Journal of Animal and Veterinary Advances 7 (2): 124-129, 2008
ISSN: 1680-5593

Genetic Parameters for Reproductive Traits of Brown Swiss Cows in the Tropics of Mexico

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Abstract: The objectives of this study were to estimate genetic parameters for Age at First Calving (AFC), Interval Calving to First Service (ICFS), Interval Calving to Conception (ICC), Number of Services per Conception (NSC) and Calving Interval (CI) in a Brown Swiss herd and to estimate the relationship between sire's Predicted Transmitting Ability (PTA) for milk yield and their daughters' phenotypic means for those reproductive traits. Data used in this study were obtained from 358-623 Brown Swiss cows in Yucatan, Mexico. The herd was founded from 1982-1985 from 120 cows bought in the region, daughters of bulls and cows imported from the United States and heifers and semen brought from the United States and Canada. The animals were kept in a semi-intensive dairy management system. Genetic parameters were estimated by Restricted Maximum Likelihood procedures using the derivative free algorithm. Except for AFC (0.28) and CI (0.11), heritability estimates were close to zero. Repeatability estimates were also low (from 0.07 for ICFS to 0.19 for ICC). Simple regression analysis showed no association ($p>0.05$) of sire's PTA for milk yield and phenotypic means of their daughters for ICC and NSC traits but an unfavourable association for ICFS (0.013 ± 0.007) and CI (0.046 ± 0.016).

Key words: Brown swiss, genetic parameters, tropics, reproductive traits

INTRODUCTION

The Brown Swiss breed is the main source of genes for commercial herds devoted to milk production systems in the tropics of Mexico. However, information on environmental and genetic factors that affect reproduction on that breed is limited. Measures of reproductive performance used as selection criteria include Age at First Calving (AFC), Interval from Calving to First oestrus (ICFE), Interval from Calving to First Service (ICFS), Number of Services per Conception (NSC) and Calving Interval (CI). CI has traditionally been used as the preferred measure of reproduction, particularly in dairy cattle systems. Genetic improvement of cow fertility is considered to be limited because of low heritabilities for cow reproductive traits. The expected breeding values for fertility traits are difficult to estimate partly because the expression of the reproductive potential of animals is often constrained by the management systems farmers employ (Notter, 1995). When managerial and nutritional conditions are optimal, most animals will reproduce, but in conditions that are less favourable, only those with the highest genetic merit for reproductive fitness will reproduce (Notter, 1995).

Estimates of genetic parameters such as heritabilities and genetic correlations for reproductive traits are important in the design of appropriate breeding programs aimed at maximizing genetic improvement. They provide an indication of the relative genetic importance of traits, as either direct genetic response or correlated response to selection. Little is known about the genetic parameters of reproductive traits of Brown Swiss cattle under tropical conditions, which is necessary to establish genetic improvement programmes. Many countries have shifted their breeding goals to include fertility traits (Van *et al*., 2004; Wall *et al*., 2003). Sire evaluations for reproductive traits in the tropics are important because of the economical impact that these traits have in the tropics (Stanton, 1991; Van, 2002), which could make a great contribution in the decision of selecting a sire.

The objectives of this study were to estimate genetic parameters for AFC, ICFS, ICC, NSC and CI in a Brown Swiss herd using an animal model and to estimate the relationship between the sire's Predicted Transmitting Ability for milk yield and phenotypic means for reproductive traits of their daughters under tropical conditions.

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MATERIALS AND METHODS

Location, animals and management: Data used in this study were obtained from a Brown Swiss herd in Yucatan, Mexico, located between 19° 40' and 21° 37' north and 87° 32' west. The climate of the region is sub-humid tropical, with a summer rainy season. The monthly maximum temperature varies between 35 and 40°C (mean 26.6°C). The relative humidity varies from 65-100% (mean 78%) and the annual rainfall varies from 800-1200 mm (INEGI, 2002).

The herd was founded in 1982 from 120 cows bought in the region, daughters of bulls and cows imported from the United States. In 1985, 150 heifers and semen from the United States and Canada were imported. Afterwards, semen from the United States and Canada and some home-bred bulls were used.

The animals were kept in a semi-intensive dairy management system. At four days of age calves were separated from their dams and given 4 l of milk (with a bottle twice a day until 4 months of age), chopped Taiwan grass (*Pennisetum purpureum)* and 0.5 kg of a commercial concentrated feed (18% CP). Afterwards and up to 11 months of age calves were maintained on direct grazing on Star grass (*Cynodon nlemfuensi)* paddocks and offered 1.0 kg day^{-1} of the commercial concentrate. Males and females were separated at that time and males sent to another area to finish growth. Some of them were selected as sires.

Feeding of heifers consisted of chopped grass (*Pennisetum purpureum*) and concentrate feed about 3% of their body weight. Heifers weighing 320 kg were exposed to a fertile bull during six months. Heifers that did not get pregnant were sold. Approximately 20% of the females available were used as replacement. Dry cows were kept on rotational grazing and given 5 kg of concentrated feed per day (16% CP). Milk producing cows were also rotationally grazed and received 3.5 kg of the same concentrate fed twice a day during milking time.

Cows were managed under an Artificial Insemination (AI) scheme and natural mating. Forty-five days after calving, heat detection was checked visually twice a day (morning and afternoon). AI was practiced 12 h after heat detection. After 3 AI, repeating oestrus cows were natural mated. Pregnancy diagnosis was practiced 60 days after the last service. Cows were culled mainly because of old age.

Cows were vaccinated against rabies every 10 months and pasterelosis every 6 months. All animals were medicated against internal (Ivermectine) and external (Asuntol) parasites every 6 months and 21 days, respectively.

Information on the reproductive performance of 358-623 Brown Swiss cows was obtained from the individual cards of each cow born between 1988 and 1999. Database included information of sire and dam identification, dates of birth, calving and service. The following reproductive traits were derived: Age at first calving (AFC, n = 358); interval calving to first service (ICFS, n = 1479); interval calving to conception (ICC, n = 1235) number of services per conception (NSC, 1174) and calving interval (CI, n = 1391). The data on ICFS, ICC and NSC were not consistently registered. The data were clustered in 3 seasons of birth or calving according to rainfall distribution in the region: dry (February to May), rainy (July to September) and rainy and windy (October to January). Parity number comprised 6 categories (1, 2,...>5). Forty-nine sires were used (33 through AI and 16 through natural mating) of which 6 had progeny only in one year, 13 in 2 years and the rest in 3 more years. Nineteen of the sires had published information on their Predicted Transmitting Ability (PTA) for milk yield, eleven with negative PTAs and 8 with positive PTAs (range-1462 to 1011) with reliabilities of 81-99%.

Statistical analysis: The General Linear Model (GLM) procedure of SAS (1989) was used to determine main fixed and simple interaction effects on the reproductive traits. None of the interactions were significant ($p>0.05$) therefore they were dropped from the final model. The animal model for AFC include the fixed effects of year of birth, season of birth of the cow, the random additive genetic effect and the random residual term. For the remaining reproductive traits the model included the fixed effects of year of calving of the cow (1988-1999), season of calving (dry, rainy and windy and rainy) and parity number (1, 2...>5).

Genetic parameters were estimated by Restricted Maximum Likelihood procedures using the derivative free algorithm (Meyer, 1998). A repeatability model was fitted due to the repeatable nature of the traits here studied (except AFC).

The animal model used to estimate heritabilities was:

$$y = Xb + Zu + Wp + e$$

Where,

- y = Vector of observations for any of the reproductive traits studied.
- X = Matrix that associates b with y.
- b = Vector of fixed effects.
- Z = Matrix that associates u with y.
- u = Vector of breeding values for direct genetic effects.

W = Matrix that associates p with y.
p = Vector of permanent environmental effects due to the dam.
e = Vector of residual effects.

Estimates of sires' PTA for the reproductive traits were obtained dividing the expected breeding values of the sires, provided by the DFREML program, by 2 (Willham, 1982). Also, simple linear regressions were carried out in order to establish the relationship between sires' PTA for milk yield (n = 19) and the phenotypic mean values of their daughters.

RESULTS AND DISCUSSION

Phenotypic means and standard deviations: The phenotypic mean and standard deviations of the reproductive traits analysed are given in Table 1. Results show that on average cows' AFC was 973.6 days. Cows were inseminated the first time 87.8 days and they got pregnant on average 172.8 days after calving; required 2.4 services for a conception and had an average number of days between 2 successive calvings of 453.9 days.

Genetic parameters: Estimates of (co)variance components, direct heritability (h^2) and repeatability values for the reproductive traits are shown in Table 2. Except for AFC (h^2 = 0.28) and CI (h^2 = 0.11), h^2 estimates were close to zero. Repeatability estimates were also low (from 0.07 for ICFS to 0.19 for ICC); which means that permanent environmental effects were also close to zero.

Predicted transmitting ability of sires and their relationship with reproductive traits of the daughters: The sires' PTA intervals for the reproductive traits were: -96.4 to +38.1 days for AFC, -3.1 to +5.2 days for ICFS, -20.4 to +13.4 days for ICC, -0.25 to +0.15 for NSC and -36.3 to +22.5 days for CI. The regression analysis showed no effect (p>0.05) of sire's PTA for milk yield on AFC, ICC and NSC phenotypic means of their daughters. The regression coefficients for those traits were: -0.042±0.052 kg*day kg^{-2}, 0.011±0.22 kg*day kg^{-2} and 0.0±0.0 kg*Num kg^{-2}, respectively. However, sire's PTA for milk yield showed a significant (p<0.05) but unfavourable effect on phenotypic mean values of their daughters for ICFS (0.013±0.007 kg*day kg^{-2}) and CI (0.046±0.016 kg*day kg^{-2}).

The means for the reproductive traits here studied are higher than the optimal values for dairy cattle in temperate regions. However, the reproductive trait values of Brown Swiss cattle in Yucatan, Mexico are within the expected values for the Latin American tropics (Cunningham and Syrstad, 1987; Lozano *et al*., 1992; Magana and Segura, 2001; Pearson, 1973; Roman *et al*., 1978, 1983).

Heritability: The heritability value for AFC (0.28), estimated in this study, is lower than that reported in Holstein cattle in Iran (0.36) (Toosi, 2002), the weighed average heritability estimate (0.31) for 94 beef and dairy studies in tropical regions by Lobo *et al.* (2000) and the value of 0.31 obtained by Grossi and Freitas (2002) for 3 dairy herds in Brazil. This indicates the existence of a relatively high additive genetic variance and therefore, a rapid genetic improvement by selection can be achieved on AFC; however, improvement of the management practices should not be discarded.

Heritability estimate for ICFS (0.04) was similar to that reported in dairy cattle in Brazil (Grossi, 2002). Heritability estimate for ICC (0.05) was similar to that obtained for Holstein cattle in Florida (0.05) (Campos, 1994), but slightly higher than that reported in Brazil (Grossi, 2002), in Iran (Tossi, 2002), in Sudan (Ageeb and Hayes, 2000) and in Mexico Tapia and Apodaca.

Table 1: Phenotypic means and standard deviation for reproductive traits of brown swiss cows in a dairy herd of yucatan, mexico/medias y errores estandares para caracteres reproductivos de vacas suizo pardo en un hato lechero de yucatán, México

Trait	Number of observations	Mean	Standard deviation
Age at first calving (days)	358	937.6	216.5
Interval calving to first service (days)	1479	87.8	42.3
Number of services per conception	1174	2.41	1.62
Interval calving to conception (days)	1235	172.8	117.2
Calving interval (days)	1391	453.9	121.5

Table 2: Component of variances and genetic parameters for reproductive traits of brown swiss cattle in yucatan, mexico/componentes de varianza y parámetros genéticos para caracteres reproductivos de ganado suizo pardo en yucatán, México

	AFC	ICFS	ICC	NSC	CI
Additive genetic variance	10309.7	67.4	616.5	0.10	1563.6
Permanent environmental variance	5.86	1798.8	0.07	1005.1	
Residual variance	27092.5	1491.5	10576.7	2.31	11437.1
Phenotypic variance	37402.2	1603.0	12992.0	2.49	14005.8
Heritability	0.28±0.08	0.04±0.03	0.05±0.03	0.04±0.03	0.11±0.04
Repeatability		0.07±0.06	0.19±0.08	0.07±0.07	0.18±0.09

AFC = Age at First Calving (days); ICFS = Interval Calving First Service (days); Interval calving to first conception (days); NSC = Number of Services per Conception; CI = Calving Interval (days)

Heritability estimate for NSC (0.04) is lower than the average weighed heritability estimate reported by Lobo *et al*. (2000) but within the range of values reported in the literature by this and other authors (Ageeb and Hayes, 2000). The low heritability estimated for the above reproductive traits indicates that environmental effects are more important than additive genetic effects. Therefore, better feeding, reproductive and health programmes should be implemented in order to obtain better productive indices.

Heritability value for CI (0.11) is similar to that reported for dairy and beef cattle in the tropics (Lobo *et al*., 2000) and for Holstein cattle in Florida (0.10) (Campos *et al*., 1994), but higher than those notified by other authors in dairy cattle in tropical countries (Ageeb and Hayes, 2000; Grossi *et al*., 2000; Ojango and Pollott, 2001). Differences found among results are probably due to breed differences, statistical analysis (animal or sire models); selection pressure within populations, sample size and environmental effects. Nevertheless it is clear that h^2 are low, which suggest that fertility traits are strongly influenced by environmental factors, substantiated in the tropics.

Repeatability: Repeatability estimates were also low and ranged from 0.07 for ICFS to 0.19 for ICC. The value for ICFS was similar to the 0.09 and 0.08 values reported for Holstein cows in UK (Kadarmideen *et al*., 2000; 2001), respectively. The repeatability value for ICC is higher than those of 0.01, 0.07 and 0.12 reported for milking cows in the tropics of Mexico; Holsteins in the UK (Kadarmideen *et al*., 2001) and Sudan (Ageeb and Hayes, 2000), respectively.

The repeatability of 0.07 for NSC is within the values of 0.0-0.12 reported by other authors (Campos *et al*., 1994; Kadarmideen *et al*., 2000, 2001). The repeatability for CI of 0.18 estimated in this study is higher than the values (range 0-0.15) reported for dairy cattle in Mexico (Hernandez *et al*., 2000) and other countries (Ageeb and Hayes, 2000; Kadarmideen *et al*., 2001, 2000; Ojango and Pollott, 1991).

In general, repeatability estimates were within the range and in few cases higher than the values reported by several authors for cow populations managed under temperate or tropical environments. However, the values are considered low, which is an indication that reproductive traits are more influenced by effects due to temporary environmental variation. Therefore, genetic improvement of those traits may be limited.

Differences between heritability and repeatability estimates are small which means that permanent environmental effects are of not much importance on the traits here studied.

Predicted transmitting ability of sires and their relationship with reproductive traits of the daughters: Dairy cows selection for milk yield seems to be unfavourably associated to fertility and reproduction efficiency (Kadarmiden *et al*., 2001). Results for Holstein populations in temperate environments have shown that for each 1000 kg increase in the breeding value of milk yield, the breeding value for CI increased 6-8 days (Kragelunda *et al*., 1979) and that for ICC increased 5-10 days (Seykora, 1983). Furthermore, Hasen *et al*. (1983), have shown that an increase of 392 kg of milk yield (using selection) will increase the number of days open in about 1.6 days and if the number of days open is reduced for about 5 or 6 days, milk production decreases about 107 kg L^{-1}. In the present study, there was no relationship (p>0.05) between sire's PTA for milk yield and the phenotypic means of their daughters for AFC, ICC and NSC. However, unfavourable relationships were obtained for ICFS and CI. If we assume that does not exist environmental correlations between sires` PTAs and phenotypic values of their daughters, their regression coefficients indicates that genes that positively affect milk production are likely to increase ICFS and CI. Therefore, selection of sires based on PTA for milk may affect unfavourably the reproductive traits of Brown Swiss cows in the tropics of Mexico. Several authors have reported unfavourable relationships between production and fertility traits in animals that have been selected for high milk production (Campos *et al*., 1994; Oltenacu *et al*., 1991). Increasing the CI is undesirable, particularly in production systems where the demand and cost for heifers is high. This can occur if higher-yielding animals produce fewer replacements, due to a negative correlation between CI and milk production. Differences may be attributed to breed differences, possible genotype-environment interaction or a small sample size.

Fulkerson *et al*. (2001) and Wicks and Leaver (2002) in the Holstein breed reported that cows with the highest genetic merit for milk production, had the highest interval calving to first oestrus and ICFS, respectively. Wicks and Leaver (2002) did not find association with ICC nor NSC, which agrees with the results of this study. Therefore, the selection of cows or sires with the best genetic merit for milk yield must be associated to better management conditions of the herd to obtain better phenotypic performance in milk yield and reproductive traits.

CONCLUSION

The heritability estimates close to zero for all reproductive traits (except AFC) found in this study were low as for dairy cattle in other countries with temperate or tropical conditions. This means that these traits depend to a large extent on the management given to the herd. The heritability estimate for AFC indicates that this trait presents a relatively high additive variance, therefore, it could be improved by selection. The use of sires with the highest PTAs for milk production may increase the ICFS and CI, therefore, reproduction traits should be included in the selection programmes probably an index with other traits of main economic importance.

ACKNOWLEDGEMENT

The authors thanks to the Fundación Yucatán Produce A. C. project 6001 for the financial support for the present study and the first author to CONACYT for postgraduate scholarsip.

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