	0.95	0.41	0.33	0.44	0.30
6	0.19	0.07	0.36	13.04	24.03	0.32	0.93	0.96	0.40	–0.03	0.45	0.29
7	–0.21	0.05	0.53	–43.73	18.17	0.49	–0.21	0.71	0.56	–0.30	0.35	0.45
8	–0.03	0.06	0.44	41.63	21.19	0.40	–0.52	0.84	0.48	0.11	0.40	0.37
9	0.02	0.06	0.44	27.97	21.32	0.40	0.38	0.85	0.47	0.23	0.40	0.36
10	–0.15	0.06	0.43	–15.13	21.67	0.39	–0.12	0.86	0.46	–0.27	0.41	0.35
11	–0.02	0.08	0.30	–5.59	26.26	0.26	0.07	1.06	0.34	–0.23	0.49	0.23
12	0.13	0.07	0.42	–7.78	22.05	0.38	–0.81	0.87	0.46	–0.29	0.42	0.34
13	0.08	0.05	0.54	–2.48	17.53	0.51	–2.36	0.69	0.57	0.65	0.33	0.47
14	–0.04	0.06	0.45	–14.61	21.01	0.41	–1.03	0.83	0.48	–0.86	0.40	0.37
15	0.13	0.06	0.44	46.46	21.08	0.41	0.72	0.84	0.48	0.12	0.40	0.37
16	–0.07	0.05	0.55	–18.40	17.15	0.52	–0.78	0.69	0.57	0.21	0.32	0.49
17	0.02	0.06	0.46	0.12	20.28	0.43	0.02	0.81	0.50	–0.04	0.38	0.40
18	–0.06	0.07	0.41	8.54	22.46	0.37	1.53	0.88	0.45	–0.03	0.43	0.33
19	–0.03	0.06	0.43	–21.21	21.47	0.40	0.72	0.86	0.46	–0.25	0.40	0.36
20	–0.04	0.06	0.44	–30.36	21.08	0.41	–0.20	0.85	0.47	–0.29	0.40	0.38
21	0.01	0.06	0.44	–5.49	21.16	0.40	0.43	0.86	0.46	0.31	0.40	0.38
22	–0.05	0.07	0.42	31.01	22.00	0.38	0.73	0.89	0.45	0.34	0.41	0.35

Table 4. Predicted breeding values (PBV), standard errors of prediction (SE), and accuracies (Acc) for kidney, pelvic, and heart fat percentage (KPH), USDA yield grade, marbling score, and USDA quality grade.

	KPH fat, %			USDA yield grade			Marbling score			USDA quality grade		
Sire	PBV	SE	Acc	PBV	SE	Acc	PBV	SE	Acc	PBV	SE	Acc
1	0.32	0.29	0.29	0.2	0.28	0.37	56.62	25.06	0.28	38.07	19.04	0.29
2	–0.08	0.28	0.32	–0.02	0.27	0.39	–50.40	24.19	0.30	–35.69	18.36	0.32
3	–0.56	0.23	0.44	–0.57	0.22	0.50	–31.06	20.16	0.42	–25.23	15.23	0.43
4	–0.18	0.27	0.34	0.08	0.25	0.44	5.13	22.89	0.34	2.53	17.35	0.35
5	0.05	0.28	0.32	–0.18	0.27	0.39	6.42	24.24	0.30	2.39	18.41	0.31
6	–0.01	0.29	0.29	0.47	0.27	0.39	17.05	24.77	0.29	15.35	18.8	0.30
7	–0.95	0.22	0.46	–0.76	0.2	0.55	–17.86	19.14	0.45	–7.66	14.44	0.46
8	0.21	0.26	0.37	0.09	0.24	0.46	–24.20	22.00	0.37	–17.68	16.66	0.38
9	–0.05	0.26	0.37	0.07	0.24	0.46	–24.87	22.14	0.36	–21.46	16.77	0.38
10	–0.29	0.26	0.37	–0.43	0.24	0.46	–39.52	22.53	0.35	–32.43	17.06	0.36
11	–0.25	0.31	0.25	0.16	0.3	0.32	–18.09	26.82	0.23	–14.91	20.41	0.24
12	0.27	0.27	0.34	0.46	0.25	0.44	20.31	22.91	0.34	24.62	17.35	0.35
13	0.18	0.21	0.49	0.03	0.2	0.55	84.80	18.37	0.47	61.07	13.88	0.48
14	–0.14	0.25	0.39	0.14	0.24	0.46	–24.37	21.87	0.37	–17.18	16.55	0.38
15	0.78	0.25	0.39	0.61	0.24	0.46	–18.57	21.86	0.37	–15.8	16.56	0.38
16	–0.02	0.21	0.49	–0.33	0.2	0.55	0.23	17.77	0.49	–2.84	13.46	0.50
17	0.46	0.24	0.42	0.21	0.23	0.48	25.67	21.09	0.39	21.12	15.96	0.41
18	0.00	0.27	0.34	–0.09	0.25	0.44	0.80	23.44	0.33	–8.53	17.74	0.34
19	0.02	0.26	0.37	–0.13	0.25	0.44	–26.97	22.15	0.36	–20.21	16.8	0.37
20	0.05	0.25	0.39	–0.20	0.24	0.46	–13.56	21.71	0.38	–10.61	16.47	0.39
21	–0.26	0.25	0.39	–0.19	0.24	0.46	–5.01	21.77	0.37	–5.85	16.52	0.38
22	–0.67	0.26	0.37	–0.38	0.25	0.44	35.13	22.62	0.35	24.54	17.17	0.36

Table 5. Predicted breeding values (PBV), standard errors of prediction (SE), and accuracies (Acc) for tenderness measures and calpastatin activity.

	Shear force, d 7			Shear force, d 14			Shear force, d 21			Calpastatin activity			Panel tenderness		
Sire	PBV	SE	Acc	PBV	SE	Acc	PBV	SE	Acc	PBV	SE	Acc	PBV	SE	Acc
1	1.02	0.88	0.12	0.82	0.84	0.13	0.09	0.55	0.06	0.04	0.15	0.06	–0.07	0.2	0.08
2	–0.79	0.86	0.15	–0.30	0.84	0.13	–0.13	0.55	0.06	–0.13	0.15	0.06	–0.05	0.19	0.13
3	–1.19	0.79	0.21	–1.77	0.77	0.20	–0.83	0.53	0.10	–0.14	0.14	0.12	0.23	0.18	0.18
4	0.02	0.84	0.17	–0.29	0.79	0.18	0.09	0.53	0.10	0.17	0.14	0.12	–0.07	0.19	0.13
5	–0.18	0.86	0.15	–0.39	0.82	0.15	–0.30	0.55	0.06	–0.02	0.15	0.06	0.06	0.19	0.13
6	–0.32	0.88	0.12	0.96	0.84	0.13	0.07	0.55	0.06	–0.07	0.15	0.06	–0.05	0.2	0.08
7	0.05	0.77	0.23	–0.71	0.73	0.25	–0.11	0.53	0.10	0.04	0.14	0.12	0.01	0.18	0.18
8	–0.22	0.82	0.19	–0.43	0.79	0.18	0.19	0.53	0.10	0.03	0.14	0.12	0.01	0.18	0.18
9	1.41	0.82	0.19	0.27	0.79	0.18	0.38	0.53	0.10	0.13	0.14	0.12	0.03	0.18	0.18
10	–0.30	0.84	0.17	–0.32	0.82	0.15	–0.41	0.53	0.10	–0.07	0.14	0.12	0.01	0.19	0.13
11	0.00	0.90	0.10	–0.82	0.88	0.09	–0.26	0.55	0.06	0.00	0.15	0.06	0.14	0.2	0.08
12	–0.18	0.84	0.17	0.41	0.82	0.15	–0.16	0.53	0.10	0.01	0.14	0.12	0.02	0.19	0.13
13	0.46	0.73	0.28	0.41	0.71	0.27	0.19	0.49	0.17	–0.07	0.13	0.18	–0.01	0.17	0.22
14	0.06	0.82	0.19	–0.03	0.79	0.18	0.60	0.53	0.10	0.06	0.14	0.12	–0.07	0.18	0.18
15	–0.01	0.82	0.19	0.00	0.77	0.20	–0.12	0.53	0.10	–0.05	0.14	0.12	0.01	0.18	0.18
16	–0.09	0.71	0.30	0.50	0.66	0.31	0.22	0.49	0.17	0.07	0.13	0.18	0.08	0.16	0.27
17	–0.39	0.79	0.21	–0.59	0.77	0.20	–0.12	0.51	0.13	0.10	0.14	0.12	0.30	0.18	0.18
18	0.59	0.88	0.12	0.79	0.84	0.13	0.13	0.57	0.02	0.01	0.15	0.06	–0.28	0.2	0.08
19	0.12	0.82	0.19	0.42	0.77	0.20	0.03	0.53	0.10	–0.10	0.14	0.12	–0.09	0.18	0.18
20	0.54	0.79	0.21	0.53	0.77	0.20	0.00	0.53	0.10	–0.11	0.14	0.12	0.07	0.18	0.18
21	0.10	0.79	0.21	–0.42	0.77	0.20	0.05	0.53	0.10	–0.09	0.14	0.12	–0.13	0.18	0.18
22	–0.50	0.82	0.19	–0.37	0.79	0.18	–0.18	0.53	0.10	0.12	0.14	0.12	0.00	0.18	0.18