Genetic and nongenetic influences on vigor at birth and preweaning mortality of purebred and high percentage Brahman calves[1,2,3]

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ABSTRACT: The objectives of this study were to assess the risk associated with proportion Brahman inheritance, cow age, dystocia, and birth date weather conditions on calf vigor at birth (n = 3,253) and preweaning mortality (n = 3,631), and to estimate heritabilities for these traits. Calves that had poor vigor at birth and calves that died before weaning were coded 1, and those that had adequate birth vigor or survived to weaning were coded 0. Traits were analyzed using GLM. Year (1951 to 2002), cow age, calf gender, minimum temperature on date of birth (two levels: ≤5.6°C; or >5.6°C), and occurrence of dystocia were main effects in models. The proportion of Brahman inheritance in calves was modeled as a covariate. Males had greater odds of poor birth vigor (odds ratio = 1.44, 95% confidence interval = 1.14 to 1.82). The odds of death before weaning for steers relative to heifers approached significance (P = 0.07; odds ratio 1.41, 95% confidence interval 0.97 to 2.04). Calves born to young (3-yr-old) or very old (13 yr or older) cows had greater (P < 0.05) odds of poor vigor and death before weaning than calves of 5-yr-old cows. Calves with difficult births had 2.59 times greater odds of poor birth vigor (95% confidence interval 1.40 to 4.79) and 12.9 times greater odds of death before weaning (95% confidence interval 8.14 to 20.39) than calves born with no dystocia. Calves born on days with minimum temperatures of 5.6°C or less had greater odds of poor vigor (odds ratio 1.97, 95% confidence interval 1.50 to 2.59) and of death before weaning (odds ratio 1.64, 95% confidence interval 1.27 to 2.13) than did calves born on days with higher minimums. The occurrence of rainfall on date of birth did not influence calf vigor at birth or preweaning mortality (P > 0.85). Purebred Brahman calves had 24.7 times greater odds (95% confidence interval 8.23 to 73.97) of poor vigor than ⅔ Brahman calves. The regression coefficient estimate for fraction of Brahman inheritance approached significance (P = 0.07) for preweaning mortality. Estimates of direct and maternal heritability were 0.09 ± 0.05 and 0.10 ± 0.04 for birth vigor, and 0.06 ± 0.05 and 0.09 ± 0.04, respectively, for preweaning mortality. Some exploitable genetic variation exists for these traits, but management of other factors may yield more immediate improvement than selection.

Key Words: Brahman, Calves, Genetic Parameters, Mortality, Vigor

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Introduction

Adaptation of Brahman cattle to hot, harsh environments (Turner, 1980), and the high heterosis for reproductive and maternal traits expressed by Brahman-*Bos taurus* cows (Cartwright et al., 1964), account for the widespread use of the breed in cow-calf production in the Gulf Coast region of the United States. Straightbred herds are necessary in order to generate these highly productive crossbreds (Gregory and Cundiff, 1980); formidable difficulties associated with straightbred Brahman production include poor neonatal performance and low calf survival rates (Cartwright, 1980). In order to obtain valuable colostrum, a newborn calf must be vigorous enough to stand, find its dam's udder, and nurse. Extremely weak calves have been frequently observed among *Bos indicus* newborns (Bauer, 1973; Olcott et al., 1987). Calf mortality before weaning accounts for almost a third of calf crop losses (Cundiff et al., 1982), and is higher in subtropical and tropical regions (Plasse, 1973), where *Bos indicus* cattle are the predominant type of cattle. Preweaning mortality is negatively

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influenced by a variety of environmental influences, including occurrence of dystocia (Laster and Gregory, 1973) and hypothermia (Rowan, 1992; Wittum et al., 1993). There may be a genetic cause for weak calf syndrome (Ogata et al., 1999), but there have been no reported estimates of genetic parameters for traits related to vigor at birth in cattle. Reported estimates of heritability for calf survival to various ages have been low (Cundiff et al., 1986; Koots et al., 1994). The objectives of this study were 1) to assess the risk associated with greater than or equal to ⅔ Brahman inheritance, cow age, occurrence of dystocia, and birth date weather conditions on calf vigor at birth and calf preweaning mortality, and 2) to estimate heritabilities for these traits.

Materials and Methods

Cattle

This study was conducted using data from the Brahman herd at the Subtropical Agricultural Research Station in Central Florida. The herd was established with the purchase of cows and bulls from a prominent Texas herd in 1949. Replacement heifers have been regularly kept, and outside bloodlines have been added to this herd from various sources one or two times each decade since that time, as purchased cows and as purchased or borrowed bulls. A crossbred cowherd consisting of high-percentage Brahman inheritance cows was begun with the purchase of Brahman-sired cows (n = 85) in 1969 that were produced in a two-breed rotational system. They were assumed to be at least ⅔ Brahman, ⅓ British (predominantly Angus) cows, and were initially mated to Brahman bulls. These cows and their ⅚ Brahman daughters were bred either inter se or to Brahman bulls until 1981, when most were culled and removed from the herd. The crossbred calves that these cows produced (n = 936) and contemporary purebred calves (n = 364) were part of the data of Olson et al. (1990), who reported calf survival rates. They are included in the present study because the subsequent Brahman herd (even to the present) consisted of high-grade cows that descend from this group in order to augment available pedigree and data. Crossbred cows that remained after 1981 were ⅚ or greater Brahman and were thereafter all mated to Brahman bulls. Consequently, calves with records in this dataset ranged from a low of ⅔ (all ⅔ Brahman calves were produced by inter se matings) to 99% Brahman inheritance (n = 1,470), or were purebred Brahman (n = 2,161).

Cow breeding and culling procedures varied. Most calves were produced by natural matings in single-sire pastures; a small number of calves (most of these were born in 2000 and 2001) were produced by AI matings. Calves were born to 3-yr-old or older cows, mostly from late December through early May of each year. Records of calves born outside these months were removed from the dataset. All calves were tagged within 24 h of birth. A few males were castrated in some years, always within 24 h of birth, and beginning in 1996, all males were castrated. All calves were weaned in the fall of each year at an average of approximately 7 mo of age. Cows have been culled for obvious health reasons and generally after failing to calve and/or wean a calf in 2 yr, but the strictness of culling guidelines has varied depending on management protocol at the time of evaluation.

Traits Evaluated

Beginning in 1964, calf vigor was evaluated within 24 h of birth and assigned one of these scores: 1) normal, vigorous calf; 2) weak calf that nursed without assistance; 3) weak calf that was assisted to nurse; or 4) stillbirth. Stillbirths were excluded from analyses of calf vigor at birth. Calves with vigor scores of 2 or 3 were assigned a value of 1 as failing to express adequate birth vigor. Calves with vigor scores of 1 were assigned a value of 0. Written notes associated with birth records were used to assign values for birth vigor for calves born from 1951 to 1963. Preweaning mortality was evaluated as a binary trait of the calf. Of the calves born, those that died before weaning were assigned 1, and the others were assigned 0.

Statistical Analyses

Birth vigor and preweaning mortality were analyzed using GLM assuming binomial distribution of the data and employing a logit link to an underlying normal distribution. Models were built using the GENMOD procedures of SAS (SAS Inst., Inc., Cary, NC). Any effect, including interaction terms, having a Wald statistic with a P-value less than or equal to 0.25 was kept for final analyses. Year of record initially had 52 levels (1951 through 2002). Calf gender consisted of two levels for birth vigor and three levels (bulls, steers, and heifers) for preweaning mortality. Cow age ranged from 3 to 17 yr, but was modeled as fixed effect using these eight age categories: 3, 4, 5, 6 to 9, 10, 11, 12, and 13 yr or older. The proportion of Brahman breeding in calves was modeled as a linear covariate.

Personnel assigned a score to each birth that rated the difficulty of the birth in one of these categories: 1) normal 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. The presence of calving difficulty at birth was modeled as a two-level fixed effect: 1) normal births and 2) births requiring any assistance, or any record of abnormal presentation or uterine prolapse.

The effect of weather conditions on these traits was evaluated by investigating main and interaction effects involving maximum and minimum temperatures and the presence of rainfall on date of birth. Temperature and rainfall data were collected at the Chinsegut Hill Climatological Station (Brooksville, FL; 28°38′00″N, 82°21′30″W, elevation = 73.2 m) of the National

Weather Service (National Oceanic and Atmospheric Administration, U.S. Department of Commerce). The Chinsegut Hill Station was missing this information for a small number of dates (n = 10) across the 52 yr. Temperature and rainfall data from the E Climatological Station (Bushnell, FL; 28°40′N, 82°5′W, elevation = 22.9 m) were used for missing Brooksville data. The range of calving dates (December to May) is typically a dry part of the year in central Florida, with mild to cold night temperatures. Based on similar work in Nebraska (Josey et al., 1993), and on graphical inspection of proportions of calves (with inadequate vigor and dead before weaning) plotted against minimum temperature on date of birth, a boundary of 5.6°C was determined to separate minimum temperatures into two categories. The occurrence of rainfall was modeled in two levels as either present or absent (minimum rainfall recorded was approximately 2.5 mm).

Odds ratios were calculated to obtain information about relative risk for expression of inadequate birth vigor and preweaning mortality for different levels of the significant fixed effects. The odds ratio is the ratio of the probability of one outcome (inadequate vigor at birth or death before weaning) relative to another (adequate vigor at birth or survival to weaning). An odds ratio of two levels of a fixed effect equal to 1 indicates no difference between the two levels, and a 95% confidence interval for two levels that contains 1.0 suggests a lack of evidence for significant difference of the odds ratio. In all but a single case, odds ratios were constructed relative to the lowest level within each fixed effect. The effect of the modeled covariate was illustrated by construction of an odds ratio and confidence interval using the regression coefficient estimate and two values of the covariate that were represented in the data.

Genetic parameter estimation was conducted with animal-model restricted maximum likelihood analyses using the ASREML program (Gilmour et al., 1999). Random effects investigated included animal and maternal effects and their covariance, and permanent environmental effects associated with dams. Statistical testing of random effects was conducted using a 50:50 mixture of χ^2 variables for the difference in model deviance from models with n and n + 1 random effects (Self and Liang, 1987; Stram and Lee, 1994). The residual variance was fixed at $\pi^2/3 = 3.29$. Estimated variances were used to estimate heritabilities. Start values of these variances and covariances were chosen within a range of reported variance estimates for binomially distributed traits in cattle (Koots et al., 1994). A convergence criterion of 10^{-9} was used for all analyses.

Results

The unadjusted means for inadequate calf vigor at birth (n = 3,253) and preweaning mortality (n = 3,631) were 0.106 and 0.108, respectively. Years in which all calves expressed adequate birth vigor and years in which all calves survived to weaning were uninformative (infinite likelihood) and were edited out of the final datasets. These included 16 yr for calf vigor at birth (1951 to 1955, 1957, 1959 to 1963, 1965 to 1967, 1973, and 1979) and 5 yr for preweaning mortality (1952, 1953, 1956, 1957, and 1967). Unadjusted means from the edited data sets were 0.122 for calf vigor at birth (n = 3,092), and 0.11 for preweaning mortality (n = 3,552).

Calf Vigor at Birth

The final model for calf vigor at birth included year ($P < 0.001$), age of dam at birth ($P = 0.06$), calf gender ($P < 0.01$), dystocia ($P < 0.01$), birth date minimum temperature category ($P < 0.001$), and fraction of Brahman inheritance ($P < 0.001$). The presence or absence of rainfall was not important ($P = 0.99$) and was excluded from the final model. Odds ratios and 95% confidence intervals for inadequate vigor expression at birth within each effect (other than year) are shown in Table 1, and corresponding unadjusted statistics are shown in Table 2. Bull calves had greater odds of poor birth vigor than heifer calves (odds ratio 1.44; 95% confidence interval 1.14 to 1.82). Calves born to 3-yr-old cows had significantly greater odds of poor vigor than calves born to 5-yr-old cows (odds ratio 1.78; 95% confidence interval 1.16 to 2.73), as did calves born to cows age 13 or older (odds ratio 2.11; 95% confidence interval 1.18 to 3.77). Calves from difficult births had 2.59 times greater odds of poor birth vigor than did calves from normal births (95% confidence interval 1.40 to 4.79). Calves born on days with minimum temperatures less than or equal to 5.6°C had greater odds of poor vigor than those born on days with minimum temperatures higher than 5.6°C (odds ratio 1.97; 95% confidence interval 1.50 to 2.59). Straightbred Brahman calves had 24.7 times greater odds (95% confidence interval 8.23 to 73.97) of poor vigor at birth than ⅔ Brahman calves (the regression coefficient estimate on the underlying scale was 10.24 ± 2.07).

The estimates of covariance and genetic parameters are shown in Table 3. Permanent environmental effects associated with dams ($P = 0.77$) and the covariance between additive and maternal effects ($P = 0.66$) were excluded from the final model. The estimate of heritability for calf vigor at birth was 0.09 ± 0.05, and the proportion of the phenotypic variance due to maternal effects was 0.10 ± 0.04.

Preweaning Mortality

Year ($P = 0.01$), age of dam ($P = 0.02$), calf gender ($P = 0.16$), dystocia ($P < 0.001$), minimum temperature on day of birth ($P < 0.001$), and the fraction of Brahman inheritance ($P = 0.07$) were retained in the final preweaning mortality model, but the presence of rainfall ($P = 0.86$) was not. The odds of death before weaning for steers relative to heifers approached significance (Table 1, odds ratio 1.41; 95% confidence interval 0.97 to 2.01). Calves born to 3- and 11-yr-old cows had 1.77

Table 1. Odds ratios and 95% confidence intervals for factors affecting inadequate calf vigor at birth and preweaning mortality of calves with two-thirds or more Brahman inheritance

	Inadequate birth vigor		Preweaning mortality	
Factor	Odds ratio	Confidence interval[a]	Odds ratio	Confidence interval[a]
Calf gender[b]				
Bulls	1.44	1.14 to 1.82	1.10	0.83 to 1.45
Steers	—		1.41	0.97 to 2.04
Heifers	NA[c]		NA	
Cow age, yr				
3	1.78	1.16 to 2.73	1.77	1.17 to 2.67
4	1.23	0.76 to 1.97	1.24	0.78 to 1.95
5	NA		NA	
6 to 9	1.22	0.83 to 1.79	1.08	0.74 to 1.60
10	1.56	0.84 to 2.89	1.56	0.84 to 2.89
11	0.92	0.41 to 2.05	2.34	1.20 to 4.56
12	1.03	0.41 to 2.56	1.49	0.57 to 3.86
≥13	2.11	1.18 to 3.77	1.56	0.81 to 3.01
Difficult birth				
Yes	2.59	1.40 to 4.79	12.88	8.14 to 20.39
No	NA		NA	
Minimum temperature				
≤5.6°C	1.97	1.50 to 2..59	1.64	1.27 to 2.13
>5.6°C	NA		NA	

[a]Confidence intervals that do not contain 1 indicate significant odds ratios.
[b]Gender consisted of two levels for calf vigor at birth and three levels for preweaning mortality (bulls, steers, and heifers).
[c]NA = not applicable—reference category.

Table 2. Unadjusted statistics for inadequate calf vigor at birth and preweaning mortality of calves with two-thirds or more Brahman inheritance within factor levels

	Inadequate calf vigor at birth			Preweaning mortality		
	n	Mean[a]	SEM	n	Mean[a]	SEM
Calf gender[b]						
Bulls	1,534	0.14	0.01	1,320	0.10	0.01
Steers	—	—	—	469	0.17	0.02
Heifers	1,558	0.11	0.01	1,763	0.10	0.01
Cow age, yr						
3	665	0.13	0.01	803	0.14	0.01
4	433	0.10	0.01	502	0.10	0.01
5	490	0.09	0.01	529	0.08	0.01
6 to 9	1,141	0.12	0.01	1,322	0.09	0.01
10	143	0.14	0.03	151	0.13	0.03
11	79	0.11	0.04	89	0.18	0.04
12	46	0.15	0.05	51	0.12	0.05
≥13	95	0.33	0.05	105	0.17	0.04
Difficult birth						
Yes	67	0.28	0.05	102	0.55	0.05
No	3,025	0.12	0.01	3,450	0.10	0.02
Minimum temperature[c]						
≤5.6°C	667	0.17	0.02	813	0.14	0.01
>5.6°C	2,425	0.11	0.01	2,739	0.10	0.01

[a]Calves that had poor vigor or died before weaning were assigned 1, whereas those that had adequate vigor or that survived to weaning were assigned 0. Means represent proportions of calves that showed poor vigor at birth or failed to survive to weaning.
[b]Gender consisted of two levels for calf vigor at birth and three levels for preweaning mortality (bulls, steers, and heifers).
[c]Minimum temperature on the date of birth.

Table 3. Estimates of variances and genetic parameters for inadequate calf vigor at birth and preweaning mortality of Brahman calves

Parameter[a]	Inadequate birth vigor	Preweaning mortality
s_e^2	3.29	3.29
s_a^2	0.35 ± 0.20	0.22 ± 0.19
s_m^2	0.41 ± 0.17	0.34 ± 0.16
s_p^2	3.84 ± 0.18	3.85 ± 0.18
h^2	0.09 ± 0.05	0.06 ± 0.05
h_m^2	0.10 ± 0.04	0.09 ± 0.04

[a]Subscripts indicate different components or proportions of variance: a = additive genetic; m = maternal genetic; e = residual; p = phenotypic.

(95% confidence interval 1.17 to 2.67) and 2.34 (95% confidence interval 1.20 to 4.56) times greater odds, respectively, of death before weaning than did calves born to 5-yr-olds. Calves from difficult births had 12.88 times greater (95% confidence interval 8.14 to 20.39) odds of death before weaning than calves from normal births. Calves born on days with minimum temperatures less than or equal to 5.6°C had greater odds of death before weaning than did calves born on days with higher minimum temperatures (odds ratio 1.64; 95% confidence interval 1.27 to 2.13). The regression coefficient estimate for the fraction of Brahman inheritance was 2.58 ± 1.51 (underlying scale). The odds ratio (constructed using this estimate) of death before weaning for straightbred Brahman calves relative to ⅔ Brahman calves approached significance (odds ratio 2.12; 95% confidence interval 0.98 to 4.73).

The estimates of variance and genetic parameters are shown in Table 3. Permanent environmental effects of the dam ($P = 0.29$) and the additive maternal genetic covariance ($P = 0.51$) were not kept in the final model. The estimate of heritability for preweaning mortality was 0.06 ± 0.05, and the estimated proportion of total phenotypic variance due to maternal effects was 0.09 ± 0.04.

Discussion

Gender Effects

Calf gender seemed to be more influential on expression of vigor at birth than on preweaning mortality. The odds of death before weaning for steers relative to heifers (Table 1) only approached significance, which was unexpected because heifers (and females of most livestock species) have had higher survival rates than males in other studies (Cundiff et al., 1982; Nix et al., 1998). However, Ogata et al. (1999) reported no gender influence on mortality in Japanese Black calves. In the current study, the interaction of the occurrence of dystocia with calf gender was not detected for calf vigor at birth ($P = 0.35$) or preweaning mortality ($P = 0.70$). However, there was a higher proportion of difficult births for bull calves than for heifer calves (0.036 and 0.022, respectively). This seems to be consistent with an early study of *Bos taurus* cattle (Laster and Gregory, 1973) in which almost all (90% or higher) difficult births (approximately 25% and 15% of male and female births, respectively, were difficult) resulted in calf death.

Age of Cow Effects

The greater odds of poor vigor and of death before weaning for calves born to 3-, 11- (vigor), or 13-yr-old cows and older (preweaning mortality) seemed to be consistent with other age-associated lower cow performance, such as calf weaning weight. Hansen et al. (2003) reported the higher postnatal mortality of Danish Holstein calves born to young cows (23 mo of age or less) than that of calves born to older cows. Cows in their prime production years may give birth to a physiologically more competent calf and/or be maternally more attentive, and therefore more successful at raising calves to weaning. Maternal inclination of heifers may be substandard relative to cows and therefore negatively affect calf birth vigor and preweaning mortality. Abnormal maternal behavior, especially among heifers, was associated with increased time from birth to first nursing (Rowan, 1992). Cloete and Scholtz (1998) reported higher desertions, higher frequency of avoidance, and less cooperation with their lambs' first attempts to nurse in young (first parity) vs. older ewes. A similar pattern of age-associated behavior may exist in cattle; however, in the present study, abandonment was listed in written records of only 8 of the 392 calves that died before weaning. Feto-pelvic incompatibility of first-calf heifers (Meijering, 1984) could be considered a potential cause of mortality or poor calf performance. However, an important and well-known breed advantage of Brahman cows is the low occurence of dystocia (Wythe, 1970). The absence of a cow age × dystocia interaction for birth vigor ($P = 0.32$) or preweaning mortality ($P = 0.61$) suggests that the generally accepted patterns of dystocia with respect to calf gender or cow age may impact Brahman calf survival to a lesser extent than that of other breeds. There were higher proportions (not statistically tested) of difficult births for calves from 3- and 4-yr-old cows. Laster and Gregory (1973) reported that although cow age did influence the rate of mortality of calves from normal births, it did not significantly influence deaths from difficult births. Another potential source of age-related stress (especially for heifers and aged cows) may be associated with the effort to match nutrient intake with lactation and body maintenance requirements.

One of the most important age-dependent factors affecting calf mortality (and possibly birth vigor) must be the structure and quality of the dam's udder (Wythe, 1970; Edwards, 1982). Olcott et al. (1987) reported no strong relationship of poor udder and teat conformation with nursing disorders. In the present study, poor udders or teats were mentioned in written notes associated with calving records (not all birth records had written notes) for 46 of the 378 calves with poor calf vigor, and for 41 of the 392 calf deaths.

Calving Difficulty Effects

The strong detrimental influence of dystocia on calf vigor at birth is not surprising. Results from the present study support the cause-and-effect relationship of dystocia with reduced vigor or vitality (Edwards, 1982; Meijering, 1984), but there has been at least one report of no relationship between neonatal weakness and dystocia (Ogata et al., 1999). Olcott et al. (1987) suggested that parturient anoxia was a cause of weak Brahman calves, but their study only involved calves from births with no dystocia; it seems that this condition would be common in difficult births.

The strong influence of dystocia on preweaning mortality was consistent with results of Philipsson (1976) who reported 20% increased mortality of calves born in difficult births compared to those born in normal births to Friesian cows and heifers. Arthur et al. (2000) reported a 12% reduction in survival associated with calving difficulty in Angus cattle. In another Angus study, Cubas et al. (1991) acknowledged the negative impact of dystocia on calf survival, and suggested selection for calving ease as a method to improve calf survival. Dystocia has been shown to be a major cause of mortality in beef calves (Cundiff et al., 1982; Bellows and Short, 1994; Nix et al., 1998). Increased calf mortality associated with increased incidence of dystocia linked with the forage-growing season of the year has been reported by studies from temperate environments (McGuirk et al., 1998a; Nix et al., 1998). Meijering (1984) suggested that seasonal effects on dystocia may be due to less attentiveness to the birthing process (i.e., less observation, but perhaps not less occurrence, of dystocia) observed when animals are grazing.

Weather Effects

Results indicated an adverse influence of cold ambient temperature at birth on Brahman calf survival, even in this subtropical environment. Calf mortality due to cold exposure has been reported to range from 10 (Cundiff et al., 1982) to 12.2% (Wittum et al., 1993) in temperate areas. In a temperate winter environment, to which Brahman and other *Bos indicus* cattle clearly are not adapted, Josey et al. (1993) demonstrated the increasingly adverse effects of cold temperatures at birth on the percentage *Bos indicus* (Brahman and Sahiwal) calves, and showed that calf survival decreased in cold temperatures with increasing percentage of *Bos indicus* inheritance.

The lack of influence of rainfall (on date of birth) on preweaning mortality was unexpected, but consistent with the results of Josey et al. (1993). However, lamb survival has been reported to be reduced in the wet season of a tropical environment (Mukasa-Mugerwa et al., 2000). We were unable to address the effects of humidity and/or wind chill, both of which probably impact newborn performance or survival, especially in cold conditions (Rowan, 1992; Josey et al., 1993).

Olcott et al. (1987) observed that nursing problems among Brahman calves were more frequent in cold weather, but were still common in good weather. Failure to stand or inability to stand quickly is frequently an indication that a calf is weak (Stanko et al., 1991; Dietz et al., 2003). Our results were not consistent with the lack of temperature influence on Brahman calf vigor score reported from East Texas (Godfrey et al., 1991); assessment of vigor in that study was based on standing or attempting to stand, and it is known that heat production is greatly enhanced in calves trying to stand (Rowan, 1992). The ability of Brahman calves to maintain body temperature in a cold environment improves substantially from 1 to 2 d of age (Stanko et al., 1991).

Brahman Inheritance Effects

Some of the high costs of producing purebreds are associated with poor calf survivability of straightbred Brahman calves (Cartwright, 1980); mating high percentage Brahman cows to straightbred Brahman bulls may be an effective way to avoid the problems associated with straightbred calf mortality and still produce high-percentage Brahman females for use in F_1 production. The non-Brahman fraction of the crossbred cattle in this project was British (Olson et al., 1990); it may be more attractive for Brahman seedstock producers to use other *Bos indicus* breeds if preweaning mortality and vigor performance results are similar to those of the present study. Our own unpublished data on Nellore-Brahman cross calves suggests (at best) that calf survival to weaning (but not vigor at birth) may be improved over that of straight Brahman, but the limited number of records prevents anything more than consideration of the notion. Cloete and Scholtz (1998) reported line differences in time between standing and first nursing in lambs. Sussex-sired calves stood and nursed sooner than Friesian-sired calves (Edwards, 1982); however, Godfrey et al. (1991) did not detect a difference in vigor scores of purebred Brahman calves and Brahman crossbred calves (¼ Brahman, ¼ Hereford, ½ Simmental). The use of non-Brahman *Bos indicus* breeds, or possibly distantly related lines of Brahman inheritance, in a crossbreeding or grading-up mating system should be investigated further to determine the effect upon vigor expressed at birth and preweaning mortality.

The effectiveness and different components of cow-calf bonding probably strongly affect variation in the traits of this study. Neonatal behavior, maternal attention, and maternal temperament likely interact in poorly understood ways to affect expression of newborn vigor and subsequent survival to weaning (Cundiff et al., 1982; Edwards, 1982; Olcott et al., 1987). There has been some attempt to identify and assess influential aspects of maternal-offspring behaviors in sheep (Lindsay, 1996; Cloete and Scholtz, 1998) and in dairy cattle (Ventorp and Michanek, 1992); meaningful opportunities to do similar work in beef cattle may be more difficult because of the more extensive management usually associated with beef cow-calf production.

There seems to be potential for reduction of preweaning death loss by improvement of calf vigor at birth. Of the 377 calves in the study that did not survive to weaning (excluding stillbirths), 148 (39%) did not exhibit adequate vigor at birth. However, inadequate calf vigor at birth may be either a cause or result of one or a combination of factors. For example, inadequate vigor has been observed in calves of cows with large udders and distended teats, but it would be difficult to determine the cause-effect relationship between poor vigor at birth and udder problems of the dam. Isolating a single cause of poor birth vigor is difficult in many cases. Some Brahman calves are active and vigorous, yet exhibit poor nursing instinct (Olcott et al., 1987), but written records associated with data in the present study indicated only three such calves.

Other aspects of calf survival in Brahman cattle need to be investigated. For example, among *Bos taurus* beef × dairy crosses, larger cows had lower calf survival rates than smaller cows (McGuirk et al., 1998a). This may be an important consideration in Brahman cattle, as Vargas et al. (1999) reported an antagonistic relationship for weaning rate and hip height in Brahman cows. This relationship was due primarily to increased dystocia, poor pregnancy rate, and poor calf survival in 3-yr-olds with large hip heights, and to poor pregnancy rate in older cows with large hip heights. Colostrum yield varies among cows (Rowan, 1992), but breed variation is unknown. Placental insufficiency influences the physiological state and cold tolerance of newborn lambs (Rowan, 1992). There may be opportunities to alter cow nutrition before parturition to improve calf survival (Lammoglia et al., 1999; Dietz et al., 2003); this could be especially important in the subtropics and tropics since the available forage is mostly of low quality.

Genetic Parameters

The low estimate of heritability for preweaning mortality (and possibly calf vigor at birth) is probably due in part to strong natural selection (Cundiff et al., 1982). There are apparently no comparable estimates of heritability in the literature for traits similar to vigor at birth, but it has been suggested that there is genetic control of neonatal performance or behavior in cattle (Ogata et al., 1999) and in sheep (Cloete and Scholtz, 1998). The estimate of heritability for preweaning mortality was within a range of reported estimates for similar traits (survival to 24 or 48 h, or perinatal mortality) from 0.02 to 0.15 in cattle (Cundiff et al., 1982, 1986; Koots et al., 1994; McGuirk et al., 1998b). The estimate of maternal heritability was consistent with low estimates reported for similar traits (Cubas et al., 1991; Koots et al., 1994; Goyache et al., 2003). Estimates of direct and maternal heritability were less than 0.01 in Danish Holstein cattle (Hansen et al., 2003). The estimate of maternal heritability was slightly larger that the estimate of direct heritability, which was inconsistent with the results of Goyache et al. (2003), who reported that the maternal heritability for calf survival to weaning (0.03) was less than half of the direct heritability (0.14) in field data of a Spanish breed (Asturiana de los Valles). The potential for selective improvement of these traits appears to be limited to long-term programs; results suggest that control of various management and risk factors would have more immediate effect.

Implications

Improvement in calf vigor at birth and preweaning mortality in cattle with high proportions of Brahman inheritance would be lowly responsive to direct selection. Other improvement programs should include the scheduling of the calving season to avoid detrimental low temperatures. Production and use of females with a high percentage of Brahman inheritance for use in a "purebred" breeding role may be an effective method of improving calf vigor at birth and, in turn, survival to weaning because almost half the calves that died before weaning expressed poor birth vigor. Other heterotic opportunities associated with crossing unrelated (as much as possible) bloodlines within the Brahman breed on these traits should be investigated. Investigations into the different aspects of cow and calf behavior and their interactions postpartum may give more insight into improvement of calf performance.

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