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Heritability Estimates of Stillbirth and Preweaning Mortality in a Zebu Population of Southeastern, Mexico

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Abstract: The objective of this study was to estimate the heritabilities of stillbirth and preweaning mortality in a Zebu herd in the tropics of Mexico. The data collected were for cows calving over a 21 years period (1989-2009). The base population was commercial Zebu cattle. The model included the fixed effects of period of year, season of birth, parity number, breed of sire and the random effects of sire within sire breed and the error term. Mean heritability estimates and standard deviations for stillbirth and preweaning mortality from posterior distributions were 0.030±0.020 and 0.031±0.025, respectively. The low heritability here found also suggested that environmental factors are more important than genetic effects on those traits. Therefore, the potential for selective improvement of stillbirth and preweaning mortality appears to be limited to long-term programs and that the control of various management and risk factors would have more immediate effect.

Key words: Heritability, preweaning mortality, stillbirth, Zebu cattle, tropics

INTRODUCTION

In the tropics of Mexico, the main populations of cattle belongs to Zebu breeds among which the Brahman and Nellore are the most important (based on number of cattle registered at the Zebu breeds cattle association). Adaptation of Zebu cattle to hot, harsh environments and the high heterosis for reproductive and maternal traits expressed by Brahman-Bos taurus cows, account for the widespread use of this breed in cow-calf production in the Gulf coast region of the United States and Mexican Tropics. However, difficulties associated with Zebu cattle include poor neonatal performance and low calf survival rates (Segura-Correa and Segura-Correa, 2009). Calf mortality before weaning accounts for almost a third of calf crop losses and is higher in subtropical and tropical regions. Preweaning mortality is negatively influenced by a variety of environmental influences such as herd-year season, age of dam or parity number, breed and sex of calf (Goyache *et al*., 2003; Riley *et al*., 2004; Tarres *et al*., 2005). Most reports in the literature indicate that heritability estimates of calf mortality are relatively low. Koots *et al*. (1994) reported an average weighted threshold model heritability estimate of 0.10 for perinatal mortality. Riley *et al*. (2004) reported an estimate of heritability of 0.06 for preweaning mortality in Brahman calves. Guerra *et al*. (2006) reported also low heritabilities for preweaning mortality in a multibreed beef cattle population. They also reported that the heritability estimated using generalized linear mixed sire model was similar to generalized threshold and logistic sire mixed models when transformed to an underlying normal distribution. Knowledge of heritability is necessary to calculate expected response to selection and to predict breeding values. To the researchers knowledge, there are no publications on genetic parameters of calf mortality of beef cattle in Mexico. Therefore, because of the importance of calf mortality in production systems and the relatively low number of heritability estimates for economical important traits in Zebu populations, the objective of this study were to estimate the heritabilities of stillbirth and preweaning mortality in a Zebu herd in the tropics of Mexico.

MATERIALS AND METHODS

The data used were obtained from a beef cattle herd in Yucatan, Mexico. The geographical coordinates for the region are 19°40' and 21°37' North latitude and 87°32 and 90°25' West longitude. The land area is about 10 m above sea level. Average annual rainfall in the region is 1100 mm of which approximately 70% falls between May and

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October. Average annual temperature is 26°C with a range from 24°C in December to 28°C in May. The region is classified as subtropical.

Cattle and management practices: The data collected were for cows calving over a 21 years period (1987-2007). The base population was commercial Zebu cattle. The main group of animals was reproduced by natural mating although, pure breed animals (Brahman and Nellore) were reproduced by controlled natural mating and artificial insemination. Sires were mostly purchased from purebred producers in Mexico, selected based on external appearance and they were unrelated. Mating of cows and bulls occurred throughout the year with a ratio of approximately 40 cows per bull. Cows were culled for illness, ageing (>10 years) or if they failed to calve or wean a calf in 2 consecutive years.

Cattle were grazed rotationally on paddocks of Guinea grass (*Panicum maximum*) during the night and were corralled during the day for watering and general management. The stocking rate was approximately one animal unit ha^{-1}. Cows calving during the dry season were supplemented for three months with a mixture of 1 kg of molasses and 2 kg of poultry litter day^{-1}. Cows and calves were kept together until weaning at approximately 8 months of age. After weaning, all heifers were kept in a single herd and grazed rotationally on Guinea grass at night and during the day were kept in corrals for watering, mineral supplementation and general management. The herd was vaccinated against rabies once a year. Ticks were controlled by monthly use of dipping baths. Internal parasites were controlled at weaning and thereafter at 15 months of age. No selection pressure was placed on replacement heifers for growth or on cows for calf performance.

Data were taken from records collected by the owner or manager. Stillbirth was defined as a calf born dead or dying within 24 h after birth. It was coded as 0 if the calf was alive and 1 if it was dead. Preweaning mortality was coded as 0 or 1 if a calf survived or died to weaning age, respectively. For each cow, information included identification, breed group (Nellore, Brahman and commercial Zebu), parity number, dates and weights at birth and date at weaning.

The breed of sire (Nellore or Brahman) was also registered. Based on the small numbers of observations per year and to management changes, years were grouped into 5 periods: Period 1, 1987-1997; period 2, 1998-1999; period 3, 2000-2001; period 4, 2002-2003; period 5, 2004-2007. Parity number was classified in 5 groups (1, 2, 3-5, 6-9 and >10). Three seasons were defined based on monthly rainfall distribution: Dry (February to May) when quantity and quality of forage is poor; rainy (June to September) when heavy rain occurs and an excess of pasture exists; windy and rainy (October to January) when rain is sporadic, pastures start to dry and quality declines. Data on twin calves were deleted from the statistical analysis. Initially, logistic regression was used to assess the role of period of years, season, parity, dam breed for explaining variation of calf mortality. Cows were sired by 91 Brahman and Nellore bulls and they were required to have at least 5 progeny.

Data (n = 1417) were analyzed with a threshold sire model. A threshold model assumes the presence of an underlying non-observable continuous variable known as liability. When liability is equal to or below a certain threshold an animal will survive when the liability is above the threshold an animal will die. The mixed model used was:

$$y = Xb+Zu+e$$

Where:

- y = A vector of ones and zeros representing observations for calf mortality
- X and Z = Incidence matrices for the b vector of fixed and for the u vector of random effects of sire within breed of sire, respectively
- e = The vector of residual error effects

The fixed effects were those significant in the logistic regression (period of years) plus sire breed. Sire within breed of sire was included as a random effect in each model. Variance components and estimates of heritability were obtained using a Bayesian framework with Markov chain, Monte Carlo simulation of the mixed procedure (SAS, 2007) with the prior option.

The priors were obtained using Jeffrey a priori distributions. Therefore, the components of variance had a priori Gamma inverse distribution. The posteriori samples were analyzed using the UNIVARIATE procedure (SAS, 2007). Inference was based on a chain length of 50,000 samples after a burn-in of 5,000 iterations. Heritabilities for stillbirth and preweaning mortality were calculated using the equaction:

$$h^2 = \frac{4\sigma_s^2}{\sigma_s^2+\sigma_e^2}$$

where, σ_s^2 and σ_e^2 are the estimated sire and residual variances, respectively.

RESULTS AND DISCUSSION

The percentage of stillbirths found in this study (1.68%) is within the range of stillbirth percentages reported in beef and dairy cattle. The percentage of stillbirth reported here for Zebu cows managed under an

Table 1: Component of variances and heritability (h^2) estimates for stillbirth and preweaning mortality in a Zebu cattle herd in Southeastern Mexico

Traits	N	Prevalence (%)	σ_s^2	σ_e^2	h^2
Stillbirth	1417	1.68	0.00011955	0.015599	0.030±0.020
Preweaning mortality	1417	4.26	0.00033961	0.043562	0.031±0.025

N = No. of observations; σ_s^2 = Sire component of variance; σ_e^2 = Residual component of variance, Sires = 91

extensive pasture is <3-4% reported for beef cattle in Nordic countries (Osteras *et al*., 2007) and in Brown Swiss cattle (Erf *et al*., 1990) but it is within the range (1-12.6%) of pregnant losses (not including abortions) reported in 14 beef cows by Plasse *et al*. (1998).

The variance components and heritability estimates for stillbirth and preweaning mortality are close to zero (Table 1). The 95% credible intervals were 0.004 -0.064 and 0.001-0.043 for stillbirth and preweaning mortality, respectively. The heritability estimate of stillbirth (0.030±0.020) is slightly higher than those notified for first parity beef cows (0.01-0.02) by Eriksson *et al*. (2004) in Sweden, in Brown Swiss cattle and the direct heritability (0.016) reported by Luo *et al*. (1999). However is lower than the heritability (0.05) reported by Erf *et al*. (1990) for Brown Swiss cattle, Citek *et al*. (2011) in beef cattle of the Czech republic (0.08) and Eriksson *et al*. (2004) in Hereford (0.06) and Charolais (0.09). Also, the heritability of stillbirth obtained in this study was more comparable with results from threshold model analyses for beef-dairy crossings by McGuirka *et al*. (1998) and for Simmental by Hagger and Hofer (1989).

Calf mortality has a major impact on herd economic efficiency. It reduces the potential number of replacements heifers and reduces the revenue from bulls for fattening. In this study, the preweaning mortality was 4.26% which is lower than that notified by Riley *et al*. (2004) for pure Brahman and high proportion Brahman calves (10.8%). However is higher than the 3.1% value found for Bruna del Pirineus beef calves in Spain (Tarres *et al*., 2005).

The heritability estimate for preweaning mortality (0.031±0.025) is lower than most estimates reported in the literature such as 0.04 reported by Tarres *et al*. (2005) using survival analysis methodology; 0.10-0.15 for perinatal mortality presented by Koots *et al*. (1994) and the estimate of heritability for preweaning mortality for Brahman cattle (0.06) reported by Riley *et al*. (2004). It is also lower than the heritability estimates calculated by Guerra *et al*. (2006) using linear, threshold and logistic models in a multibreed beef cattle population. The low estimate of heritability for preweaning mortality is probably due in part to strong natural selection.

The low heritability for stillbirth and preweaning mortality was due to the lack of additive genetic variance from the sire component of variance but also could be attributed to a greater environmental variation. Environmental variation for stillbirth is dependent basically on the maternal environment whereas environmental variation for preweaning mortality will depend on maternal ability of the dam and non-maternal environmental factors.

CONCLUSION

The low heritability here found also suggested that environmental factors are more important than genetic effects on stillbirth and preweaning mortality. Therefore, the potential for selective improvement of these traits appears to be limited to long-term programs and that the control of various management and risk factors would have more immediate effect.

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