Postweaning and Feedlot Growth and Carcass Characteristics of Angus-, Gray Brahman-, Gir-, Indu-Brazil-, Nellore-, and Red Brahman-Sired F1 Calves

J. C. Paschal*, J. O. Sanders†, J. L. Kerr‡, D. K. Lunt§, and A. D. Herring†

*Texas Agricultural Extension Service, Corpus Christi 78406-9704; †Animal Science Department, Texas A&M University, College Station 77843; ‡International Brangus Breeders Assn., San Antonio 78369-6020; and §Animal Science Department, Texas A&M University, McGregor 76657

ABSTRACT: Postweaning, feedlot, and carcass data from crossbred calves sired by five Bos indicus breeds and one Bos taurus breed were evaluated. Data included records from F1 calves out of multiparous Hereford cows sired by Angus, Gray Brahman, Gir, Indu-Brazil, Nellore, and Red Brahman bulls. The Zebu crosses grew faster postweaning and were heavier and taller as yearlings than the Angus crosses \((P < .05)\). Among the Zebu-sired calves, the Red and Gray Brahman crosses were faster gaining and were heavier at a year of age than the Gir, Indu-Brazil, and Nellore. The Nellore crosses were significantly taller than the Gray Brahman- and Gir-sired crosses; the Indu-Brazil and Red Brahman were intermediate. Angus crosses were lightest on and off feed but were not significantly different from Gir, and Red and Gray Brahman were heaviest \((P < .05)\). The Nellore and Indu-Brazil calves were similar in initial weight, but Indu-Brazil calves were similar to Red and Gray Brahman for final weight. The Angus cross was more desirable \((P < .05)\) in marbling score and quality grade, although the Nellore crosses had the most desirable score and grade of the Zebu crosses. Gir crosses had higher skeletal maturity scores \((P < .05)\) than Nellore, Gray Brahman, Indu-Brazil, and Angus crosses; Red Brahman crosses were intermediate. Angus crosses had the lightest carcasses but not significantly lighter than the Indu-Brazil, Gir, or Nellore. Red Brahman-cross carcasses were heaviest and Gray Brahman-cross carcasses were intermediate. Gir crosses had the greatest actual fat thickness, but Nellore and Angus were not significantly different. Yield grade was lowest for Indu-Brazil but not significantly different from Angus. The Red and Gray Brahman crosses had the highest yield grades, and Nellore and Gir were intermediate. These results indicate that no major differences exist among these Zebu breed crosses in carcass quality or yield characteristics.

Key words: Postweaning, Feedlots, Carcasses, Breed Differences, Zebu

Introduction

In the United States, the greatest advantage of Bos indicus (Zebu) cattle lies in the crossbreeding programs in the South and Southwest where the crosses are well adapted to hot, humid climates and areas of poor forage quality. Zebu cattle are particularly popular along the U.S. Gulf Coast, where crossbreeding with non-Zebu breeds has allowed the utilization of heterosis for production characters and increased resistance to heat, diseases, and parasites (Wythe, 1970). Until 1980, the Zebu breeds of principal use to cattlemen in the Southern United States were the Gray and Red Brahman breeds, and they were used almost exclusively for crossbreeding purposes (Cartwright, 1980).

The influence of Bos indicus cattle has increased in commercial herds in the more temperate areas of the United States in recent years due to higher cow productivity and increases in longevity and maternal calving ease in the Bos indicus-Bos taurus crossbreds (compared to straight Bos taurus) (Turner, 1980). Brahman cattle and their crosses (both Gray and Red) have been shown to have lower carcass quality attributes (primarily marbling) (Butler et al., 1956; Koch et al., 1982; Cundiff et al., 1993) and lower meat tenderness scores (Damon et al., 1960; Koch et al., 1982; Cundiff et al., 1993).

In 1980, 1981, and 1982, Bos indicus cattle from Brazil were imported into the United States through the Harry Truman Import Center off the Florida Coast. Bulls and heifers of the Gir, Indu-Brazil,
Nellore, and Guzerat breeds were imported. This was the first importation of Indian or Brazilian breeds since the 1946 importation from Brazil. This study was initiated in 1980 with the objective of comparing the different aspects of productivity of these newly imported breeds, Gir, Indu-Brazil, and Nellore, with each other, and with the American Gray Brahman and the American Red Brahman from crosses out of Hereford cows. Because only two Guzerat bulls were imported, the Guzerat was not included in this study. The characterization of these breeds for calving and weaning differences was reported by Paschal et al. (1991).

Materials and Methods

A description of the Texas Agricultural Experiment Station project S-6509, "Evaluation of Zebu Breeds for Beef Production" was previously described by Paschal et al. (1991) for the calving and weaning phases of the project. Hereford cows were bred by AI to either bulls of the five Zebu breeds or the Angus breed, which served to tie these data with other studies. Calves were born in the fall of each year from mid-October through early January from 1982 to 1985 at the Blacklands Conservation Research Center in Reisel, TX. The Center at Reisel served as the location for the cow herd for all four calf crops and as the site of the feedlot for the steers from the 1982 and 1983 calf crops. The steers from the 1984 and 1985 calf crops were fed at the Texas A&M University Agricultural Research Center at McGregor, TX; however, all carcass data were collected by Center personnel within 24 h postmortem. The ration at McGregor consisted of 70% ground sorghum, 20% cottonseed hulls, and 10% cottonseed meal and Bovatec®. The ration at McGregor consisted of 65% ground grain sorghum, 25% cottonseed hulls, and 10% cottonseed meal and Rumensin®. The cattle remained on feed until early April for an average of 125 d across the 4 yr. The actual numbers of days on feed for steers born in 1982, 1983, 1984, and 1985 were 135, 122, 120, and 129 d. During the feeding period, only three steers were removed (in 1983) for blindness, bloat, and urinary calculi. Final feedlot weights and heights were recorded.

The steers born in 1982 and 1983 were slaughtered at the Texas A&M University Meat Science and Technology Center at College Station, whereas steers born in 1984 were slaughtered at a commercial plant; however, all carcass data were collected by Center personnel within 24 h postmortem at both locations. The steers averaged 504 d of age at slaughter. Table 1 shows the distribution of calves by sire breed for the postweaning and feedlot growth and carcass characteristics. Actual slaughter weights were not collected every year, so dressing percentage could not be analyzed. Steers born in 1982, 1983, and 1985 were slaughtered on different days during a 1-wk period. Steers born in 1984 were slaughtered together except for five steers, one of each Zebu sire breed, which were slaughtered 21 d later. Final feedlot weights were taken on a single day during the week before slaughter.
Table 1. Distribution of calves by sire breed for postweaning and feedlot growth and carcass characteristics

<table>
<thead>
<tr>
<th>Sire breed</th>
<th>Postweaning growth</th>
<th>Feedlot growth</th>
<th>Carcass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angus</td>
<td>33</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Gray Brahman</td>
<td>42</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Gir</td>
<td>42</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Indu-Brazil</td>
<td>39</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Nellore</td>
<td>46</td>
<td>21a</td>
<td>20</td>
</tr>
<tr>
<td>Red Brahman</td>
<td>43</td>
<td>21</td>
<td>21</td>
</tr>
</tbody>
</table>

a20 calves in analyses of feedlot growth characteristics.

The data were analyzed by least squares, mixed-model procedures for unequal subclass numbers (Harvey, 1977). Sire breed was the major effect of concern in all analyses and sire within sire breed (sire:breed) was considered a random effect and used to test sire breed. All other effects were considered fixed. Postweaning pasture growth characteristics included postweaning average daily gain (PWG), yearling weight (YW), and yearling height (YH). The model for the analysis of postweaning pasture growth included the main effects of sire breed (B), sire:breed (S:B), calf sex (C), birth year (Y), and origin of dam (D). Age of the calf at the time of measurement was included as a covariate. Two interaction effects were included: sire breed × calf sex (BxC) and sire breed × birth year (B×Y).

An origin of dam effect was included in the model because the cows were acquired from 15 different sources in Central Texas and were both horned and polled, purebred and grade in breeding. Cows from 13 of those locations were born from 1979 to 1980 and were 3 to 4 yr old when they had their first calf in the project in 1983. All calves born in 1982 were from mature cows from the other two locations, and they produced calves in the remaining 3 yr of the project.

Characteristics measured at the feedlot included initial weight (INWT) and final weight (FNWT), initial height (INHT), final height (FNHT), and average daily gain (FADG). Carcass characteristics included both carcass quality and yield measurements. Carcass quality measurements included skeletal (SM), lean (LM), and overall maturity (OM) and USDA marbling score (MS) and quality grade (QG). Carcass yield measurements included warm carcass weight (WCW), longissimus muscle area (LMA), actual (ACTF) and adjusted fat thickness (ADJT), estimated kidney, pelvic and heart fat (KPH), and USDA yield grade (YG). The main effects of interest in the postweaning statistical model were B, S:B, C, Y, and D, and the statistical model for all carcass measurements included the main effects of B, S:B, Y, and D. The B×Y interaction was included in earlier analyses of feedlot and carcass characteristics but was found to be nonsignificant and removed from the final model. For all analyses of characteristics measured at the feedlot, initial age (age at the beginning of the feeding period) was used as a covariate, whereas slaughter age was used as a covariate for the carcass characteristics. Additional analyses of MS and REA substituted YG and WCW for age at slaughter as the covariate. Least squares mean separation for significant sire breed effects were conducted using Fisher’s LSD method (Snedecor and Coehran, 1980).

Results and Discussion

Postweaning Pasture Growth Characteristics. Least squares means and standard errors for all postweaning pasture-growth characteristics are presented by breed of sire in Table 2. Birth year and origin of dam were partially confounded with each other and had significant effects on all birth and weaning characters (Paschal et al., 1991). Breed of sire, sex of calf, and birth year had significant effects on PWG, YW, and YH ($P < .001$). Age of calf was significant only for YW and YH ($P < .001$). There was an interaction of breed of sire and birth year for PWG ($P < .01$) and YW ($P < .05$) but not for YH.

The significant B×Y interaction for PWG was due to postweaning gains that were higher in 1982 and 1985 than in 1983 and 1984, especially for the Zebu crosses. Average gains for Zebu-sired calves in 1982, 1983, 1984, and 1985 were .57, .27, .23, and .42, respectively, whereas the gains for the Angus crosses were .27, .23,

Table 2. Least squares means and standard errors for postweaning growth characteristics by sire breed

<table>
<thead>
<tr>
<th>Sire breed</th>
<th>Postweaning gain, kg/d</th>
<th>Yearling wt, kg</th>
<th>Yearling hip height, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angus</td>
<td>0.22 ± 0.02a</td>
<td>231.4 ± 4.2a</td>
<td>109.9 ± 6b</td>
</tr>
<tr>
<td>Gray Brahman</td>
<td>0.39 ± .01c</td>
<td>270.2 ± 3.8c</td>
<td>119.8 ± 5bc</td>
</tr>
<tr>
<td>Gir</td>
<td>0.37 ± 0.01bc</td>
<td>249.4 ± 4.0b</td>
<td>118.9 ± 6c</td>
</tr>
<tr>
<td>Indu-Brazil</td>
<td>0.55 ± 0.02b</td>
<td>254.9 ± 5.0b</td>
<td>121.0 ± 7d</td>
</tr>
<tr>
<td>Nellore</td>
<td>0.36 ± .01bc</td>
<td>288.0 ± 3.6b</td>
<td>121.7 ± 5f</td>
</tr>
<tr>
<td>Red Brahman</td>
<td>0.39 ± 0.01c</td>
<td>271.3 ± 3.7c</td>
<td>121.0 ± 5d</td>
</tr>
</tbody>
</table>

a,b,c,dMeans within a column with no superscripts in common differ ($P < .05$).
.13, and .24 kg/d. The data indicate that the Angus crosses were not as adapted to a Central Texas summer environment (e.g., management, stocking rate, forage availability, plane of nutrition, etc.) as were as the Zebu crosses and that the difference was accentuated in the years with the poorest grazing conditions. Rollins et al. (1964) and Long et al. (1979a) found significant breed type × management interaction differences (primarily due to nutrition) when Brahman crosses were compared with Bos taurus cattle.

Preliminary analysis of PWG revealed a sex × year interaction \( (P < .10) \) because the sex differences were larger for the 1982 birth year than for the remaining 3 yr. This interaction was omitted from the final analysis because these differences were a result of weighing steers and heifers at different intervals. As mentioned earlier, the 1982 yearling heifer weights were recorded in September, whereas the steers were weighed in November. Although the data were adjusted for age and analyzed as ADG rather than absolute gain, the plane of nutrition changed considerably from September to November as cattle began grazing winter oat pasture before November 1. In this situation, sex and year were partially confounded. The BxC interaction \( (P = .06) \) was retained in the model for PWG. This interaction was caused by Gray Brahman and Indu-Brazil steers gaining .03 and .01 kg/d less than their heifer mates \( (.38 \pm .03, .41 \pm .03 \text{ kg/d for Gray Brahman, } .35 \pm .03, .36 \pm .03 \text{ kg/d for Indu-Brazil steers and heifers, respectively}) \). The postweaning gains for Angus, Gir, Nellore, and Red Brahman steers and heifers were .26 ± .02, .18 ± .03, .43 ± .02, .32 ± .03, .40 ± .02, .34 ± .02, and .44 ± .02, .35 ± .02 kg/d, respectively. The BxC interaction term for YW \( (P = .07) \) was also retained in the model. The difference in YW between the Angus steers and heifers was 20 kg, well within the range of the Zebu crosses. The differences between the Zebu-cross steers and heifers ranged from a low of 3 kg (for Indu-Brazil crosses) to a high of 36 kg (for Gir crosses), whereas the differences for Gray Brahman, Nellore, and Red Brahman steers and heifers were 9, 20, and 22 kg, respectively.

Angus-sired calves did not gain as well postweaning (.22 kg/d) as the Zebu crosses \( (P < .05) \) (Table 2). Among the Zebu breeds, Indu-Brazil had the lowest gains (.35 kg/d), although they did not differ significantly from the Nellore (.36 kg/d) or Gir (.37 kg/d). Gray Brahman and Red Brahman crosses had the highest postweaning gains in the study (.39 and .39 kg/d) but did not differ \( (P > .05) \) from Gir and Nellore crosses. In Brazil, Fontes (1950), in an evaluation of monthly gains of Gir, Guzerat, Indu-Brazil, and Nellore cattle, ranked the breeds for gain from 5 to 11 mo (highest to lowest) as follows: Indu-Brazil \( (14.1 \text{ kg/mo}), \) Gir \( (13.3 \text{ kg/mo}), \) Nellore \( (12.9 \text{ kg/mo}), \) and Guzerat \( (10.9 \text{ kg/mo}), \) with little difference between Gir and Nellore. In Mexico, Carrera and Erazo (1977) reported no significant difference in PWG between Brahman and Indu-Brazil bulls (.42 vs .46 kg/d). Although these results are not directly comparable due to management regimen and location, in general, Brazilian reports indicate that Gir cattle gain the least postweanings whereas Indu-Brazil gain the most and Nellore are intermediate. In this study, although there were no significant differences between these three Zebu crosses, they grew significantly faster than the Angus crosses \( (P < .05) \); the Indu-Brazil crosses gained significantly less weight \( (P < .05) \) postweaning than the Gray and Red Brahman crosses.

Age of calf had an effect only on YW and YH \( (P < .001) \). The regression of YW on age of calf was .80 kg/d and the regression of YH on age of calf was .09 cm/d. The average age of calves when yearling measurements were taken was 355 ± 30 d.

For YW, all the Zebu-sired crosses were heavier than the Angus crosses (231.4 kg, \( P < .05 \)). Among the Zebu crossbreds, the Red Brahman and Gray Brahman were similar (271.3 and 270.2 kg) but heavier than the Nellore, Indu-Brazil, and Gir crosses (258, 254.9, and 249.4 kg, respectively, \( P < .05 \)). Fontes (1950) reported that purebred Indu-Brazil and Nellore calves were heavier at 12 mo than Gir calves. Straightbred Brahman bull calves were lighter as yearlings on pasture than Angus in a study by Long et al. (1979b), but their heifer mates on pasture were heavier than the Angus heifers (Long et al., 1979a). Further, the Brahman × Hereford bull calves were also lighter on pasture than the Angus × Hereford bull calves, whereas the Brahman × Hereford heifers on pasture were heavier than their Angus × Hereford heifer mates (Long et al., 1979a,b). Gregory et al. (1979) also reported heavier yearling weights for Brahman-sired heifers than for Hereford-Angus heifers.

All the Zebu-sired crosses were taller for YH than the Angus-sired calves (109.9 cm, \( P < .05 \)). Nellore-, Indu-Brazil-, and Red-Brahman-sired calves were the tallest \( (P < .05) \) among the Zebu crosses. Calves sired by Gray Brahman bulls were intermediate and calves from Gir sires were significantly shorter than Indu-Brazil, Nellore, and Red Brahman crosses \( (P < .05) \). Long et al. (1979b) reported similar results for straightbred and crossbred Angus and Brahman bulls at 360 d of age.

Feedlot Growth Characteristics. Breed was significant for all feedlot growth characteristics \( (P < .05) \) except FADG. Origin of dam was significant for INWT and FNHT \( (P < .05) \). Birth year was significant for all variables except FNHT \( (P < .05) \), and the covariate, age, was significant for all variables except FADG \( (P < .001) \). Sire:breed was not significant for any of the feedlot growth characteristics. The B×Y interaction was tested for all feedlot growth characteristics, found to be nonsignificant, and was removed from the final model.
Origin of dam was confounded with age of dam in this study. Most of the Hereford females were primiparous when they entered the project; however, some of the groups were composed of older, multiparous females. Least squares estimates of origin of dam effects did not indicate that older females had larger effects on INWT than younger females. Differences for INWT among groups of dams could be a result of additive genetic differences, or a residual effect of milk production among dam groups, or a combination of the two.

Least squares means and standard errors for the feedlot growth characteristics are given by sire breed in Table 3. For INWT, Gray Brahman and Red Brahman crosses were the heaviest and Nellore and Indu-Brazil were intermediate, whereas the Gir crosses were lightest of the Zebu crosses. Angus-sired steers had the lowest INWT but did not differ (P > .05) from the Gir crosses. Crockett et al. (1979) also reported significantly heavier initial feedlot weights for Brahman crosses compared with calves by Beefmaster, Brangus, Limousin, Maine-Anjou, and Simmons mental sires out of Angus, Brangus, and Hereford cows. Cundiff et al. (1984) reported that Brahman-sired crosses out of Angus and Hereford dams were heaviest but not significantly heavier than Tarentaise crosses; they were significantly heavier than the Angus-Hereford, Pinzgauer, and Sahiwal crosses for initial weight. Indu-Brazil, Red Brahman, and Nellore crosses were the tallest at the initiation of the feeding period (Table 3). Gir-sired steers were intermediate and did not differ (P > .05) from the Nellore and Red Brahman crosses, or from the Gray Brahman-sired steers, which were the smallest-framed of the Zebu crosses.

Angus and Gir crosses had the lowest final weights (468.4 and 471.9 kg) but did not differ (P > .05) from Nellore (480.1 kg) or Indu-Brazil (491.7 kg). Red Brahman and Gray Brahman crosses were the heaviest at the end of the feeding period (511 and 499.7 kg). In comparing breed rank between initial and final weights, the only change that occurred was between the Indu-Brazil and Nellore crosses; however, these sire breeds did not differ significantly for either character. Damon et al. (1960) and Young et al. (1978) reported significantly heavier final weights for Brahman crosses than for Angus, and Cundiff et al. (1984) reported that the final weights of Brahman crosses and Angus-Hereford crosses were not significantly different from those of Pinzgauer and Tarentaise crosses; only Sahiwal crosses were significantly lighter. Damon et al. (1960) reported that Brahman-Hereford crosses outweighed the Angus-Hereford crosses by 96.3 kg at slaughter. When this weight was adjusted for age of dam and age of steer, the difference increased to 126.6 kg. Crockett et al. (1979) reported that Brahman-sired crosses were significantly heavier than all other crosses except Maine-Anjou. However, Cundiff et al. (1993) reported that Nellore crosses weighed more than the Hereford- Angus crosses from sires of an earlier generation but were lighter than the Hereford-Angus crosses by current sires.

Nellore, Red Brahman, and Indu-Brazil crosses were the tallest at the end of the feeding period. Gray Brahman-sired steers were taller than Gir but not significantly different (P > .05). There were significant differences among dam groups for FNHT but they did not seem to be associated with age or parity.

There were no significant differences due to breed for FADG, although the average of Zebu crosses was slightly lower than that of the Angus crosses (1.55 vs 1.57 kg/d). The Gray Brahman and Indu-Brazil crosses tended to be the fastest-gaining calves, followed by Red Brahman-, then Nellore- and Gir-sired, steers. The regression coefficients for INWT (P < .001), INHIT (P < .001), FNWT (P < .001), FNHT (P < .001), and FADG on age were .65 kg/d, .07 cm/d, .69 kg/d, .06 cm/d, and .0005 kg, respectively.

Damon et al. (1959) reported that Angus crosses out of Hereford, Brahman, and Brangus cows gained slightly more than Brahman-sired crosses out of these cow breeds; however, the Brahman-Hereford crosses outgained the Angus-Hereford crosses. Brahman crosses gained 1.29 kg/d in work conducted by Crockett et al. (1979), outgaining all other crosses except Maine-Anjou. In Brazil, Carneiro et al. (1975) studied gains among Gir, Nellore, and Indu-Brazil bulls that had ad libitum access to feed. In one location bulls were placed on feed at 12 mo of age and fed for 154 d. Indu-Brazil calves had the highest ADG.

Table 3. Least squares means and standard errors for feedlot growth characteristics by sire breed

<table>
<thead>
<tr>
<th>Sire breed</th>
<th>Initial wt, kg</th>
<th>Initial height, cm</th>
<th>Final wt, kg</th>
<th>Final height, cm</th>
<th>Average daily gain, kg/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angus</td>
<td>270.5 ± 7.4a</td>
<td>112.0 ± 8a</td>
<td>468.4 ± 10.6a</td>
<td>122.4 ± 9a</td>
<td>1.57 ± .06</td>
</tr>
<tr>
<td>Gray Brahman</td>
<td>301.5 ± 7.6b,c</td>
<td>112.1 ± 8b</td>
<td>499.7 ± 10.9b</td>
<td>132.3 ± 9bc</td>
<td>1.60 ± .06</td>
</tr>
<tr>
<td>Gir</td>
<td>266.8 ± 7.6bc</td>
<td>122.3 ± 7bc</td>
<td>471.9 ± 10.2b</td>
<td>131.9 ± 8b</td>
<td>1.47 ± .06</td>
</tr>
<tr>
<td>Indu-Brazil</td>
<td>290.3 ± 7.8b</td>
<td>124.4 ± 9b</td>
<td>491.7 ± 11.1abc</td>
<td>134.1 ± 9e</td>
<td>1.60 ± .06</td>
</tr>
<tr>
<td>Nellore</td>
<td>291.7 ± 7.0b</td>
<td>129.6 ± 9cd</td>
<td>480.1 ± 10.3ab</td>
<td>134.5 ± 9e</td>
<td>1.50 ± .06</td>
</tr>
<tr>
<td>Red Brahman</td>
<td>311.4 ± 7.9a</td>
<td>123.8 ± 9cd</td>
<td>511.0 ± 10.6a</td>
<td>134.3 ± 8ed</td>
<td>1.57 ± .06</td>
</tr>
</tbody>
</table>

a,b,c,dMeans within a column with no superscripts in common differ (P < .05).
Angus crosses averaged  High Good (High Select)  in both  reported more desirable marbling scores and less youthful at fat trim and marbling end

Nellore and Gir. Brazil calves still had the highest ADG, followed by Nellore crosses had the most desirable MS in maturity scores between Brahman and the other breed crosses, although Brahman crosses tended to be Zebu crosses, but they were not significantly different.

Gir
Nellore
Indu-Brazil
Red Brahman

highest marbling scores and quality grades were from Brahman crosses (Average Small and High Good) when they were compared with Beefmaster-, Brangus-, Limousin-, Maine-Anjou-, and Simmental-sired calves out of Angus, Brangus, and Hereford cows. Cundiff et al. (1993) reported that the Nellore crosses had the lowest marbling scores (Slight 86) of all the breeds evaluated and that they had the highest shear force.

Origin of dam effects on MS and QG were not related to age of dam, which indicates either direct additive genetic differences for marbling among dam groups or possibly a residual effect of differences between dam groups for milk production. Year differences for MS and QG were not significant and did not reflect the number of days on feed. Steers born in 1982 had the least desirable MS and QG (344.8 and 339.2) yet were fed the longest (135.7). The steers born in 1984 had the most desirable MS and QG (375.3 and 367.5) and were on feed for the shortest time (120.7). The regression coefficient and standard error for SM, LM, and OM; MS; and QG on age were .17 ± .05 (P < .001), .07 ± .06, .12 ± .04 (P < .01), .22 ± .23, and .08 ± .18 units/d, respectively. Somewhat lower coefficients were reported for maturity score, marbling score, and quality grade by Koch et al. (1982).

When MS was adjusted for YG rather than slaughter age to evaluate MS at a constant degree of lean carcass yield, origin of dam was not significant; however, MS differed for breed (P < .001) andYG (P < .05). The breed means for MS adjusted for YG were 416.1 ± 12.3, 343.6 ± 12.6, 348.1 ± 11.9, 354.1 ± 13.1, 355.9 ± 11.6, and 344.9 ± 11.7 for Angus-, Gray Brahman-, Gir-, Indu-Brazil-, Nellore-, and Red Brahman-sired steers. Angus crosses still had more desirable MS (P < .05) than the Zebu crosses. With YG included as the covariate instead of slaughter age, Indu-Brazil crosses had MS similar to those of Nellore. The regression coefficient of MS on YG was 28.4 ± 12.4 units.

The analyses of variance for carcass yield characteristics revealed significant breed differences in WCW (P < .01), ACTF (P < .05), and YG (P < .05). There were significant S:B effects for LMA (P < .05) and KPH (P < .05). Birth year was significant for

### Table 4. Least squares means and standard errors for carcass quality characteristics by sire breed

<table>
<thead>
<tr>
<th>Sire breed</th>
<th>Skeletal maturity&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Lean maturity&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Overall maturity&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Marbling score&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Quality grade&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angus</td>
<td>140.0 ± 2.4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>136.9 ± 2.7</td>
<td>138.5 ± 1.9</td>
<td>410.2 ± 12.6&lt;sup&gt;e&lt;/sup&gt;</td>
<td>391.2 ± 9.8&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Gray Brahman</td>
<td>143.2 ± 2.4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>135.7 ± 2.7</td>
<td>139.4 ± 1.9</td>
<td>347.7 ± 12.6&lt;sup&gt;d&lt;/sup&gt;</td>
<td>344.2 ± 9.9&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Gir</td>
<td>148.8 ± 2.0&lt;sup&gt;e&lt;/sup&gt;</td>
<td>139.9 ± 2.3</td>
<td>144.4 ± 1.6</td>
<td>349.6 ± 11.6&lt;sup&gt;d&lt;/sup&gt;</td>
<td>345.5 ± 9.1&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Indu-Brazil</td>
<td>141.3 ± 2.5&lt;sup&gt;d&lt;/sup&gt;</td>
<td>137.9 ± 2.8</td>
<td>139.6 ± 1.9</td>
<td>344.5 ± 12.5&lt;sup&gt;d&lt;/sup&gt;</td>
<td>340.4 ± 10.2&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Nellore</td>
<td>143.3 ± 2.3&lt;sup&gt;d&lt;/sup&gt;</td>
<td>135.3 ± 2.6</td>
<td>139.3 ± 1.8</td>
<td>358.9 ± 11.5&lt;sup&gt;d&lt;/sup&gt;</td>
<td>354.1 ± 9.3&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Red Brahman</td>
<td>144.3 ± 2.2&lt;sup&gt;de&lt;/sup&gt;</td>
<td>137.2 ± 2.5</td>
<td>140.8 ± 1.7</td>
<td>345.5 ± 11.2&lt;sup&gt;d&lt;/sup&gt;</td>
<td>347.0 ± 9.1&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Maturity: 100 = A<sup>ss</sup>; 200 = B<sup>ss</sup>; etc.
<sup>b</sup>Marbling: 300 = SI<sup>ss</sup>; 400 = Sm<sup>ss</sup>; etc.
<sup>c</sup>Quality grade: 300 = Se<sup>ss</sup>; 400 = Ch<sup>ss</sup>; etc.
<sup>d</sup>Means within a column with no superscripts in common differ (P < .05).

(.92 kg/d), followed by Nellore (.88 kg/d) and Gir (.83 kg/d) calves. At two other locations, bulls were fed harvested forage supplemented with grain. Indu-Brazil calves still had the highest ADG, followed by Nellore and Gir.

**Carcass Characteristics.** The results of the analysis of carcass quality characteristics indicated significant breed differences for SM (P < .05), MS (P < .001), and QG (P < .01). There were significant differences due to origin of dam (P < .05) for MS and QG and significant effects of birth year (P < .01) and age of calf (P < .01) on SM and OM. The least squares means and standard errors for the carcass quality characteristics are listed by breed of sire in Table 4. All carcasses were in the A maturity range for both SM and LM (A = 100); however, the SM mean for Gir-sired steers (148.8) was significantly higher (P < .05) than those for Angus, Gray Brahman, Indu-Brazil, and Nellore crosses (140, 143.2, 141.3 and 143.3). Red Brahman crosses were intermediate with a mean of 144.3. Although breed was not significant for LM, Gir crosses also had the highest average score (139.9).

Koch et al. (1982) reported no significant differences in maturity scores between Brahman and the other breed crosses, although Brahman crosses tended to be as youthful as or more youthful at constant age, carcass weight, and fat thickness end points than Angus and less youthful at fat trim and marbling end points.

Angus crosses had the most desirable MS and QG (P < .05), whereas there were no significant differences among the Zebu crosses for these characteristics. Nellore crosses had the most desirable MS (358.9 or Slight 58.9) and QG (354.1 or Select 54.1) among the Zebu crosses, but they were not significantly different. Damon et al. (1960) reported that Brahman-sired crosses averaged Low Good (Low Select), whereas Angus crosses averaged High Good (High Select) in calves out of Angus, Brahman, Brangus, and Hereford dams. Young et al. (1978) and Koch et al. (1982) both reported more desirable marbling scores and quality grades for Angus than for Brahman crosses. However, Crockett et al. (1979) reported that the highest marbling scores and quality grades were from Brahman crosses (Average Small and High Good) when they were compared with Beefmaster-, Brangus-, Limousin-, Maine-Anjou-, and Simmental-sired calves out of Angus, Brangus, and Hereford cows. Cundiff et al. (1993) reported that the Nellore crosses had the lowest marbling scores (Slight 86) of all the breeds evaluated and that they had the highest shear force.

Origin of dam effects on MS and QG were not related to age of dam, which indicates either direct additive genetic differences for marbling among dam groups or possibly a residual effect of differences between dam groups for milk production. Year differences for MS and QG were not significant and did not reflect the number of days on feed. Steers born in 1982 had the least desirable MS and QG (344.8 and 339.2) yet were fed the longest (135.7). The steers born in 1984 had the most desirable MS and QG (375.3 and 367.5) and were on feed for the shortest time (120.7). The regression coefficient and standard error for SM, LM, and OM; MS; and QG on age were .17 ± .05 (P < .001), .07 ± .06, .12 ± .04 (P < .01), .22 ± .23, and .08 ± .18 units/d, respectively. Somewhat lower coefficients were reported for maturity score, marbling score, and quality grade by Koch et al. (1982).

When MS was adjusted for YG rather than slaughter age to evaluate MS at a constant degree of lean carcass yield, origin of dam was not significant; however, MS differed for breed (P < .001) andYG (P < .05). The breed means for MS adjusted for YG were 416.1 ± 12.3, 343.6 ± 12.6, 348.1 ± 11.9, 354.1 ± 13.1, 355.9 ± 11.6, and 344.9 ± 11.7 for Angus-, Gray Brahman-, Gir-, Indu-Brazil-, Nellore-, and Red Brahman-sired steers. Angus crosses still had more desirable MS (P < .05) than the Zebu crosses. With YG included as the covariate instead of slaughter age, Indu-Brazil crosses had MS similar to those of Nellore. The regression coefficient of MS on YG was 28.4 ± 12.4 units.

The analyses of variance for carcass yield characteristics revealed significant breed differences in WCW (P < .01), ACTF (P < .05), and YG (P < .05). There were significant S:B effects for LMA (P < .05) and KPH (P < .05). Birth year was significant for
Table 5. Least squares means and standard errors for carcass yield characteristics by sire breed

<table>
<thead>
<tr>
<th>Sire breed</th>
<th>Carcass wt, kg</th>
<th>Longissimus muscle area, cm²</th>
<th>Actual fat thickness, cm</th>
<th>Adjusted fat thickness, cm</th>
<th>Kidney, pelvic and heart fat, %</th>
<th>Yield grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angus</td>
<td>275.8 ± 6.6a</td>
<td>76.6 ± 2.2</td>
<td>1.0 ± 1.0b</td>
<td>1.2 ± 0.1</td>
<td>1.7 ± 0.1</td>
<td>2.5 ± 0.6ab</td>
</tr>
<tr>
<td>Gray Brahman</td>
<td>300.1 ± 6.6b</td>
<td>75.5 ± 2.3</td>
<td>1.0 ± 1.0b</td>
<td>1.2 ± 0.1</td>
<td>2.0 ± 0.1</td>
<td>2.8 ± 1.0bc</td>
</tr>
<tr>
<td>Gir</td>
<td>287.6 ± 5.8ab</td>
<td>77.1 ± 2.4</td>
<td>1.2 ± 1.1c</td>
<td>1.3 ± 0.1</td>
<td>1.9 ± 0.1</td>
<td>2.7 ± 1.0bc</td>
</tr>
<tr>
<td>Indu-Brazil</td>
<td>287.4 ± 6.8ab</td>
<td>75.5 ± 2.3</td>
<td>1.0 ± 1.0b</td>
<td>1.0 ± 0.1</td>
<td>1.7 ± 0.1</td>
<td>2.3 ± 1.0bc</td>
</tr>
<tr>
<td>Nellore</td>
<td>292.2 ± 6.3ab</td>
<td>75.5 ± 2.1</td>
<td>1.0 ± 1.0b</td>
<td>1.2 ± 0.1</td>
<td>1.9 ± 0.1</td>
<td>2.7 ± 1.0bc</td>
</tr>
<tr>
<td>Red Brahman</td>
<td>307.4 ± 6.1c</td>
<td>77.0 ± 2.1</td>
<td>0.9 ± 1.0b</td>
<td>1.2 ± 0.1</td>
<td>1.8 ± 0.1</td>
<td>2.7 ± 1.0c</td>
</tr>
</tbody>
</table>

a,b,c Means within a column with no superscripts in common differ (P < .05).

WCW (P < .05), LMA (P < .001), and KPH (P < .01, and age at slaughter was significant for WCW (P < .001) and LMA (P < .01).

Least squares means and standard errors for carcass yield characteristics are presented by sire breed in Table 5. Red Brahman and Gray Brahman crosses had the heaviest carcass weights (307.4 and 300.1 kg) but Gray Brahman were not different from Gir, Indu-Brazil, or Nellore. Angus crosses had the lightest WCW (275.8 kg) but were not significantly different from Gir, Indu-Brazil, or Nellore (287.6, 287.4, and 292.2 kg, respectively). Young et al. (1978), Peacock et al. (1979), Koch et al. (1982), and Baker et al. (1984) all reported heavier carcass weights for Brahman crosses than for Angus.

There were no significant differences due to sire breed for LMA adjusted for slaughter age, although the Indu-Brazil, Gir, and Red Brahman crosses tended to have larger longissimus muscle areas than the Nellore and Gray Brahman crosses. Angus crosses were intermediate in LMA. When LMA was adjusted for WCW to evaluate differences at a constant weight (a live weight was not obtained), breed was still not significant although carcass weight was (P < .001). The breed type means for LMA adjusted for carcass weight for Angus, Gray Brahman, Gir, Indu-Brazil, Nellore, and Red Brahman were 78.4 ± 1.6, 74 ± 1.5, 77.3 ± 1.5, 77 ± 1.6, 74.9 ± 1.5, and 73.7 ± 1.5 cm², respectively. Young et al. (1978) and Baker et al. (1984) did not find breed differences for LMA between Angus and Brahman. Damon et al. (1960) reported smaller LMA (adjusted for slaughter weight) for Brahman-sired crosses but not significantly smaller than those of Angus. Crockett et al. (1979) reported that only Brangus crosses had significantly smaller LMA than Brahman crosses, which were not significantly different from Beefmaster crosses. Longissimus muscle areas of Brahman crosses were larger at all end points than Hereford-Angus crosses but were smaller than those of the Tarentaise and Pinzgauer crosses (Koch et al., 1982). Longissimus muscle areas in Nellore crosses were higher than for either the earlier generation or current Hereford-Angus crosses (Cundiff et al., 1983).

In the analysis of ACTF, Indu-Brazil crosses had the least ACTF but were not significantly different from those of Red Brahman. Nellore were intermediate but not significantly different from Angus or Gir crosses, which had the greatest amount of ACTF. Gray Brahman did not differ significantly from Red Brahman, Nellore, or Angus crosses. Because there were no breed differences (P > .05) for ADJF, means for ACTF indicate differences in distribution of fat deposition among breeds. The Brahman crosses evaluated by Damon et al. (1960) had significantly less fat thickness than the Angus crosses. Crockett et al. (1979) reported that the greatest fat thicknesses were measured on the Brahman crosses but were not significantly greater than the Beefmaster crosses. Baker et al. (1984) did not find significant breed differences for fat thickness between straightbred Brahman and Angus bulls. Cundiff et al. (1993) reported that Nellore crosses had the same fat thickness as Shorthorn crosses (1.2 cm), but less than the Hereford-Angus crosses.

Breed was not significant for KPH; however, sire within breed (P < .05) and year (P < .01) were significant. Koch et al. (1982) and Young et al. (1978) did not detect differences in KPH between Brahman and Angus crosses. Differences in KPH were not significant in a study of Angus and Angus-Nellore-cross steers slaughtered at 773 d (414 kg) and 855 d (443 kg) by Garcia et al. (1986).

Indu-Brazil crosses had the most desirable YG (2.3) but were not significantly leaner than Angus crosses (2.5). Angus crosses were similar to Nellore (2.7) and Gir (2.7) crosses but were significantly leaner than Red (2.7) and Gray Brahman crosses (2.8). Crockett et al. (1979) reported significantly higher (less desirable) yield grades for the Brahman crosses compared to the other breeds evaluated. This was due primarily to overfattening of the Brahman crosses. Koch et al. (1982) reported that Brahman crosses had the highest percentage retail product at carcass weight and fat thickness end points but were intermediate at the age and fat trim end points and lowest at the marbling end point. Cundiff et al. (1993) found that Nellore crosses ranked only above
the Shorthorn crosses and the Hereford-Angus crosses for percentage retail product at both the .1-cm and .0-
cm trim.

**Implications**

Major differences (Angus vs Zebu) exist between these breed crosses in postweaning gain, carcass quality, and yield characteristics but differences among the Zebu crosses are relatively minor. The comparisons between the Zebu sire breeds and the Angus for the carcass characters were similar to those in the reported literature. These differences as well as differences in maternal ability and birth and preweaning growth should be considered to enhance effective selection among these breeds for the purposes of crossbreeding and composite breed development.

**Literature Cited**


