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Maternal and reproductive performance of Brahman × Angus, Senepol × Angus, and Tuli × Angus cows in the subtropics

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ABSTRACT: To determine the maternal and reproductive performance of F1 cows in the subtropics, 42 Brahman × Angus, 34 Senepol × Angus, and 50 Tuli × Angus cows were bred to Angus bulls to calve first and subsequently bred to Charolais bulls to calve as 3- to 8-yr-olds. Age at first calving did not differ among crossbred cows. Angus-sired calf birth weights were heavier (P < 0.01) from Senepol × Angus than either Brahman × Angus or Tuli × Angus cows. Weaning weights of Angus-sired calves were heavier (P < 0.01) from Brahman × Angus (213.5 kg) than either Senepol × Angus (194.9 kg) or Tuli × Angus (191.5 kg) cows. As 3- to 8-yr-old cows, calf birth weights were heavier (P < 0.05) from Senepol × Angus compared with Brahman × Angus but not Tuli × Angus cows. Weaning weights of Charolais-sired calves were heaviest (P < 0.05) from Brahman × Angus cows (268.9 kg), lightest from Tuli × Angus cows (233.4 kg), and intermediate from Senepol × Angus cows (245.0 kg). Calf crop born and calf crop weaned were lowest (P < 0.05) for Senepol × Angus cows (76.9 and 70.2%) and did not differ between Brahman × Angus (89.0 and 86.1%) and Tuli × Angus (94.7 and 86.5%) cows. Tuli × Angus cows tended (P < 0.10) to have a lower percentage of unassisted births and lower (P < 0.05) calf survival to weaning than Brahman × Angus but not Senepol × Angus cows. As 3- to 8-yr-olds, weaning weight per cow exposed was greatest (P < 0.05) for Brahman × Angus (234.2 kg), least (P < 0.05) for Senepol × Angus (173.0 kg), and intermediate (P < 0.05) for Tuli × Angus (209.1 kg) cows. Also as 3- to 8-yr-olds, efficiency (205-d calf weight per 100 kg of cow exposed) was similar for Brahman × Angus (42.2%) and Tuli × Angus cows (40.7%), and both were greater (P < 0.01) than for Senepol × Angus cows (33.8%). These data indicate that, in the subtropics, maternal and reproductive performance of Tuli × Angus cows, but not Senepol × Angus cows, was comparable to Brahman × Angus cows, except for lower calf survivability and weaning weight.

Key Words: Calving Rate, Cattle Breeds, Crossbreeding, Efficiency, Subtropics, Weaning Weight

Introduction

Crossbreeding research has consistently documented higher levels of heterosis in Bos indicus × Bos taurus cows compared with temperate-climate-adapted Bos taurus crossbreds (Long, 1980). During the last two decades, increased emphasis has been placed on the evaluation of tropically adapted Bos taurus breeds of cattle (Franke, 1997; Thrift, 1997). As with the Brahman, the usefulness of these breeds will likely be in crossbreeding programs. The Senepol, an adapted Bos taurus breed from St. Croix, U.S. Virgin Islands, and the Tuli, an adapted Sanga breed from Zimbabwe, became available to researchers in the United States during this period of time. In the early 1990s, a concerted research effort to evaluate Tuli crossbred cattle was initiated. This research involved the production of Tuli and Brahman-sired F1 calves in Brooksville, FL (Chase et al., 2000); Tifton, GA (Baker et al., 2001); Clay Center, NE (Cundiff et al., 2000); Las Cruces, NM (Winder and Bailey, 1995); El Reno, OK, and McGregor, TX (Herring et al., 1996); Overton, TX (Browning et al., 1995); and Uvalde, TX (Holloway et al., 2002a). Our site, Brooksville, FL, representative of a hot, humid, subtropical environment, also produced contemporary Senepol-sired calves, as did Uvalde, TX, representative of a hot and arid environment. From the outset, it was
expected that, for these breeds to be successful, the F1 crossbred dams would have to compare favorably with the reproductive and maternal performance of the F1 Brahman crossbred cow. Some information on the reproductive and maternal traits of Tuli-sired cows has been published (Cundiff et al., 2000; Holloway et al., 2002b; Key et al., 2003) from other locations. The objective of this study was to evaluate the reproductive and maternal performance of F1 Brahman × Angus, Senepol × Angus, and Tuli × Angus crossbred cows in the hot and humid subtropics of central Florida.

Materials and Methods

This study was conducted at the Subtropical Agricultural Research Station (28°37′ N latitude, 82°22′ W longitude), located near Brooksville, FL, to determine maternal and reproductive performance among F1 Brahman × Angus (n = 42), Senepol × Angus (n = 34), and Tuli × Angus (n = 50) cows. Crossbred cows used in this study were born in 1993 (n = 59; 19 Brahman × Angus, 15 Senepol × Angus, and 21 Tuli × Angus) and 1994 (n = 67; 23 Brahman × Angus, 15 Senepol × Angus, and 29 Tuli × Angus) and were produced by breeding Angus cows by AI to Brahman (n = 10), Senepol (n = 10), and Tuli (n = 9) bulls. Semen from all bulls was used for both years of production. Brahman and Senepol semen was obtained from U.S. sources to be representative of current herd sire prospects. Tuli semen was purchased and imported from Australia. Tuli sires represented nine paternal lines exported from Zimbabwe to Australia as embryos in 1988. Details of the management and performance of the Angus cows and of their F1 calves through weaning have been described previously (Chase et al., 2000).

At weaning (September 8, 1993, and September 14, 1994), F1 calves were separated by sex and fed a preconditioning diet until the first week of October. At that time, F1 heifers were placed on bahiagrass (Paspalum notatum Fluegge) pastures with access to bahiagrass hay (round bales). A mixture of minerals was offered free choice (25 to 35% salt, 15 to 18% Ca, 5 to 8% P, ≥0.94% Fe, ≤0.15% Fl, ≥0.10% Cu, ≥0.01% Co, and 0.0010 to 0.0015% Se). Heifers were supplemented three times each week with concentrate (75% wheat middlings and 25% soybean meal mixture or 70% soybean hulls and 30% soybean meal mixture) at a rate equivalent to 2.3 kg/d (as-fed basis) fed in bunks and two times each week with blackstrap molasses at a rate equivalent to 1.8 kg/d (as-fed basis) fed in open troughs. The feeding of hay and supplements were discontinued in late spring (mid-May) when forage became available. From late spring through fall, heifers grazed bahiagrass and mixed bahiagrass and rhizoma peanut (Arachis glabrata Benth.) pastures. After first frost (mid-November), heifers were offered bahiagrass hay (round bales) free choice and blackstrap molasses was fed in open troughs two times each week at a rate equivalent to 1.8 kg/d (as-fed basis). Additionally, after calving, heifers were supplemented with concentrate (2.3 kg/d, as-fed basis) fed in bunks three times each week.

Two-year-old heifers were managed in this fashion until spring when forage became available.

Following weaning of their first calf and for subsequent calves, management of the crossbred cows was according to normal station practices that were considered to be typical of industry. Crossbred cows were placed on bahiagrass pastures at the same location throughout the study. After first frost (mid-November), bahiagrass hay (round bales) was offered free choice to all cows until spring when grass became available (approximately April 1). Also from first frost until spring, rhizoma peanut hay (round bales) was limited-fed as a supplement three times each week at a rate equivalent to 4.5 kg/d (as-fed basis; as a substitute for 0.9 kg/d of 20% CP range cubes). In winter of 1997 to 1998, owing to the unavailability of rhizoma peanut hay, crossbred cows were supplemented three times each week at a rate equivalent to 0.9 kg/d of a commercially available 20% CP (as-fed basis) range cube supplement (≥5.72% CP from nonprotein nitrogen) fed on the ground for the first 2 mo of supplementation. Rhizoma peanut hay was fed for the last 2 mo of supplementation. Additionally, at the start of calving until spring, cows were supplemented with blackstrap molasses fed in open troughs two times each week at a rate equivalent to 1.8 kg/d (as-fed basis). A mixture of minerals (described previously) was offered free choice throughout the year.

Angus bulls selected on the basis of low birth weight and that scored satisfactory on breeding soundness examinations were placed (two bulls with each group) with the crossbred heifers beginning in October after weaning for at least 1 yr and until the crossbred heifers were palpated as being pregnant. Angus bulls were rotated among groups or rested at 2-wk intervals throughout this time period. Calving dates were collected to determine age at first calving.

For the second and subsequent calves, crossbred cows were exposed to Charolais bulls during a 90-d breeding season (beginning March 20 of each year). During the breeding season, crossbred cows were managed in two groups, one group of crossbred cows born in 1993 (n = 59) and the second group of crossbred cows born in 1994 (n = 67). Two or three Charolais bulls ( multisire breeding herds) were used in each group each year.

Angus-sired calves from crossbred heifers were born throughout the year. Charolais-sired calves from crossbred cows were born from late December through March. At calving, personnel assigned a score to each birth that rated the difficulty of the birth in one of these categories: 1) unassisted birth, 2) slight hand pull, 3) moderate hand pull, and 4) Caesarean section. Personnel also noted abnormal presentation during delivery and uterine prolapse of the cow. Within 24 h of birth, calves were ear-tagged, tattooed, and weighed. Male calves were castrated. Birth date, dam identification, and sex of calf were also recorded. From 1997 through
1999, beginning at the end of the breeding season (mid-June) and until weaning, half the Charolais-sired calves were allowed to creep-feed molasses slurry (80% blackstrap molasses, 15% soybean meal, and 5% feather meal, as-fed basis), whereas the other half did not receive supplement (Skipper et al., 1998). In all other years (1996, 2001, 2002) calves were not creep-fed. At approximately 8 mo of age (September), cows and calves were weighed, body condition was scored, and hip height was measured. Calves were separated by sex and weaned. Cows were palpated for pregnancy.

Statistical Analyses

Data were analyzed with mixed models using the MIXED procedures of SAS (SAS Inst. Inc., Cary, NC). The following fixed effects and their interactions were investigated in preliminary analyses: year of record, age of cow (or birth year of cow), sex of calf, and breed of cow. Random effects investigated were sire of cow within breed, and cow within sire of cow (for traits in which cows had more than one record). Models for calf weaning traits also included calf age in days as a covariate. Model components that explained little trait variance were excluded from final analyses, with the exception of breed of cow, which was retained in all models as the effect of interest. The sire of cow within breed error term was used to test for differences among least squares means of breed groups.

All traits were analyzed as characters of the cow. Traits of first-calf (calves were Angus-sired) cows were analyzed as a separate data set because of the design to evaluate age at first calving. Because their first calves were born year-round, month of birth was included as a fixed effect for weight and weaning traits. Models for age at first calving included breed and cow birth year as fixed effects and sire of cow within breed as a random effect. Cow and calf body condition score were assessed on a scale from 1 to 9, where higher scores indicated increasing amounts of apparent fat cover (Herd and Sprott, 1986). The percentage of unassisted births, calf crop born, calf crop weaned, and calf survival rate were analyzed as 0 or 1 traits: 0 was assigned to records of calves that did not calve or wean a calf (excluding first-calf cows). The sire of cow within breed groups was compared with expected values representing the entire data set, and 33 values for 3- to 8-yr-old cows. These were analyzed using GLM procedures of SAS with the following fixed effects: breed of cow’s sire, year, cow birth year, and all possible interactions. Breed group least squares means were multiplied by 100 and presented as 205-d weight per 100 kg of exposed cow weight. Finally, numbers and proportions of cows with perfect calving and weaning records within breed groups were compared with expectations using $\chi^2$ tests.

Results and Discussion

Calf Traits

Angus-Sired Calves from Two-Year-Old Crossbred Cows. Cow breed type affected birth weight, weaning weight, and weaning hip height ($P < 0.001$ for each), but not weaning body condition score ($P = 0.25$) of calves from 2-yr-old crossbred cows. Birth weights of calves from 2-yr-old Senepol × Angus cows were heavier ($P < 0.01$) than those of calves from Brahman × Angus or Tuli × Angus cows (Table 1). Calves from 2-yr-old Brahman × Angus cows were heavier ($P < 0.01$) and taller ($P < 0.05$) at weaning than calves from Senepol × Angus or Tuli × Angus cows. As expected, male calves were heavier ($P < 0.05$) than female calves at birth ($30.3 \pm 0.54$ vs. $28.7 \pm 0.52$ kg) and tended ($P < 0.10$) to be heavier ($203.2 \pm 2.56$ vs. $196.8 \pm 2.52$ kg) and taller ($102.9 \pm 0.63$ vs. $101.2 \pm 0.62$ cm) at weaning. Heifer calves had a higher ($P < 0.001$) body condition score at weaning than steer calves ($6.2 \pm 0.10$ vs. $5.7 \pm 0.10$), but body condition score did not differ ($P = 0.25$) by cow breed type. Birth weights of calves from 2-yr-old crossbred cows were not affected by year ($P = 0.41$) or month ($P = 0.66$) of birth. Weaning weight and weaning hip height of calves from 2-yr-old crossbred cows were affected ($P < 0.001$) by year and age (as a linear covariate) at weaning.

These results agree with those from Holloway et al. (2002b) who reported that Hereford-sired calves out of first-parity Senepol × Angus cows were heavier at birth than calves from Brahman × Angus or Tuli × Angus cows. Calves from first-parity Brahman × Angus cows were heavier at weaning and had greater preweaning ADG than calves from Tuli × Angus and Senepol × Angus cows. However, in contrast to the present study, they reported that weaning traits for calves from first-parity Tuli × Angus cows were intermediate to those for calves from Brahman × Angus and Senepol × Angus cows. In Nebraska, Freely and Cundiff (1998) reported similar birth weights of calves from first-parity Brahman- and Tuli-sired cows but heavier weaning weights and greater preweaning ADG for calves from Brahman-sired cows.
Charolais-Sired Calves from Three- to Eight-Year-Old Crossbred Cows. Breed type affected birth weight \((P < 0.05)\), weaning weight \((P < 0.001)\), weaning hip height \((P < 0.001)\), and weaning body condition score \((P < 0.001)\) of calves from 3- to 8-yr-old crossbred cows. Birth weights of calves from Senepol \(\times\) Angus cows were heavier \((P < 0.05)\) than those from Brahman \(\times\) Angus cows but not Tuli \(\times\) Angus cows (Table 1); however, there was a breed type \(\times\) sex interaction \((P < 0.05)\) for birth weight. Male calves were heavier \((P < 0.001)\) than female calves from Senepol \(\times\) Angus and Tuli \(\times\) Angus cows but not from Brahman \(\times\) Angus cows. Additionally, for male calves, those from Senepol \(\times\) Angus cows tended \((P < 0.10)\) to have the heaviest birth weights, those from Brahman \(\times\) Angus had the lightest, and those from Tuli \(\times\) Angus were intermediate. For female calves, those from Senepol \(\times\) Angus cows had heavier \((P < 0.05)\) birth weights than those from either Brahman \(\times\) Angus or Tuli \(\times\) Angus cows, which did not differ from one another. Birth weight of Charolais-sired calves was affected by year \((P < 0.01)\) and age of crossbred cow \((P < 0.001)\).

Others have also reported no difference in birth weights between calves from Brahman- and Tuli-sired cows (Cundiff et al., 2000; Key et al., 2003). Butts (1988) reported heavier birth weights of calves from Senepol \(\times\) Angus cows than Brahman \(\times\) Angus cows. Brahman and Brahman crossbred cows have an innate ability to restrict fetal growth (Ellis et al., 1965; Roberson et al., 1986) that is believed to be due in part to uterine environment (Ferrell, 1991). As expected based on earlier studies (Butts, 1988; Chase et al., 1998), results of the present study do not indicate that the Senepol has this characteristic (i.e., an ability to restrict fetal growth). The breed type \(\times\) sex interaction that was observed for birth weight in the present study was due in part to a smaller difference in birth weight between male and female calves from Brahman \(\times\) Angus cows compared with those from the other breed types. Others have reported lower birth weights of calves from Bos indicus crossbred cows than calves from Bos taurus crossbred cows (Comerford et al., 1987; Morrison et al., 1989; Olson et al., 1991); none of the B. taurus cattle in those studies was tropically adapted. The trend for heavier birth weights of male calves, but not female calves, from Tuli \(\times\) Angus cows compared with Brahman \(\times\) Angus cows could be problematic because Tuli-sired cows were smaller than Brahman-sired cows in all studies (Cundiff et al., 2000; Holloway et al., 2002b; Key et al., 2003).

At weaning, Charolais-sired calves from Brahman \(\times\) Angus cows were the heaviest \((P < 0.05; 268.9 \text{ kg})\), calves from Tuli \(\times\) Angus cows were the lightest \((P < 0.05; 233.4 \text{ kg})\), and calves from Senepol \(\times\) Angus cows were intermediate \((P < 0.05; 256.0 \text{ kg}; \text{ Table 1})\). Calves from Brahman \(\times\) Angus cows were taller \((P < 0.01)\) and had higher \((P < 0.01)\) body condition scores at weaning than did calves from Senepol \(\times\) Angus or Tuli \(\times\) Angus cows. Steer calves were heavier \((P < 0.01; 256.0 \pm 2.82 \text{ kg})\) and taller \((P < 0.001; 113.6 \pm 0.45 \text{ cm})\) at weaning than heifer calves \((242.2 \pm 2.81 \text{ kg} \text{ and } 110.8 \pm 0.45 \text{ cm})\), but heifer calves had higher \((P < 0.001)\) body condition scores \((6.3 \text{ vs. } 6.0 \pm 0.03)\) at weaning. Weaning weight was affected by year \((P < 0.001)\), age of calf \((P < 0.001)\), and age of crossbred cow \((P < 0.01)\); weaning hip height was affected by year \((P < 0.001)\) and age of calf \((P < 0.05)\); and weaning body condition score was affected by year \((P < 0.001)\) and age of calf \((P < 0.001)\).

Others have reported heavier weaning weights for calves from Brahman-sired cows than Tuli-sired cows.
that from Brahman × Angus cows in 1999 compared with Tuli × Angus cows in 1998 and 2001, but in 1999, calf crop born from both Brahman × Angus and Senepol × Angus cows was lower (P < 0.01) than from Tuli × Angus cows.

A similar relationship was observed for the percentage of cows that weaned a calf (calf crop weaned). Calf crop weaned was affected by breed type (P < 0.01), year (P < 0.05), and breed type × year (P < 0.001). Averaged over all years (as 3- to 8-yr-old cows), calf crop born was lower (P < 0.05) from Senepol × Angus cows than from Tuli × Angus or Brahman × Angus cows (Table 3). The breed type × year interaction was characterized by a lower (P < 0.05) calf crop born from Senepol × Angus cows than from Brahman × Angus or Tuli × Angus cows in 1998 and 2001, but in 1999, calf crop born from both Brahman × Angus and Senepol × Angus cows was lower (P < 0.01) than from Tuli × Angus cows.

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crop born and weaned. Perhaps this high level of productivity was not sustainable because one-third did not calve in 1999.

Others have reported that calving rates and weaning rates did not differ between Brahman- and Tuli-sired cows (Cundiff et al., 2000; Key et al., 2003). Additionally, Holloway et al. (2002b) observed similar weaning rates between Brahman- and Tuli-sired cows; both were higher than that of Senepol-sired cows. In contrast, Butts (1988) reported that overall conception rates were similar between Brahman × Angus and Senepol × Angus cows with a slight advantage for Senepol × Angus cows in early parities.

Breed type tended to affect ($P < 0.10$) the percentages of 3- to 8-yr-old crossbred cows with unassisted births of Charolais-sired calves. Brahman × Angus cows had a greater ($P < 0.05$) percentage of unassisted births than did Tuli × Angus cows (Table 2). The percentage of Senepol × Angus cows with unassisted births did not differ ($P = 0.12$) from those of either Brahman × Angus or Tuli × Angus cows. A greater ($P < 0.05$) percentage of 3- to 8-yr-old crossbred cows that gave birth to heifer calves had unassisted births than those that gave birth to male calves ($96.8 ± 1.62$ vs. $92.6 ± 1.65$). No differences were reported in the percentage of unassisted calvings between Brahman- and Tuli-sired cows in Nebraska (Cundiff et al., 2000).

The percentage of Charolais-sired calves from 3- to 8-yr-old crossbred cows that survived to weaning tended to be affected by breed type ($P = 0.10$) and year ($P < 0.10$) but not breed type × year ($P = 0.22$). Averaged over all years, calving survival to weaning tended to be greater ($P < 0.10$) for Brahman × Angus cows than for Tuli × Angus cows (Table 3). Calving survival to weaning from Senepol × Angus cows did not differ ($P = 0.14$) from that for Brahman × Angus or Tuli × Angus cows. Calving survival to weaning is presented for breed type × year to be consistent with calf crop born and weaned (Table 3). Year differences seemed to be due to lower calving survival to weaning from Tuli × Angus ($P < 0.05$) cows compared with the other breed types in 1996 and from Senepol × Angus ($P < 0.05$) cows compared with the other breed types in 1998. Thus, the lower calf crop weaned from Senepol × Angus cows in 1998 was due to low calf survivability as well as to failure to calve. The low calf survivability from Tuli × Angus cows in 1996 was also associated with their lowest calf crop weaned (69.4%, calf crop born = 84%, all 1996) for any year. Data from 1996 are from the F_{1} cows born in 1993 having their first Charolais-sired calves. Therefore, calf survivability was compromised for Tuli × Angus cows when they were bred to Charolais bulls for their second calves to calve as 3-yr-olds. This lowered calf survivability observed from Tuli × Angus cows was mostly due to problems at calving (Table 2). Of the 19 Charolais-sired calves that were lost from Tuli × Angus cows from birth to weaning, 11 were lost due to dystocia (included one abnormal presentation and two uterine prolapses). In contrast, 4 (two abnormal presentations) of 12 calves from Senepol × Angus cows, and only 1 (abnormal presentation) of 7 calves from Brahman × Angus cows were lost due to dystocia. Additionally, the percentage of Charolais-sired calves that survived to 3 d of age tended ($P < 0.10$) to be lower for calves from Tuli × Angus cows (93.4 ± 1.5%) than Brahman × Angus cows (97.9 ± 1.7%) but not Senepol × Angus cows (94.9 ± 1.9%). Therefore, the decreased calving survival to weaning for calves from Tuli × Angus cows was largely due to a decreased calving survival to 3 d of age as a result of an increase in calving difficulty (as indicated by the incidence of assisted births).

Cundiff et al. (2000) did not report a significant difference in the percentage of calves that survived to weaning between Brahman- and Tuli-sired cows. Data in the present study suggest that the apparent advantage of Tuli × Angus cows observed for fertility (calf crop born) seemed to be offset by a slightly increased number of difficult calvings (fewer unassisted calvings) and slightly fewer calves that survived to weaning than for Brahman × Angus cows. This resulted in a similar calf crop weaned for Brahman × Angus and Tuli × Angus cows (Table 3).
For 3- through 8-yr-old cows, weaning weight per cow only Charolais-sired calves (i.e., for 3- to 8-yr-old cows). Weaning weight per cow exposed was calculated using (Table 5). Breed type differences were greater when Angus cows, and intermediate for Tuli × Angus cows (194.1 kg). In Nebraska, Cundiff et al. (2000) reported that weaning weight (200 d) per cow exposed for first parity did not differ between Brahman- and Tuli-sired cows but for second through subsequent parities was greater for Brahman- than for Tuli-sired cows. In Texas, Holloway et al. (2002b) reported that Senepol-sired cows had the lightest weaning weight per cow exposed when compared with Brahman- and Tuli-sired cows for first, second, and third parities. For Brahman- vs. Tuli-sired cows, Tuli-sired cows had an advantage over Brahman-sired cows for first-parity weaning weight per cow exposed, but, by the third parity, Brahman-sired cows had an advantage over Tuli-sired cows. Differences between the present study and Texas study are in part due to greater calf crop born for first and second calvings from all breed types, including Brahman × Angus cows in Florida compared with Texas. Management of the crossbred heifers, primarily nutrition and length of exposure to bulls (year-round vs. defined season), differed between locations and may have influenced first and second calf crops born and cow weights.

As 2-yr-olds, Brahman × Angus cows were heavier (P < 0.01) than both Senepol × Angus and Tuli × Angus cows (Table 6). Brahman × Angus cows tended (P < 0.10) to be the tallest, Tuli × Angus the shortest, and Senepol × Angus intermediate in hip height as 2-yr-old cows. As 7-yr-old cows, Brahman × Angus cows tended (P < 0.10) to be the heaviest and tallest, Tuli × Angus cows the lightest and smallest, and Senepol × Angus cows were intermediate in body weight and hip height. Body condition score was similar among breed types as 2-yr-old cows, and as 7-yr-old cows was greater (P < 0.01) for Tuli × Angus cows than either Brahman × Angus or Senepol × Angus cows. Body weights of second- and third-parity cows in Texas were ranked similarly to those in the present study: Brahman-, Senepol-, and Tuli-sired cows (from heaviest to lightest, respectively; Holloway et al., 2002b). Also, Key et al. (2003) reported that mature Brahman-sired cows were heavier than mature Tuli-sired cows.

### Table 4. Numbers (and percentages) of cows in each sire breed group that calved and weaned a calf every year

<table>
<thead>
<tr>
<th>Trait</th>
<th>Sire breed</th>
<th>No. of cows</th>
<th>Perfect calving</th>
<th>Perfect weaning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brahman</td>
<td>42</td>
<td>20 (47.6%)</td>
<td>17 (40.5%)</td>
</tr>
<tr>
<td></td>
<td>Senepol</td>
<td>34</td>
<td>7* (20.6%)</td>
<td>5† (14.7%)</td>
</tr>
<tr>
<td></td>
<td>Tuli</td>
<td>50</td>
<td>31† (62.0%)</td>
<td>21 (42.0%)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>126</td>
<td>58 (46.0%)</td>
<td>43 (33.0%)</td>
</tr>
</tbody>
</table>

*aCows with perfect records calved or weaned a calf each time they were exposed to bulls.

*b, †Differ from expectation, χ²,1 df; P < 0.05 and P < 0.10, respectively.

Numbers and the percentages of crossbred cows by each breed type that had perfect calving and weaning records are shown in Table 4. The percentage of Tuli × Angus cows that had perfect calving records tended (P < 0.10) to be greater than expected; the percentage of Senepol × Angus cows that had perfect calving records was less (P < 0.05) than was expected; and the percentage of Brahman × Angus cows with perfect calving records was as expected. The percentage of cows having perfect weaning records was as expected for both Brahman × Angus and Tuli × Angus cows but tended (P < 0.10) to be less than was expected for Senepol × Angus cows. These data also indicate the relatively high fertility of Tuli × Angus cows observed in this study. However, calf losses resulted in similar percentages of Tuli × Angus and Brahman × Angus cows to have perfect records at weaning.

**Efficiency of Crossbred Cows.** Breed type affected (P < 0.001) weaning weight per cow exposed. Weaning weight per cow exposed for 2- through 8-yr-olds (i.e., includes first Angus-sired calves) tended (P < 0.10) to be greatest for Brahman × Angus cows, least for Senepol × Angus cows, and intermediate for Tuli × Angus cows (Table 5). Breed type differences were greater when weaning weight per cow exposed was calculated using only Charolais-sired calves (i.e., for 3- to 8-yr-old cows). For 3- through 8-yr-old cows, weaning weight per cow exposed was greatest (P < 0.05) for Brahman × Angus cows (214.8 kg), least for Senepol × Angus cows (164.9 kg), and intermediate for Tuli × Angus cows (194.1 kg). In Nebraska, Cundiff et al. (2000) reported that weaning weight (200 d) per cow exposed for first parity did not differ between Brahman- and Tuli-sired cows but for second through subsequent parities was greater for Brahman- than for Tuli-sired cows. In Texas, Holloway et al. (2002b) reported that Senepol-sired cows had the lightest weaning weight per cow exposed when compared with Brahman- and Tuli-sired cows for first, second, and third parities. For Brahman- vs. Tuli-sired cows, Tuli-sired cows had an advantage over Brahman-sired cows for first-parity weaning weight per cow exposed, but, by the third parity, Brahman-sired cows had an advantage over Tuli-sired cows. Differences between the present study and Texas study are in part due to greater calf crop born for first and second calvings from all breed types, including Brahman × Angus cows in Florida compared with Texas. Management of the crossbred heifers, primarily nutrition and length of exposure to bulls (year-round vs. defined season), differed between locations and may have influenced first and second calf crops born and cow weights.

As 2-yr-olds, Brahman × Angus cows were heavier (P < 0.01) than both Senepol × Angus and Tuli × Angus cows (Table 6). Brahman × Angus cows tended (P < 0.10) to be the tallest, Tuli × Angus the shortest, and Senepol × Angus intermediate in hip height as 2-yr-old cows. As 7-yr-old cows, Brahman × Angus cows tended (P < 0.10) to be the heaviest and tallest, Tuli × Angus cows the lightest and smallest, and Senepol × Angus cows were intermediate in body weight and hip height. Body condition score was similar among breed types as 2-yr-old cows, and as 7-yr-old cows was greater (P < 0.01) for Tuli × Angus cows than either Brahman × Angus or Senepol × Angus cows. Body weights of second- and third-parity cows in Texas were ranked similarly to those in the present study: Brahman-, Senepol-, and Tuli-sired cows (from heaviest to lightest, respectively; Holloway et al., 2002b). Also, Key et al. (2003) reported that mature Brahman-sired cows were heavier than mature Tuli-sired cows.

### Table 5. Efficiency for F₁ Brahman × Angus, Senepol × Angus, and Tuli × Angus cows

<table>
<thead>
<tr>
<th>Trait</th>
<th>n</th>
<th>Brahman</th>
<th>Senepol</th>
<th>Tuli</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(n = 42)</td>
<td>(n = 34)</td>
<td>(n = 50)</td>
</tr>
<tr>
<td>Weaning wt per cow exposed, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3- through 8-yr-olds</td>
<td>633</td>
<td>234.2 ± 9.5*</td>
<td>173.0 ± 9.8*</td>
<td>209.0 ± 9.1*</td>
</tr>
<tr>
<td>2- through 8-yr-olds</td>
<td>759</td>
<td>214.8 ± 8.2*</td>
<td>164.9 ± 8.9*</td>
<td>194.1 ± 7.5*</td>
</tr>
<tr>
<td>Weaning wt per 100 kg of cow exposed</td>
<td>633</td>
<td>42.2 ± 1.41*</td>
<td>33.8 ± 1.41*</td>
<td>40.7 ± 1.41*</td>
</tr>
<tr>
<td>2- through 8-yr-olds</td>
<td>759</td>
<td>45.0 ± 1.36*</td>
<td>37.6 ± 1.36*</td>
<td>44.2 ± 1.36*</td>
</tr>
</tbody>
</table>

*aIncludes weights of Angus-sired calves (first parities).

*Means in the same row without a common superscript differ (P < 0.01).

*means in the same row without a common superscript differ (P < 0.05).

**x**Means in the same row without a common superscript differ (P < 0.10).
Holloway et al. (2002b) reported that efficiency, expressed as kilograms of weaned calf per 100 kg of cow exposed, from first- and second-parity cows was greatest from Tuli-, least from Senepol-, and intermediate from Brahman-sired cows. Efficiency from third-parity cows, however, was similar between Tuli- and Brahman-sired cows. Like that study, we calculated efficiency expressed as 205-d weaning weight per 100 kg of cow exposed (Table 5). For 2- to 8-yr-old (includes Angus-sired calves) cows, efficiency was similar from Brahman × Angus cows (45.0) and Tuli × Angus cows (44.2) and both had greater ($P < 0.01$) production per unit of cow BW than Senepol × Angus cows (37.6). A similar relationship was observed for 3- to 8-yr-old cows, efficiency did not differ between Brahman × Angus and Tuli × Angus cows and both were greater ($P < 0.01$) than Senepol × Angus cows. Weaning weight per cow exposed did not account for differences in cow size. When the larger size and heavier body weight of the Brahman × Angus cows was accounted for by 205-d weaning weight per 100 kg of cow exposed, efficiency was similar between the small Tuli × Angus cows and the large Brahman × Angus cows, despite the much heavier weaning weights for calves from Brahman × Angus cows. These data suggest that, in the subtropics, Tuli × Angus cows may serve a role similar to that of Brahman × Angus cows, the industry standard.

## Implications

Tropically adapted sire breeds will likely be most efficiently utilized in warm regions of the United States in the formation of F$_1$ or composite cows. Brahman × Angus cows excel in the subtropics and are the standard to which other breeds should be compared in this environment. Reproductive and maternal performance of Senepol × Angus cows was generally inferior to that observed for Brahman × Angus cows. Performance by Tuli × Angus cows, however, was comparable to that of Brahman × Angus cows for all traits except calf survivability, primarily as a result of calving difficulty and weaning weight. The smaller size of Tuli vs. Brahman crosses may be a benefit in the subtropics and tropics as related to overall efficiency of production, particularly when bulls are selected for calving ease.

## Literature Cited


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### Table 6. Weight, hip height, and BCS for F$_1$ Brahman × Angus, Senepol × Angus, and Tuli × Angus cows as 2- and 7-yr-olds

<table>
<thead>
<tr>
<th>Trait</th>
<th>Breed of cow’s sire</th>
<th>2-yr-old cows</th>
<th>7-yr-old cows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>n</td>
<td>Weight, kg</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
<td>---------------</td>
<td>-------------</td>
</tr>
<tr>
<td></td>
<td>Brahman</td>
<td>126</td>
<td>442.2 ± 7.9$^v$</td>
</tr>
<tr>
<td></td>
<td>Senepol</td>
<td>126</td>
<td>411.4 ± 7.7$^w$</td>
</tr>
<tr>
<td></td>
<td>Tuli</td>
<td>126</td>
<td>401.2 ± 7.2$^x$</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
<td>---------------</td>
<td>-------------</td>
</tr>
<tr>
<td></td>
<td>Brahman</td>
<td>105</td>
<td>132.4 ± 0.9$^a$</td>
</tr>
<tr>
<td></td>
<td>Senepol</td>
<td>105</td>
<td>126.1 ± 0.9$^a$</td>
</tr>
<tr>
<td></td>
<td>Tuli</td>
<td>105</td>
<td>123.9 ± 0.5$^a$</td>
</tr>
</tbody>
</table>

*Traits were measured in conjunction with weaning of calves in the fall of the respective years.

$^a$Means in the same row without a common superscript differ ($P < 0.01$).

$^b$Means in the same row without a common superscript differ ($P < 0.10$).

$^c$BCS was measured on 1-to-9 scale, where lower numbers indicate thinner cows.

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References

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