Variance component and heritability estimates for first and second lactation milk traits in the South African Ayrshire breed

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For the estimation of additive and error variances and resulting heritability estimates 9 050 first and 5 541 second lactation records were used. Analyses were conducted using DFREML procedures. The heritabilities for first (and second) lactation for milk, fat and protein yield and fat and protein percentages were as follows: 0.342 (0.195); 0.332 (0.187); 0.296 (0.179); 0.451 (0.377) and 0.533 (0.464).

Vir die beraming van additiewe en foutvariansies en die voortspruitende oorerflikheidsberamings is 9 050 eerste en 5 541 tweede laktasierekords gebruik. Analises is gedoen met behulp van DFREML prosedures. Die oorerflikhede van eerste (en tweede) laktasies vir melk-, vet- en proteïenopbrengs en vet- en proteïenpersentasie was soos volg: 0.342 (0.195); 0.332 (0.187); 0.296 (0.179); 0.451 (0.377) en 0.533 (0.464).

Keywords: Ayrshire, heritability estimates

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Introduction

The main aim of any selection programme in dairy cattle is usually the improvement of traits related to yield and composition. Milk yield and composition, which are the main economic traits used for selection in dairy cattle are fortunately easily measured. Progress is therefore largely dependant on the effective utilisation of the additive genetic variance. This necessitates accurate estimations of the genetic parameters for the traits considered.

Although there are widely reported heritability estimates on milk yield and composition none relate to the South African Ayrshire breed and very few to other South African dairy breeds. The purpose of this study was to estimate the variance components and heritabilities for milk yield and composition traits in the Ayrshire breed in South Africa over the first two lactations.

Materials and Methods

Data used in this analysis were 9 050 first and 5 541 second lactation production records of the entire South African Ayrshire breed, registered and grade, participating in the National Dairy Cattle Performance Testing Scheme, calving from 1977 to 1992. Analyses were conducted by means of the restricted maximum likelihood (REML) procedures using the programme of Meyer (1989) and fitting the models described by Hallowell (1994) for the variables milk, fat and protein yield and fat and protein percentages. The basic model fitted was as follows:

$$y = Xa + Zb + e$$

where:

y = a vector of observations on first and second lactation milk, fat and protein yield, fat and protein percentage;

X and Z = known incidence matrices relating observations to effects;

a = a vector of fixed effects consisting of year of calving, month of calving, herd and times milked depending on which were significant;

b = a vector of continual effects, age and calving interval with the effect of sire randomised;

e = a vector of unknown residual effects.

Results and Discussion

Additive and error variance

The additive and error variances are presented in Table 1. Those reported in this study are in close agreement with those found in the literature (Tong *et al*., 1979; Chauhan & Hayes, 1991; Vermeulen, 1991).

In this study the changes in both additive and error variances for the first and second lactations were greater than those reported by Tong *et al.* (1979) which could be ascribed to dataset differences, but more likely to effects such as dry period not being included as an effect on second lactation in this analysis.

Tong *et al.* (1979) found sire (additive) variance for yield traits to be relatively constant over lactations, with slight increases for percentage traits. The error variance for yield traits increased steadily with parity, but did not change appreciably for the percentage traits.

The increases in error variance over lactations may be attributed to additional sources of variation (Butcher & Freeman, 1968) which do not influence first lactation. The fact that heritability is a function of both the additive and error variance means that reasons given for changes or differences between the heritabilities and variances could apply to both parameters.

Table 1 First and second lactation, additive and error variance

	Milk kg	Fat kg	Prot. kg	Fat %	Prot %
Additive					
1st Lactation	255 874	340	251	0.0448	0.0190
2nd Lactation	192 592	263	202	0.0416	0.0176
Error					
1st Lactation	492 785	686	599	0.0545	0.0166
2nd Lactation	795 226	1 146	927	0.0689	0.0203

Heritability

Table 2 contains the estimates of heritabilities and standard errors. For the yield traits, milk had the highest heritability and protein the lowest. The range in heritabilities as reported in the literature is presented in brackets.

Heritability estimates for percentage traits were considerably higher than yield traits with protein percentage being the highest. A comparable study done in South Africa was that of Vermeulen (1991) on Holstein-Frieslands which had much higher values for yield traits, possibly owing to a

Table 2 Estimates of heritabilities and standard errors (Range in literature)

Parameter	Milk kg	Fat kg	Prot. kg	Fat %	Prot.%
1st Lactation					
h^2	0.3418	0.3177	0.2956	0.4510	0.5329
(Range)	0.24–0.42	0.26–0.36	0.19–0.36	0.35–0.77	0.45–0.64
S.E.	0.0270	0.0265	0.0258	0.0308	0.0280
2nd Lactation					
h^2	0.1950	0.1866	0.1791	0.3756	0.4628
(Range)	0.19–0.30	0.18–0.35	0.15–0.24	0.43	0.78
S.E.	0.0299	0.0310	0.0296	0.0421	0.0396

bias caused by a selected dataset with higher production.

Most researchers (Butcher & Freeman, 1968; Tong *et al.*, 1979) have found that the heritability estimates for the first lactation traits were considerably higher than those for the second lactation traits. A possible explanation is that not all of the non-genetic effects on second lactation are accounted for by the model (e.g. management prior to calving).

The difference between the heritability estimates of first and second lactations was greater than that described in the literature, which could possibly be due to the fact that only those cows with both first and second lactations were included in the study, and also that an effect such as dry period was not included in the analysis.

Literature estimates of the heritabilities for fat and protein percentages are considerably higher than those for the yield traits (Chauhan & Hayes, 1991; Hargrove *et al.*, 1981; Hermas *et al.*, 1987). The values reported are all higher than found in this study, ranging from 0.51 to 0.77 for fat and 0.52 to 0.64 for protein percentages. The fact that heritability estimates for percentage yields are higher than those for absolute yields indicates that selection should be directed towards percentages. However, this would result in large sacrifices in genetic gains for yield traits because of the negative correlation between yield and percentage traits (Farthing & Legates, 1957; Simianer *et al.*, 1991; Welper & Freeman, 1992).

Conclusion

The variance components and heritability estimates derived in this study are in agreement with those described in the literature, although heritabilities for second lactation were somewhat lower than expected. It is essential to utilise these genetic parameters for the evaluation of breeding values of South African Ayrshire rather than relying on literature values.

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