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ADDITIVE AND NONADDITIVE GENETIC EFFECTS OF SERUM POTASSIUM AND SODIUM AND WEIGHT AT WEANING IN AN ANGUS-BRAHMAN MULTIBREED HERD[1]

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Introduction

In the southern region of the U.S., beef cattle, which include the Angus (A) and Brahman (B) breeds and more frequently their crosses, are managed under extensive pasture conditions. The pastures utilized are often low in sodium (Na), especially during summer. In Florida, pastures also are low in K during winter (Kiatoko et al., 1982). In tropical countries, minerals are low for longer periods of time. The lactation period for beef cows in Florida often begins in December and lasts approximately seven months, thus imposing strains on Na and K reserves.

Sodium and K are required for osmotic balance between cells and extracellular fluids and for base regulation and water balance in the animal (Underwood, 1981; Beede et al., 1983). Sodium is largely extracellular and occurs mainly in body fluids and bones whereas K is primarily intracellular and occurs mainly in muscle and nervous tissue (Underwood, 1981). In ruminants, Na preserves the acid base balance in the rumen by neutralizing acidic compounds produced by rumen fermentation (Payne and Payne, 1987).

Because K is predominantly found in muscle, a measurement of total body K usually is used as an index of fat free mass in animals (Gibson, 1990). Potassium is the mineral element present in

[1]Animal Breeding Mimeo, University of Florida, 1992, pp 1-19.

highest concentration in milk (.15% K compared to .11% Ca, .08% P, .05% Na) (Underwood, 1981; Beede et al., 1983). Thus, K and Na may become limiting factors in high milk producing cows. Since a lactating cow needs a continuous supply of K and has little capacity for body storage for it, she must consume adequate amounts in her diet to meet daily lactation demands (Beede et al., 1983). Potassium activates amino acid chain elongation during protein synthesis (Lewin, 1970). Increased serum K also causes release of insulin (Church, 1988) which is a growth factor for cells (Darnell et al., 1990). Church (1988) reported that, when there is Na deficiency, growth, milk production and body condition are reduced. In both K and Na deficiencies, feed intake also is reduced (Church, 1988). If choices of breed groups are to be made in relation to their potential for use in alternative breeding systems, each breed group needs to be evaluated for additive and nonadditive genetic effects.

From nutritional and physiological standpoints, K and Na seem to influence growth. However, there is little information concerning genetic effects of K and Na and their influence on growth in beef cattle. Thus, the objectives of this study were:

i) To estimate differences between A and B breed additive direct and maternal genetic effects for serum Na and K and weight at weaning;

ii) To estimate A x B nonadditive direct and maternal genetic effects for serum Na, K and weaning weight; and

iii) To evaluate the combining ability of straightbred (A and B breed groups) and crossbred (.75A.25B, .5A.5B (F_1) and .25A.75B) sire breed groups for serum Na and K and weight at weaning when mated across breed groups of dams.

Materials and Methods

Animals

Data were obtained in 1989 and 1990 from calves reared at the Pine Acres Experimental Farm, near Citra, Florida. The calves were from a multibreed herd involving Angus (A), Brahman (B) and intermediate A x B crosses. Six breed groups of sires consisting of A, B, .75A.25B, .5A.5B, .25A.75B and Brangus (.625A.375B) were mated to five dam breed groups of the same genetic composition (except .25A.75B that were unavailable). The distribution of the number of sires used each year is shown in Table 1. A total of 28 sires were used. Thirteen of these were used in both years. This created connectedness in the herd across the two years. The number of dams used in each year are shown in Table 2. There were a total of 243 dams. Of these, 135 dams were used in both years. A total of 380 calves (Table 3) resulted from the mating of breed groups of sire by breed groups of dam. The largest number of calves were from straightbred groups. For example, there were 26 A, 40 B and 29 Brangus calves.

Management

The cows were synchronized for estrus using Prostaglandin $F_{2\alpha}$ and then inseminated artificially. The A and A x B crosses were inseminated in March while B cows were inseminated in April. The cows were then assigned to six clean up herds for 60 days with one clean up bull representing each breed group of sire.

The cows and calves were grazed on bahiagrass (Paspalum notatum) during summer and fall. During winter and early spring (mid-December to March), they were assigned to six replicated, forage supplementation regimens and a control herd. The supplement consisted of molasses and bermudagrass (Cynodon dactylon) hay fortified with urea (32% N). A free choice mineral supplement containing 20% Ca, 9% P, .25% Mg, 6.12% Na and 18.18% Cl was available to the animals throughout the year. Some of the male calves were castrated.

Records

Birth weight, weaning weight (WW) and intermediate weights between birth and weaning were taken at an interval of five to six weeks. Blood samples were taken concurrently with weights except at birth.

Table 1. NUMBER OF SIRES USED EACH YEAR BY BREED GROUP

	Number of sires		
Sire breed group[a]	1989	1990[b]	Total[c]
A	4	4 (3)	5
.75A.25B	2	3 (2)	3
.5A.5B	2	3 (1)	4
.25A.75B	4	3 (3)	4
B	3	4 (2)	5
Brangus	4	5 (2)	7
Total	19	22 (13)	28

[a]A = Angus, B = Brahman
[b]Number of sires used in 1990 that were used also in 1989 shown in parenthesis
[c]Total number of different sires used

Table 2. NUMBER OF DAMS USED IN EACH YEAR BY BREED GROUP

Dam breed group[a]	Number of dams 1989	1990[b]	Total[c]
A	65	42 (42)	65
.75A.25B	18	14 (14)	18
.5A.5B	30	33 (25)	38
B	52	59 (35)	76
Brangus	25	40 (19)	46
Total	190	188 (135)	243

[a]A = Angus, B = Brahman
[b]Number of dams used in 1990 that were also used in 1989 shown in parenthesis
[c]Total number of different dams used

Table 3. NUMBER OF CALVES PRODUCED BY BREED GROUP OF SIRE BY BREED GROUP OF DAM SUBCLASS

	Breed group of sire[a]						
Breed group of dam	A	.75A.25B	.5A.5B	.25A.75B	B	BRANGUS	TOTAL
A	26	13	7	17	20	24	107
.75A.25B	6	5	3	6	6	6	32
.5A.5B	12	9	5	9	16	12	63
B	14	18	11	15	40	13	111
BRANGUS	8	6	5	8	11	29	67
TOTAL	66	51	31	55	93	84	380

[a]A = Angus, B = Brahman.

Blood samples were obtained by jugular puncture. Blood samples were then centrifuged at 700 g per 30 min to separate the serum from the hematocrit.

Serum samples were deproteinized using 10% trichloroacetic acid (TCA). The deproteinization process involved adding one milliliter (ml) of serum to 9 ml of TCA. Dilutions of 100 and 1000 were made from the deproteinized samples using deionized water. Concentration of K and Na were read (from the 100 factor dilution for K and 1000 factor dilution for Na) using the flame atomic absorption spectrophotometry method (Fick et al., 1979).

It was assumed that growth is linear from birth to weaning. Swiger et al. (1962) reported that the effect of weaning age on weight at weaning in beef cattle is linear. In a similar study, Marlowe et al. (1965) obtained a linear relationship of growth from birth to weaning in Angus and Hereford calves. The curves for WK and that of WNa followed that of WW closely. Thus, WNa, WK and WW were adjusted to 205 days using the Beef Improvement Federation formula (BIF, 1990). To adjust the K and Na concentration for age at 205 days, the first sample taken after birth was used as a substitute for that at birth. The amount of WK and WNa was calculated as a product of concentration and the approximate serum volume. The serum volume was calculated as the product of weight and the proportion of blood relative to weight of the calf (.077; Frandson, 1975) times the proportion of serum relative to blood in the calf (.6; Jesse, 1979). The amounts of serum WK and WNa were expressed in mg whereas WW was expressed in kg.

Calf age at first sampling after birth was divided arbitrarily into 17 periods of 5 days each (one day through 85 days). Six age groups of dams at calving were represented in the data set (3, 4, 5, 6, 7, and 8 years and above).

Genetic Analysis

Data recorded in the study were classified by year, winter management within year, natural service herd within year, calf age at first sampling after birth, sex, age of dam and the sex by age of dam interaction as fixed environmental effects. Genetic effects were regressions on: Angus sire additive, Angus dam additive, A x B direct nonadditive and A x B dam nonadditive. Genetic effects were assumed fixed. Residual effects were assumed random, distributed with zero mean and having a common variance. Age of dam was tested for quadratic and cubic relationship with WK, WNa and WW but the effects were not significant. Thus, only the linear effect was included in the final model. Similarly, interactions among environmental effects were tested for significance but only the sex x age of dam interaction was found significant and, hence, was included in the final model. The model resulted in a singular matrix because the sum of the proportion of alleles for the additive direct and for the additive maternal components equals one. Subsequently, two restrictions were imposed on the matrix to remove the dependency: 1) A breed additive (direct and maternal) were deviated from B breed and 2) A x B nonadditive genetic effects were deviated from the intrabreed intralocus interaction at one locus.

Best linear unbiased estimates (BLUE) were obtained using the two step procedure described by Elzo et al.(1990). In the first step, the BLUE of A sire additive, A dam additive, A x B direct nonadditive and A x B dam nonadditive genetic effects were estimated using the ordinary least squares procedures. The A sire and dam additive genetic effects were defined as linear functions of the expected fraction of A alleles in the sire and the dam of a calf, respectively. The A x B direct and dam nonadditive genetic effects were assumed to be proportional to the expected fraction of AB intralocus combinations in calves and dams. In the second step, the BLUE of the A additive and A x B nonadditive direct and maternal genetic effects were computed as linear combinations of the

BLUE of the genetic effects from step one, as follows: 1) A additive direct genetic effects = 2(A sire additive genetic effect), 2) A maternal genetic effect = A dam additive genetic effects - A sire additive genetic effects, 3) A x B nonadditive direct genetic effect = A x B calf nonadditive genetic effects and 4) A x B nonadditive maternal genetic effects = A x B calf nonadditive genetic effects and 4) A x B nonadditive maternal genetic effects = A x B dam nonadditive genetic effects.

The BLUE of combining ability of breed groups of sires when mated to breed groups of dams was computed as a linear combination of the expected A additive (sire and dam), and nonadditive (direct and dam) genetic effects. Thus, it was computed as a total of all genetic effects weighted by their corresponding coefficients for the fractions of direct and maternal additive and nonadditive genetic effects.

It was assumed that: 1) all interlocus interactions at two or more loci are negligible, 2) all intralocus interbreed interactions are the same for all interbreed combinations.

Because the subclass numbers were unequal, computations were done using the generalized least squares program of Statistical Analysis System (SAS, 1985).

Results and Discussion

Environmental Effects

______Environmental effects for serum WNa and WK and weight at weaning (WW) are shown in Table 4. Only year and sex of calf were important environmental effects common to all three traits ($P<.01$). Church (1988) reported that males have greater percent of body K than females of comparable weight. Thus, the effect of sex might have been significant because males were heavier than females, hence had larger amounts of WK and WNa. Clean up herd was important for WNa

(P <.05) and WW (P <.08). Age of dam was important for WNa (P <.03) and WW (P <.09). The effect of age of dam may be due to differences in milk yield of younger and older cows. Sex of calf by age of dam interaction was important for WNa (P <.07) and WW (P <.04). This effect might have been due to the behavioral mechanism that male calves nurse more frequently and as a result their dams produce more milk. This occurred in studies reported by Cundiff et al. (1966) and by Daley et al. (1987). Winter management within year influenced WNa and WW. This might have been due to the diet the cows were maintained on during the winter. McDowell et al. (1983) reported that winter pastures are deficient in Na. Studies done by Espinoza et al.(1991) showed that beef cattle in central Florida do not get enough Na from forages during winter to meet their nutritional requirements. Thus, it is possible that the cows did not obtain adequate levels of Na to support the milk production on which the calves were dependent. Both WNa and WW were influenced by year (P<.01), winter management (year) (P<.01) and clean up herd within year (P<.05 for WNa, P<.08 for WW), thus, suggesting that both traits are similarly affected by the same environmental effects. This also was suggested by the lack of significance for the effect of calf age at initial sampling (P<.88 for WNa, P<.90 for WW). Thus, WNa followed the pattern of WW better than WK.

Table 4. F-VALUES AND PROBABILITY LEVELS OF ENVIRONMENTAL AND GENETIC EFFECTS FOR SERUM POTASSIUM AND SODIUM AND WEIGHT AT WEANING

		Trait					
		Potassium		Sodium		Weight at weaning	
Source[a]	df	F	P>F	F	P>F	F	P>F
Year	1	25.47	.01	11.31	.01	16.28	.01
Winter management (year)	24	1.36	.12	2.13	.01	2.56	.01
Clean up herd (year)	10	.97	.47	1.89	.05	1.70	.08
Calf age at first sampling	16	.81	.67	.61	.88	.58	.90
Sex of calf	2	15.42	.01	14.83	.01	20.63	.01
Age of dam	5	1.66	.14	2.48	.03	1.93	.09
Sex of calf x age of dam	10	1.57	.11	1.76	.07	1.92	.04
Angus sire additive[b]	1	10.16	.01	11.58	.01	12.23	.01
Angus dam additive[b]	1	.04	.83	.52	.47	1.66	.20
A x B direct nonadditive[c]	1	4.35	.04	21.46	.01	21.38	.01
A x B maternal nonadditive[c]	1	23.16	.01	88.26	.01	115.88	.01

[a]Residual mean squares were 50.073 mg^2 for weaning potassium, 3846.212 mg^2 and .0435 kg^2 for weaning weight; df residual effects = 308
[b]Angus additive genetic effects are expressed as deviations from Brahman
[c]A x B intralocus nonadditive genetic effects are defined as deviations from those of the parental breeds; A = Angus; B = Brahman

Genetic Effects

Genetic effects for serum Na and WK and weight at weaning are shown in Table 4. All genetic effects were important for the three traits except the Angus dam additive effect that was not significant (P>.46 for WNa and WK and P<.20 for WW). The BLUE for genetic effects are shown in Table 5. Angus sire additive genetic effect was large, negative and significant (P<.01) for all the traits. The Angus direct additive genetic effect was -216.70 ± 63.68 mg for WNa, -23.16 ± 7.26 mg for K and -.74 ± .22 kg for WW which suggests that B sires had significantly higher genetic abilities for WNa, WK and WW than A sires. Thus, B alleles in sires promoted larger amounts of WNa and WK and higher WW. This agrees with studies done by Bailey (1981) who found B sired calves to exceed (P<.01) progeny of A bulls in WW. Thus, to maximize or optimize these traits, B would be more suitable as a sire breed than A in a crossbreeding program involving A and B breeds.

The A dam additive genetic effects (.5 direct plus maternal) were small and positive with large standard errors for all three traits. Thus, the values (23.44 ± 32.65 mg WNa, .79 ± 3.73 mg WK and .14 ± .11 kg WW) were not significant. This suggests that A and B dams did not differ on these traits. However, A additive maternal genetic effects were large and significant (131.79 ± 56.37 for WNa, 12.37 ± 5.21 for WK, .52 ± .16 for WW; P <.05) indicating that A has better maternal genetic abilities for WNa, WK and WW than B. This would also indicate that the B direct additive genetic effects in the dam was more important than maternal for these traits. However, since the dam effect of A and B breeds were similar, either A or B would be suitable as dams in a crossbreeding program involving A and B breeds to maximize WNa, WK and WW.

Additive genetic effects (sire and dam) accounted for only .9, 1.4 and .9% of the total genetic effects for WNa, WK and WW, respectively. This difference of .5% between WNa and WK and between WK and WW may not be significant. Thus, the proportion of additive genetic effects relative to total genetic effects for WNa, WK and WW was essentially the same for the three traits.

The BLUE for A x B direct nonadditive genetic effects were large, positive and significant for all traits (5931.66 ± 1280.58 mg WNa, 304.58 ± 146.11 mg WK and 19.91 ± 4.31 kg WW). Thus, the interaction of A and B alleles promoted large genetic values for WNa, WK and WW. The A x B nonadditive direct genetic effect for WW concurred with 21.20 ± 3.60 kg reported by Peacock et al. (1981) and 24.20 ± 1.04 kg reported by Wyatt and Franke (1986). These results suggest that A x B crossbred calves may be superior to straightbred A and B calves in one or more of grazing efficiency, digestive efficiency, efficiency of absorption of nutrients, metabolism and excretion of Na and K.

The direct nonadditive genetic effects accounted for 38.3%, 35.1% and 35.1% of the total genetic effects for WNa, WK and WW. Thus, WK followed the pattern shown by WW better than WNa.

The intrabreed intralocus interactions for the maternal nonadditive genetic effects were significant ($P<.01$) and about one and a half times larger than the direct nonadditive genetic effects (9422.95 ± 1003.02 mg WNa, 550.72 ± 114.44 mg WK and 36.31 ± 3.37 kg WW). This indicates that calves produced by A x B crossbred dams had higher amounts of WNa, and WK and larger WW than those produced by A and B straightbred dams. Reynolds et al. (1978) reported that A x B crossbred dams produce substantially higher milk yields than straightbred A and B dams. Thus, the large WNa, WK and WW realized might have partly been attributed to larger milk yields from crossbred dams. Nonadditive maternal genetic effects accounted for 60.8, 63.5, 64.0 % of the total genetic effects for WNa, WK and WW. Thus, the trend of WK and WW was similar.

Table 5. BEST LINEAR UNBIASED ESTIMATES OF ADDITIVE AND NONADDITIVE GENETIC EFFECTS FOR SERUM POTASSIUM, SODIUM AND WEIGHT AT WEANING

	Trait		
	Potassium	Sodium	Weight at weaning
Genetic effect[a]	mg	mg	kg
Angus sire additive[b]	-11.58 ± 3.63**	-108.35 ± 31.84**	-.38 ± .11**
Angus dam additive[b]	.79 ± 3.73	23.44 ± 32.65	.14 ± .11
A x B direct nonadditive[c]	304.58 ± 146.11*	5931.66 ± 1280.58**	19.91 ± 4.31**
A x B maternal nonadditive[c]	550.72 ± 114.44**	9422.95 ± 1003.02**	36.31 ± 3.37**

[a]A = Angus, B = Brahman
[b]Angus additive genetic effects are expressed as deviations from Brahman
[c]A x B intralocus nonadditive genetic effects are defined as deviations from those of the parental breeds
**P <.01
*P <.05

The similarity of response of WK and WW for all genetic effects in this study could be attributed to the physiological link that exists between K and growth. The elongation process of protein synthesis in which amino acids are esterified to the corresponding transfer RNA requires K (Lewin, 1970). Potassium also activates the activity of glutamylcysteine synthetase enzyme to produce glutamylcysteine which is used in the synthesis of glutathione that is required for synthesis of amino acids (White et al., 1973). On the other hand, Na is a constituent of the enzyme Na, K-ATPase which activates DNA synthesis that is essential for cell growth and differentiation (Lingrel et al., 1990; Kaplan, 1978). Thus, the similar response between WNa and WW might exist because of this metabolic relationship that exists between Na and growth. Similarities between WK and WNa which were also observed in this study. This suggests that the functions of K and Na might be related. This observation supports the findings of Sanchez (1992) in Central Florida who reported K and Na to perform some of the same functions. Underwood (1981) also reported that K can meet the needs of Na. The large nonadditive genetic effects realized in all the traits suggest that the: 1) alleles for WNa, WK and WW are different in A and B breeds, 2) alleles in A and B breeds differ in frequency in these traits, and 3) favorable alleles for these traits exhibit nonadditive gene action. It is generally also recognized that the A breed is not well adapted in the southern region of U.S. The B breed also is somewhat unadapted to the region since the climatic conditions are not as tropical as the region where B originally evolved (the cattle used to develop the B breed in the U.S were largely from Brazil, Sanders, 1980). It is plausible that heterosis might be optimized in an intermediate environment (subtropical) which would be more suitable for the crossbred animals but would not be perfectly suitable for either of the two parental breeds.

Combining Ability of Sire and Dam Breed Groups

The combining abilities (Table 6) are the total of additive and nonadditive genetic effects of using sires of different breed groups in the multibreed herd of A and B breeds and their crosses.

Irrespective of the breed group of sire mated to, calves from F_1 dams had the largest amount of serum WNa and WK and highest WW. This result was due of the large nonadditive maternal genetic effect obtained in the F_1 dams. The largest amount of WNa and WK and highest WW were obtained in calves when B sires were mated to F_1 dams (12,400 ± 1113.28 mg WNa, 703.41 ± 127.02 mg WK and 46.34 ± 3.74 kg WW). This was due to: 1) the extremely large nonadditive A x B maternal genetic effect expressed by F_1 dams (100% maternal heterosis), and 2) large A x B nonadditive direct genetic effect (representing 50% individual heterosis) of calves from F_1 dams. Except for the mating of A sires to .25A.75B dams, calves from .5A.5B (F_2) dams had the second largest amount of serum WNa and WK and highest WW when mated to all breed groups of sire. This was due to the same reasons for F_1 dams. Calves from the mating of A sires x A dams had the lowest combining ability. This was a result of the large negative value for direct additive genetic effects (-216.70 mg WNa, -23.16 mg WK, -.74 kg WW) and low positive additive maternal genetic effects (131.79 mg WNa, 12.37 mg WK, .51 kg WW).

There was a consistent increase in WNa, WK and WW in calves as the proportion of B increased in the breed group of sire. This was a result of 1) high additive genetic values of WNa, WK and WW in B sires (-108.35 ± 31.84 mg WNa, -11.58 ± 3.63 mg WK and -.38 ± .11 kg WW), and 2) higher A x B nonadditive genetic values of WNa, WK and WW in calves from A and crossbred A x B dams sired by B bulls. Thus, the B bulls were superior in both additive genetic and total genetic values (additive plus nonadditive).

Table 6. COMBINING ABILITY OF SIRE BREED GROUPS MATED ACROSS DAM BREED GROUPS FOR SERUM POTASSIUM, AND SODIUM AND WEIGHT AT WEANING

Breed group of dam[1]	Trait[2]	Breed group of sire[1] Angus	.75A.25B	.5A.5B	.25A.75B	Brahman
Angus	WK	-10.79 ± 4.87*	68.25 ± 36.75	147.29 ± 73.06*	226.33 ± 109.48*	305.37 ± 145.92*
	WNa	-84.91 ± 42.74*	1425.09 ± 322.10**	2935.09 ± 640.32**	4445.09 ± 959.48*	5955.09 ± 1278.89**
	WW	-.23 ± .14	4.84 ± 1.08**	9.91 ± 2.15**	14.98 ± 3.23**	20.06 ± 4.30**
.75A.25B	WK	271.68 ± 52.39**	312.64 ± 64.78**	353.61 ± 79.45**	394.58 ± 95.35*	435.55 ± 111.95*
	WNa	4925.75 ± 15.92**	5694.30 ± 567.75**	6462.83 ± 696.29**	7231.38 ± 835.63**	7999.93 ± 981.19*
	WW	18.33 ± 1.54**	20.91 ± 1.91**	23.49 ± 2.34**	26.08 ± 2.81**	28.66 ± 3.30**
.5A.5B(F_1)	WK	691.83 ± 127.01**	694.72 ± 127.01**	697.62 ± 127.01**	700.51 ± 127.01**	703.41 ± 127.02**
	WNa	12292.15 ± 1113.18**	12319.24 ± 38.60**	12346.33 ± 1113.12**	12373.41 ± 1113.17**	12400.50 ± 1113.28**
	WW	45.96 ± 3.74**	46.06 ± 1.91**	46.15 ± 3.74**	46.25 ± 3.74**	46.34 ± 3.74**
.5A.5B(F_2)	WK	416.47 ± 86.48**	419.36 ± 86.43**	422.26 ± 86.39**	425.15 ± 86.36**	428.05 ± 86.34**
	WNa	7580.68 ± 757.97**	7607.76 ± 757.53**	7634.85 ± 757.18**	7661.94 ± 756.91**	7689.03 ± 756.72**
	WW	27.81 ± 2.55**	27.90 ± 2.55**	28.00 ± 2.55**	28.09 ± 2.55**	28.18 ± 2.55**
.25A.75B	WK	423.57 ± 112.31**	388.40 ± 95.58**	353.22 ± 79.57**	318.04 ± 64.81**	282.86 ± 52.38**
	WNa	7879.86 ± 984.30**	7165.49 ± 837.67**	6451.12 ± 697.35**	5736.75 ± 568.03**	5022.38 ± 459.11**
	WW	28.21 ± 3.31**	25.82 ± 2.82**	23.42 ± 2.35**	21.03 ± 1.91**	18.63 ± 1.54**
Brahman	WK	293.00 ± 146.44	219.75 ± 109.83*	146.50 ± 73.22*	73.25 ± 36.61*	0
	WNa	5823.31 ± 1283.40	4367.48 ± 962.55**	2911.66 ± 641.70**	1455.83 ± 320.85**	0
	WW	19.54 ± 4.32**	14.66 ± 3.24**	9.77 ± 2.16**	4.89 ± 1.08**	0

[1]A = Angus, B = Brahman.
[2]Total genetic values for WCa, WP and WMg are expressed in mg, and for WW in kg.
**P < .01

The B x A calves excelled over A x B calves in all the three traits indicating that reciprocal differences were important. The advantage of B x A calves in WW found in this study concurred with the results of the studies done by Turner (1969) in Louisiana and Long et al. (1980) in Texas.

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