Genetic and Phenotypic Parameters of Reproduction and Lactation Traits of Friesian X Boran Crossbred Cattle in Kagera Region, Tanzania

[1]Mwatawala, H.W*, G.C.Kifaro[1] and P.H.Petersen[2]

[1]Sokoine University of Agriculture, Morogoro

[2]The Royal Veterinary and Agricultural University, Copenhagen

Abstract

This study was done to estimate genetic and phenotypic parameters for Friesian x Boran crossbred dairy cattle of Kagera region. Parameters estimated were heritability, repeatability and phenotypic correlations of various lactation and reproductive traits. Variance Component (VARCOMP) Procedure and General Linear Models (GLM) Procedure of SAS were employed in data analyses. Heritability estimates for 100-day milk yield, 305-day milk yield, lactation milk yield (LMY), lactation length (LL), dry period (DP), age at first calving and calving interval (CI) were 0.27, 0.40, 0.40, 0.00, 0.04, 0.05 and 0.06, respectively. Heritabilities for first, second and third CI were 0.02, 0.06 and 0.11, respectively. Coefficients of repeatability for 100-day, 305-day, LMY, LL, DP and CI were 0.34, 0.40, 0.38, 0.15, 0.12 and 0.16, respectively. Correlation coefficients between mean daily milk yield (DMY) in a month with 100-day and 305-day milk yield and LMY ranged from 0.11 to 0.90, -0.35 to 0.78 and 0.42 to 0.63, respectively. Correlation coefficient between 100-day milk yield and 305-day milk yield (r_c=0.87) was higher than correlation coefficient between 100-day and total lactation yield (r_c=0.70). The correlation coefficient between 305-day milk yield and LMY was 0.85. All correlations were highly significant (P < 0.001). Heritability estimates were moderate for milk yields and low for LL, DP, AFC and CI. Selection for genetic improvement in milk yield is possible while low estimates for LL, DP, CI and AFC suggest that environment plays a major role in affecting these traits.

Keywords: Heritability, repeatability, phenotypic correlation, lactation traits, reproductive traits, dairy cattle, Tanzania.

Introduction

The concept of heritability (h^2) is of central importance to modern animal breeding theory (Pirchner, 1983). First, it is of considerable interest to know the extent to which traits are influenced by the genotype. Second, and possibly even more important to breeders, h^2 provides, as the term implies, an estimate of the degree to which differences between animals are repeated in their progeny. Repeatability is important for estimation of breeding values from performance averages. It is directly applied when the performance potential or real producing ability of animals is to be estimated. Increased repeatability indicates the performance potential with higher accuracy.

The main reason for the relatively low reproductive efficiency of cattle in the tropics is recognized to be environmental. However, the limited evidence available from tropical regions suggests that there is also substantial genetic variation (Seebeck, 1973; Mackinnon *et al.*, 1990). Majority of past studies on reproductive performance from tropical areas have been largely limited to the assessment of effects of non-genetic factors and breed differences (Galina and Arthur, 1989). Genetic parameter estimates and information on the extent of within

*Corresponding author

breed variation differ between breeds and locations. The additive genetic variance among reproductive traits is often low due to natural selection. Thus, reported heritabilities for measures of reproduction are generally also low. As a result of this, selection of replacement heifers for early pregnancy may be useless in the light of the low heritabilities for reproductive traits. This is contrary to productive traits i.e. lactation and growth performance traits which usually have heritabilities ranging from medium to high.

In 1982, a small-scale dairy development project was started in Kagera region under Kagera Small Holder Dairy Extension Project (KSHDEP), which later merged with three other projects, namely; Kagera Indigenous Livestock Project (KILIP), Kikulula Heifer Breeding Unit (KHBU) and Kikulula Farmers Extension Centers (KFEC) to form Kagera Livestock Development Project (KALIDEP). The project was initiated in order to improve small-scale dairy production through provision of F_1 crossbred heifers (Friesian x Boran) to interested and willing farmers. The F_1 heifers were being supplied by Kikulula Heifer Breeding Unit (KHBU), which was established in 1976.

The proper use of crossbred cattle for both production and breeding requires understanding of genetic parameters expressed under the local environmental conditions. This study therefore presents the results of the genetic and phenotypic parameter estimates for various lactation and reproductive traits among crossbred dairy cattle in Kagera region.

Materials and methods

Description of the study area

Kagera region is located in the extreme northwestern corner of Tanzania. It lies just below the equator between latitudes 1° 00′ and 2° 45′ south. The altitude varies between 1128 and 1646 m above sea level. Mean temperature is close to 20°C throughout the year. Annual rainfall varies between 800 and 2000mm. The region experiences continuous high rainfall from October to May. Months of January and February are slightly drier than the other remaining months. June to August is moderately dry, but can occasionally have a total rainfall of about 200mm.

According to 1998/99 surveys, the livestock population of Kagera region consisted of 667,745 head of cattle, out of which around 15,000 were improved dairy cattle (MAFS, 2001). Like in the rest of Tanzania, smallholder farmers keep the majority of dairy cattle.

Source of data and data collection

Data used in this study were extracted from KALIDEP monitoring unit and at KHBU in Kagera region covering the period between 1979 and 1996. The improved dairy cattle dealt with in this study were crosses of Friesian x Boran only. The data collection process involved four levels namely; farmer, village/ward extension worker, district extension office and regional level (Project headquarters).

Data classification

Seasons of birth and calving were classified into four as heavy wet season (March-May), light wet season (September-December), early dry season (January-February) and late dry season (June-August). Genotypes of cows that were used in the analyses of were F_1 (½Friesian½Boran), F_2 (F_1 x F_1), 5/8 Friesian crosses and > 5/8 Friesian crosses. Six districts were involved i.e. Bukoba rural, Bukoba urban, Muleba, Karagwe, Biharamulo and Ngara. Parturition numbers one to five were coded 1 to 5 and code 6 included 6^{th} and above parturitions.

Data analyses

Heritabilities were estimated for age at first calving (AFC), calving interval (CI), 100-day milk yield, 305-day milk yield and lactation milk yield (LMY), dry period (DP) and lactation length (LL). VARCOMP procedure of SAS (2000) was used to obtain estimates of sire variance components. Models I and II described below were used and included the 'sire factor' as a random effect. The number of Friesian sires in the data sets were 132, 92, 107, 104, 144, 144 and 105 for AFC, CI, 100-day milk yield, 305-day milk yield, LMY, LL and DP, respectively.

Estimates of repeatability for 100-day, 305-day and total lactation milk yield, LL, DP and CI were computed for cows with multiple records as intra-class correlation, r_c. The coefficient k, between cow and within cow variance components were obtained by using the VARCOMP procedure of SAS (2000). Model II was used and included `cow factor' as a random effect.

Multivariate Analysis of Variance (MANOVA) option of GLM Procedure of SAS (2000) was employed in the analysis of phenotypic correlations among different milk yields studied.

Model I:

$Y_{ijklmn} = \mu + \alpha_i + \delta_j + \gamma_k + \chi_l + \varsigma_m + e_{ijklmn}$

Where;

Y_{ijklmn} = Age at first calving; μ = Overall mean; α_i = Effect of genetic group (1,2,3,4)

δ_j = Effect of district (1…6); γ_k = Effect of year of birth (1979…1996)

χ_l = Effect of season of birth (1,2,3,4); ς_m = Effect of sire; e_{ijklmn} = Random residual effect $N(0,\sigma_e^2)$. All factors, except effect of sire were considered fixed effects.

Model II:

$Y_{ijklmno} = \mu + \alpha_i + \beta_j + \delta_k + \chi_l + \gamma_m + \varsigma_n + (\alpha\delta)_{ik} + e_{ijklmno}$

Where;

$Y_{ijklmno}$ = An observation on trait (100-day milk yield, 305-day milk yield, LMY, LL, DP, CI)

μ = Overall mean; α_i = Effect of genetic group (1,2,3,4); β_j = Effect of parity (1…6);

δ_k = Effect of district (1…6) χ_l = Effect of season of calving (1,2,3,4); γ_m = Effect of year of calving (1983…1999); ς_n = Effect of sire or dam; $(\alpha\delta)_{ik}$ = Interaction of genetic group and district; $e_{ijklmno}$ = Random residual effect $N(0,\sigma_e^2)$. The residual effect was used as the within cow variance component in computing repeatability.

Results

Heritability estimates

Results from analysis of variance and heritability estimates and their standard errors for lactation and reproductive traits based on sire variance components are summarized in Table 1. Additive genetic variances for AFC, CI, LL and DP were low. Heritability estimates for 100-day, 305-day and total lactation milk yield, lactation length, dry period, age at first calving and calving interval were 0.27, 0.40, 0.40, 0.00, 0.04, 0.05 and 0.06, respectively. Heritability estimates for first three calving intervals are shown in Table 2.

Repeatability

Repeatability estimates and their standard errors for calving interval, 100-day milk yield, 305-day milk yield, total lactation milk yield, lactation length and dry period are presented in Table 3. Repeatability estimates for 100-days, 305-days and total lactation milk yields were 0.34, 0.40 and 0.38, respectively. The estimates for lactation length, dry period and calving interval were 0.15, 0.12 and 0.16, respectively.

Table 1: Genetic (σ^2a), phenotypic (σ^2a) and error (σ^2e) Variances and heritability estimates for various traits

Trait	(σ^2a)	(σ^2_p)	(σ^2e)	h^2
AFC	3.92	72.5	68.6	0.05 ± 0.04
CI	568.4	9889.5	9321.1	0.06 ± 0.03
100-day milk yield	21944.4	80151.4	58207.0	0.27 ± 0.07
305-day milk yeild	199349.3	498373.3	299024.0	0.40 ± 0.10
Lactation milk yield	252878.4	638323.3	385444.9	0.40 ± 0.08
Lactation length	0	5637.2	5637.2	0.00
Dry period	197.6	4636.8	4439.2	0.04 ± 0.03

Table 2: Estimates of h^2 for the first three calving intervals

	Heritability estimate
First CI	0.02 ± 0.04
Second CI	0.06 ± 0.07
Third CI	0.11 ± 0.09

Phenotypic correlations

Partial correlation coefficients (r_c) between mean daily milk yield (DMY) in a month with 100-day and 305-day milk yield and LMY ranged from 0.11 to 0.90, 0.35 to 0.78 and 0.42 to 0.63, respectively (see Table 4). Correlation coefficient between 100-day milk yield and 305-day milk yield (r_c=0.87) was higher than correlation coefficient between 100-day and total lactation yield (r_c=0.70). Correlation coefficients between mean daily milk yields in a month and 100-day milk yields were decreasing with advancement of lactation. All correlations were highly significant (P < 0.001).

Table 3: Estimates of repeatability (rc) and their Standard errors (se) of 100-day MY, 305 day MY, LMY, LL, DP and CI

	100-day MY	305-day MY	LMY	LL	DP	CI
Number of records(M)	5 401	4 189	6770	6770	4 793	6 388
Number of cows (N)	2 302	1 926	2 611	2611	2 236	2 587
σ^2Between	24 029.6	199 773.0	318 393.1	1 288.1	400.7	1 527.8
σ^2Within	47 127.1	294 982.4	525705.0	7 300.8	3 00.3	8 084.3
k^1	2.3	2.2	2.4	2.4	2.1	2.5
r_c	0.34	0.40	0.38	0.15	0.12	0.16
s.e(r_c)	0.02	0.02	0.01	-0.01	0.02	0.01

K^1 = average number of records per cow

r_c = repeatability estimate

s.e (r_c) = standard error of repeatability estimate

Discussion

Due to the fact that h^2 of AFC and CI observed in the present study are close to zero, and that the h^2 of different calving intervals varied

Table 4: Correlation coefficients between mean daily milk yield in a month and 100-day, 305 day and lactation milk yields

	Correlation coefficients		
Milk yields	100-day MY	305- day MY	LMY
Month 1	0.75 (2967)	0.61 (2276)	0.48(2281)
Month 2	0.90 (2967)	0.78 (2276)	0.63(2281)
Month 3	0.84(2843)	0.76 (2276)	0.61(2281)
Month 4	0.70(2690)	0.71 (2276)	0.58(2281)
Month 5	0.56(2573)	0.68 (2276)	0.55(2281)
Month 6	0.50(2442)	0.67 (2276)	0.56(2281)
Month 7	0.34(2310)	0.57(2276)	0.50(2281)
Month 8	0.30(2204)	0.55(2204)	0.50(2204)
Month 9	0.24(2052)	0.50(2052)	0.48(2052)
Month 10	0.11(1833)	0.35(1833)	0.42(1833)
100-day		0.87(2276)	0.70(2281)
305 - day			0.85(2276)

NB: All correlations where highly significant (P<0.001)

In parentheses are the numbers of observations

100-day MY=100-day milk yield

305-day MY=305 -day milk yield

considerably, any improvement of these traits by selection would be rather difficult. Since the variation in AFC could arise from differences in growth rate, age at the onset of puberty and how soon heifers conceive from first mating (Galina and Arthur, 1989), the h^2 estimates observed here reflect variations in a number of interrelated traits. Further, and more important, reproductive traits are largely influenced by random environmental factors (Ménissier and Frisch, 1992). It was also observed in the present study that the h^2 estimates of first and second CI were lower than the third, which suggested that selecting cows at younger age for CI would be futile.

The h^2 value of LMY and 305-day milk yield of 0.40 in this study is higher compared with 0.08 and 0.32 reported by Haile-Mariam (1994) for Friesians and their crosses in Ethiopia and Rege (1991) for Friesian cattle in Kenya, respectively. Relatively higher h^2 estimates for LMY and 305-day milk yield in the current study might be attributed to decrease in error variance without marked effect on the additive genetic variance assumed to arise during data editing by omitting some records in both extremes after conducting preliminary analyses. The low genetic parameter estimates for LL, DP, AFC and CI might be attributable to the variable and stressful nature of the environment whereby individual animals responded differently to environmental fluctuations including herd differences.

Repeatability estimate for milk yield was higher than that reported by Haile-Mariam (1994). However Msuya (2002) working with the same herds as the current study reported similar repeatabilities for LMY and LL. In the present study repeatability estimates for CI, LL and DP were low. Balikowa (1997) working with *Bos taurus* and their crosses with *Bos indicus* dairy cattle in the southern highlands of Tanzania reported fairly high repeatabilities for LL (0.27), DP (0.16) and CI (0.27). Also Ageeb and Hiller (1991) reported a fairly high coefficient of repeatability of 0.44 for calving interval. However, estimates for CI and DP in this study are higher than estimates by Haile-Mariam (1994) and Msuya (2002). Low estimates of repeatability for traits such as CI, LL and DP revealed the presence of large temporary environmental effects such as climate, management decisions, feeding and breeding/mating inefficiency contribute more to the variation in these traits than genetic and permanent non-genetic differences between animals. This suggests that problems of long CI, short LL and long DP could be more alleviated through improvement in management than manipulation of genetic constitution of the animals.

It has been observed in this study that correlation coefficients of mean DMY with 100-day and 305-day milk yields are higher in the early months of lactation than in last months. This is in agreement with report by Balikowa (1997). High phenotypic correlations for various milk yields estimated in the present study suggests that it is possible to predict 100-day, 305-day milk yield and total lactation milk yield from mean DMY in early months of lactation accurately. Also 100-day milk yield can be used reliably to predict 305- day milk yield and LMY due high correlation coefficients between these traits. This is of great importance when selecting animals for improvement in breeding programs. It permits early selection of better producing cows rather than waiting for 305-day yields or total lactation yields. The decrease in associations between mean DMY and 100-day milk yield was expected. It is apparent that mean DMY in early lactation would have higher correlation with 100-day milk yield because of the part-to-whole relationship between them.

Conclusions

Estimates of heritability in the current study are moderate for LMY, 100-day milk yield and 305-day milk yield. This implies that genetic improvement for these traits is possible through selection. Low estimates for LL, DP, CI and AFC suggest that environment plays a bigger role than genetic make up of animal in affecting these traits. Improvement of environment through better decision making, feeding and disease control is important in order to have long LL, short DP, short CI and low AFC. Phenotypic correlations among different milk yields suggests that it is possible to use early lactation records to predict full lactation performance and select cows in early lactation for improvement of dairy performance in crossbred cattle.

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