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# DIRECT AND MATERNAL GENETIC EFFECTS DUE TO THE INTRODUCTION OF *BOS TAURUS* ALLELES INTO BRAHMAN CATTLE IN FLORIDA: II. PREWEANING GROWTH TRAITS[1]

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**ABSTRACT**

Records of birth weight (BW), weaning weight (WW) and condition score (CS) from 1,467 Brahman and Brahman × Angus crossbred calves from Brahman and crossbred Brahman sires and Brahman, crossbred Brahman and Angus dams were collected at the Subtropical Agricultural Research Station, Brooksville, Florida, from 1971 to 1982. Best linear unbiased estimates (BLUE) of Brahman sire and dam group additive genetic effects (as deviations from Angus) and Brahman × Angus dam and calf group nonadditive (intralocus) genetic effects (as deviations from intralocus group genetic effects in the parental breeds) were obtained. Linear combinations of these were used to compute direct and maternal Brahman additive and Brahman × Angus nonadditive (intralocus) group genetic effects. The respective BLUE of these four effects were 5.99 ± 2.08, –5.70 ± 1.91, .52 ± 1.81 and 2.85 ± .72 kg for BW; 9.60 ± 10.29, 8.76 ± 9.47, 9.47 ± 8.96 and 20.95 ± 3.56 kg for WW; and –1.10 ± .55, 1.64 ± .50, 1.47 ± .47 and .05 ± .19 units for CS. Linear combinations of the BLUE of sire, dam and calf group genetic effects can be used to predict the genetic worth of crossbred groups composed of any combination of Brahman and Angus breeding. Nonadditive maternal group genetic effects were the most important factor for BW and WW, whereas nonadditive direct group genetic effects were the most important for CS.

(Key Words: Brahman, Aberdeen-Angus, Birth Weight, Weaning Weight, Crossbreeding, Maternal Effects.)

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## Introduction

Beef production in Florida is primarily commercial cow-calf production. Thus, cow fertility, calf survival and growth to weaning are important economically for cattle producers in this state. Brahman is used extensively in crossbreeding programs with various *Bos taurus* breeds in Florida and throughout the Gulf Coast region of the U.S. Angus is commonly used in crossbreeding programs with Brahman. Previous studies have found large increases in preweaning growth traits as a result of crossbreeding Brahman and Angus due both to direct and maternal effects (Cundiff, 1970; Koger et al., 1975; Franke, 1980; Peacock et al., 1981; Wyatt and Franke, 1986). Crosses in these studies usually included first-generation Brahman × *Bos taurus* ($F_1$) crossbreds and backcrosses to Brahman and *Bos taurus* bulls. Little or no data are available on estimates of additive and nonadditive direct and maternal group genetic effects on preweaning growth traits in upgraded Brahman, and especially in populations of *Bos indicus* × *Bos taurus* crossbred ancestry mated *inter se*. Growth traits considered were birth weight (BW), weaning weight adjusted to 205 d (WW) and condition score at

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TABLE 1. NUMBER OF CALVES BY BREED GROUP COMPOSITION OF THEIR SIRES AND DAMS

| Breed composition[a] | | | No. of calves |
|---|---|---|---|
| Sire | Dam | Calf | |
| Brahman (B) | Brahman | Brahman | 332 |
| Brahman | 2/3B:1/3A | 5/6B:1/6A | 162 |
| Brahman | 5/6B:1/6A | 11/12B:1/12A | 75 |
| Brahman | 11/12B:1/12A | 23/24B:1/24A | 14 |
| Brahman | Angus | 1/2B:1/2A | 126 |
| 2/3B:1/3A | 2/3B:1/3A | 2/3B:1/3A | 301 |
| 2/3B:1/3A | Angus | 1/3B:2/3A | 61 |
| 5/6B:1/6A | 5/6B:1/6A | 5/6B:1/6A | 330 |
| 5/6B:1/6A | Angus | 5/12B:7/12A | 58 |
| Angus (A) | 2/3B:1/3A | 1/3B:2/3A | 8 |

[a]2/3B:1/3A dams were obtained from a long-term two-breed rotatinal crossbreeding program in a private herd.

weaning (CS). The objectives of this study were 1) to estimate additive direct and maternal group genetic differences between Brahman and Angus for BW, WW and CS and 2) to estimate direct and maternal nonadditive group genetic effects for BW, WW and CS.

#### Materials and Methods

A complete description of the experimental procedure was given elsewhere (Olson et al., 1989), thus only a brief description of the data used in this analysis is included.

Records of BW, WW and CS from 1,467 Brahman (B), crossbred Brahman (2/3 or more B) and Brahman ×-Angus (A) crossbred calves were collected at the Subtropical Agricultural Research Station (STARS), Brooksville, Florida from 1971 to 1982. The distribution of calves by breed composition of their parents is shown in Table 1. Only B and 5/6B:1/6A calves were produced in all years. Two groups of B × A crossbred animals (2/3B:1/3A and 5/6B:1/6A) were mated *inter se*. The total number of sires used in the experiment was 68, most of them 5/6B and higher (Table 2). Almost half the sires were used for two or more consecutive years. This ensured connectedness among breed groups of sires over years. A total of 582 dams were represented. Their distribution according to the breed composition of each dam's sire and dam is shown in Table 2. Cows that failed to conceive usually were culled from the herd. On the average a cow stayed in the herd for three calvings. Brahman and 2/3B:1/3A dams were present throughout the experiment. This ensured connectedness among breed groups of dams across years.

Foundation 2/3B:1/3A dams (93 cows) had alleles from other *Bos taurus* breeds in addition to A. Thus, the results of this research reflect to some extent the effect of these alleles. However, because the 2/3B:1/3A bulls and their female descendants that were used in this experiment had documented A parentage, the word "Angus" will be used throughout this paper to indicate the effect of *Bos taurus* germ plasm.

Weaning weight was adjusted to 205 d as suggested by the Beef Improvement Federation (BIF, 1986). Condition scores represented the average of three different appraisers.

Regression methods for group genetic effects, as described by Elzo and Famula (1985), were used to compute best linear unbiased estimates (BLUE) of additive and nonadditive (intralocus) direct and maternal group genetic effects. Group genetic effects refer to differences between average genetic values of groups of animals (e.g., B, 2/3B:1/3A) and the average genetic value of a reference group of animals (e.g., A) for a specific effect on a trait (e.g., additive direct group genetic effect of B for BW). This procedure is equivalent to the calf-dam group model used by various authors (Koger et al., 1975; Dillard et al., 1980; Peacock et al., 1981; Robison et al., 1981). A calf-dam group model assumes that sire and dam additive direct genetic effects are equal. This may be untrue due to nonrandom sampling of breeding animals, especially of sires. If so, a calf-dam group model overpredicts or underpredicts the additive direct genetic value of crossbred groups, unless the parental groups have the same expected breed composition. On the other hand, the sire-dam group model used in this paper yields

TABLE 2. NUMBER OF SIRES AND DAMS BY BREED GROUP COMPOSITION OF THEIR SIRES AND DAMS

| Breed group composition[a] | | | Number | |
|---|---|---|---|---|
| Sire of parent | Dam of parent | Parent | Sires | Dams |
| Brahman (B) | Brahman | Brahman | 37 | 144 |
| Brahman | 1/3B:2/3A | 2/3B:1/3A | 7 | 93 |
| Brahman | 2/3B:1/3A | 5/6B:1/6A | 5 | 66 |
| Brahman | 5/6B:1/6A | 11/12B:1/12A | | 11 |
| 2/3B:1/3A | 2/3B:1/3A | 2/3B:1/3A | 7 | 72 |
| 5/6B:1/6A | 5/6B:1/6A | 5/6B:1/6A | 10 | 66 |
| Angus (A) | Angus | Angus | 2 | 130 |

[a]1/3B:2/3A dams of bulls were produced in a long-term, rotational crossbreeding experiment at the Beef Research Unit, University of Florida. 1/3B:2/3A dams of dams were produced in a similar rotational crossbreeding program in a private herd.

unbiased values for additive direct genetic group effects irrespective of the expected breed composition of the parental breed groups because it accounts for sire and dam breed groups separately. Separate predictions of sire and dam group genetic effects not only help one understand the results of a crossbreeding experiment more thoroughly but also help to explain differing results obtained in separate crossbreeding trials that used the same parental breeds. Because of problems of estimability, however, the assumptions of equal additive direct genetic effects in the sire and dam breed groups also must be made in the sire-dam group model in order to estimate direct and maternal genetic group effects separately.

The computational procedure to obtain these BLUE for each trait had two steps. First, BLUE of sire and dam additive group genetic effects and dam and calf nonadditive group genetic effects were obtained using ordinary least squares analyses. This model contained the effects of year, sex of calf, age of dam, B sire additive group genetic effect, B dam additive group genetic effect, B × A dam nonadditive (intralocus) group genetic effect, B × A calf nonadditive (intralocus) group genetic effect and residual. All effects were assumed to be fixed, except for residuals, which were assumed to be random, with a common variance and uncorrelated. Interactions among environmental effects were left out of this model because they were found to be nonsignificant in preliminary analyses. Additive and nonadditive genetic effects were expressed as continuous variables. Brahman sire and dam group additive genetic effects were defined as deviations from A. Thus, the predictors entered in the incidence matrix were the probabilities of having B alleles present in the sire of the calf and the dam of the calf. Dam and calf group nonadditive (intralocus) genetic effects were defined as deviations from the parental breeds, B and A. The values used as predictors in the incidence matrix were the probabilities of having heterozygous (B × A) loci in the dam of the calf and in the calf.

Secondly, additive and nonadditive group genetic effects were written in terms of their direct and maternal genetic components, equated to their BLUE and solved for. The BLUE for direct and maternal additive and nonadditive (intralocus) group genetic effects were obtained as follows: (i) Brahman additive direct group genetic effect = 2 × Brahman sire group additive genetic effect, (ii) Brahman additive maternal group genetic effect = Brahman dam group additive genetic effect − Brahman sire group additive genetic effect, (iii) B × A nonadditive (intralocus) direct group genetic effect = B × A calf nonadditive group genetic effect, and (iv) B × A nonadditive maternal group genetic effect = B × A dam nonadditive group genetic effect.

The generalized least squares program of SAS (1985) was utilized to perform the computations.

## Results and Discussion

The *F*-values and probability levels of all effects included in the model for the three traits (BW, WW and CS) are presented in Table 3. The three environmental factors (i.e., year, sex and age of dam) all affected BW, WW and CS ($P < .01$). Group genetic effects, on the other hand, had various degrees of importance depending on the trait. The BLUE of these group genetic effects and their standard errors are shown in Table 4. Linear combinations of the BLUE of

TABLE 3. *F*-VALUES AND PROBABILITY LEVELS FROM THE LEAST SQUARES ANALYSES OF PREWEANING GROWTH TRAITS

| | | Trait | | | | | |
|---|---|---|---|---|---|---|---|
| | | Birth wt | | Weaning wt | | Condition score | |
| Source[a] | df | *F* | *P* > *F* | *F* | *P* > *F* | *F* | *P* > *F* |
| Year | 11 | 14.81 | .01 | 15.64 | .01 | 18.65 | .01 |
| Sex | 2 | 67.46 | .01 | 161.52 | .01 | 31.02 | .01 |
| Age of dam | 7 | 2.71 | .01 | 21.41 | .01 | 11.05 | .01 |
| Brahman dam additive[b] | 1 | 2.68 | .10 | 2.74 | .10 | 6.34 | .01 |
| B × A dam nonadditive[c] | 1 | 15.69 | .01 | 34.62 | .01 | .07 | .79 |
| Brahman sire additive[b] | 1 | 8.29 | .01 | .87 | .35 | 4.03 | .05 |
| B × A calf nonadditive[c] | 1 | .08 | .77 | 1.12 | .29 | 9.55 | .01 |

[a]A = Angus, B = Brahman.

[b]Brahman additive group genetic effects are expressed as deviations from Angus.

[c]B × A intralocus nonadditive group genetic effects are defined as deviations from those of the parental breeds.

sire, dam and calf group genetic effects were used to compute the BLUE of the separate direct and maternal additive and nonadditive (intralocus) group genetic effects for BW, WW and CS.

*Birth Weight.* The only negative genetic value for BW in Table 4 is that of the B dam additive group genetic effect (–2.71 ± .65 kg). This value is the BLUE of 1/2B (as a deviation from A) additive direct plus maternal group genetic effect for BW. The BLUE of the B (as a deviation from A) additive direct group genetic effect for BW was positive (2.99 ± 1.04 kg = B sire additive genetic group effect in Table 4). Thus, the BLUE of the B (as a deviation from A) additive maternal group genetic effect for BW must be negative. Such BLUE was found to be equal to –5.70 ± 1.91 kg ($P < .01$). This means that given calves of comparable prebirth growth potential, B (or B × A crossbred) dams will produce calves with lower birth weights than those born to A dams. The negative BLUE for the maternal B group genetic effect was very similar to the one reported by Wyatt and Franke (1986) in their comprehensive analyses of beef cattle data from the southern region (–6.1 ± .24 kg). This unique ability of B and B crossbred dams to restrict birth weights of their calves increases their potential value as dams in terminal crossbreeding systems. The mechanisms by which this occurs should be investigated.

TABLE 4. BEST LINEAR UNBIASED ESTIMATES OF ADDITIVE AND NONADDITIVE GROUP GENETIC EFFECTS FROM LEAST SQUARES ANALYSES OF PREWEANING GROWTH TRAITS

| | Trait | | |
|---|---|---|---|
| Group genetic effect[a] | Birth wt, kg | Weaning wt, kg | Condition score, units |
| Brahman dam additive[b] | –2.71 ± 1.65 | 13.56 ± 8.19 | 1.10 ± .44* |
| B × A dam nonadditive[c] | 2.85 ± .72** | 20.95 ± 3.56** | .05 ± .19 |
| Brahman sire additive[b] | 2.99 ± 1.04** | 4.80 ± 5.15 | –.55 ± .27* |
| B × A calf nonadditive[c] | .52 ± 1.81 | 9.47 ± 8.96 | 1.47 ± .47** |

[a]A = Angus, B = Brahman.

[b]Additive group genetic effects are expressed as deviations from Angus.

[c]B × A intralocus nonadditive group genetic effects are defined as deviations from those of the parental breeds.

*$P < .05$.

**$P < .01$.

The BLUE of the B additive direct group genetic effect was found to be almost identical, but opposite in sign (5.99 ± 2.08 kg, $P < .01$), to the maternal. Thus, the sum of the direct and the maternal (i.e., the B total) additive group genetic effects was very close to zero (.29 ± 1.99 kg). Maternal effects are genetic to the dam but environmental to the calf; thus the value of .29 ± 1.99 kg is actually the BLUE of a phenotypic effect on the calf.

Interbreed nonadditive (intralocus) group genetic effects for BW were important ($P < .01$) only for maternal effects (2.85 ± .72 kg, Table 4). Thus, calves of similar fetal growth potential will be larger when born out of B × A crossbred dams than when their dams are either B or A. On the other hand, interbred nonadditive direct genetic effects were found to be small and nonsignificant (.52 ± 1.81 kg, Table 4). Wyatt and Franke (1986), however, reported significant positive effects for both direct and maternal heterosis from crosses of B and A.

*Weaning Weight.* The BLUE of all the group genetic effects for WW were positive. The largest and only significant ($P < .01$) estimate was that for the nonadditive maternal group genetic effect (20.95 ± 3.56 kg, Table 4). The BLUE of the nonadditive direct group genetic effect was approximately half the value (9.47 ± 8.96 kg) of the maternal nonadditive effect. In contrast, Wyatt and Franke (1986) found both direct and maternal heterotic effects of B × A crosses to be highly significant, with that of the direct effect being larger.

The BLUE of both the B additive direct and maternal group genetic effects were comparable to the nonadditive direct effect (9.60 ± 10.29 and 8.76 ± 9.47 kg, compared with 9.47 ± 8.96 kg, Table 4). The BLUE of the sum of the direct and maternal nonadditive group genetic effects (30.41 ± 7.73 kg, $P < .01$) is approximately 1.5 times that of the sum of the corresponding values for additive genetic effects (18.35 ± 9.86 kg). Thus, nonadditive group genetic effects for WW were found to be at least as important as the B (as a deviation from A) additive group genetic effects.

*Condition Score.* The CS of calves at weaning is an estimate of s.c. fat thickness. The apparent fatness of a calf also can be a reflection, to some degree, of the ability of calves to adapt and to thrive under unfavorable conditions as well as the maternal ability of their dams (Koger et al., 1975; Peacock et al., 1981). The BLUE of the additive group genetic effects were found to be negative for B direct genetic group effects (−1.10 ± .55 units, $P < .05$, Table 4) and positive for the maternal genetic group effects (1.64 ± .50 units, $P < .01$). Peacock et al. (1981) also observed an advantage of A over Brahman for direct additive effects on calf CS and an advantage of Brahman over Angus for maternal additive effects. Apparently these results are indicative of the faster maturing rate of Angus, which results in earlier fattening of A calves and of the greater milk production of B than of A under these subtropical conditions.

Nonadditive group genetic effects were found to be important only for the direct component (1.47 ± .47 units, $P < .01$, Table 4). A similar large positive effect on calf CS at weaning due to nonadditive direct effects (B × A) was reported by Peacock et al. (1981). The nonadditive maternal component was close to zero and nonsignificant (.05 ± .19 units, Table 4). In contrast, however, Peacock et al. (1981) also found that nonadditive maternal effects significantly increased calf CS. This disparity may be due to the absence of $F_1$ dams in this study as opposed to their exclusive use (as crossbred dams) in the research of Peacock et al. (1981).

In summary, important direct and maternal additive and nonadditive group genetic effects were found. The results of this study reemphasize the importance of both direct and maternal additive and nonadditive genetic effects on preweaning growth traits under these conditions. Interbreed nonadditive maternal group genetic effects were particularly important for BW and WW. An additional use of the results of this study would be to predict sire, dam and calf breed groups of any expected B and A breed composition from linear combinations of the BLUE of the B sire additive, B dam additive, B × A dam nonadditive and B × A calf nonadditive group genetic effects. The BLUE of some of the group genetic effects in this paper, however, had large standard errors. Also, the samples of animals used for some crosses were small. Thus, a larger sample and more B × A types of mating will be required to obtain more accurate estimates of the group genetic effects for use as predictors of B × A crossbred performance.

## Implications

These results serve to stress the importance of Brahman breeding in commercial crossbred cows in the southeastern U.S. Their calves had low birth weights but high weaning weights. In addition, the prediction procedure could be useful in determining the optimum breed composition of a composite population, or the most appropriate crossbreeding strategy. Finally, although the American Brahman Breeders Association does not allow upgraded animals to be included in the breed registry, and thus the incorporation of *Bos taurus* germ plasm to improve maternal productivity, use of unrelated *Bos taurus* breeds now available may offer another avenue for genetic change.

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