Genetic and environmental trends for first lactation milk traits in the South African Ayrshire breed

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Estimated breeding values and genetic trends were obtained in Ayrshire cattle by using DFREML procedures for 9 050 first lactation records calving down from 1977 to 1992. Environmental trends were calculated as the difference between the phenotypic and genetic values. The Ayrshire breed showed a positive trend of 19 kg per year for milk yield, with similar trends for fat and protein yield, while the trends for fat and protein percentage were negative.

Beraamde teelwaardes en genetiese tendense is vir Ayrshires deur middel van DFREML prosedures vir 9 050 eerste laktasie rekords, wat vanaf 1977 tot 1992 gekalf het, verkry. Omgewingstendense is as die verskil tussen die fenotipiese en genetiese waardes bereken. Die ras het 'n positiewe tendens van 19 kg per jaar vir melkproduksie met soortgelyke tendense vir vet- en proteïenopbrengs getoon. Die tendens vir vet- en proteïenpersentasie was negatief.

Keywords: Ayrshire, fat, genetic trends, milk, protein

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Introduction

The effectiveness of any animal breeding programme is measured by the genetic progress obtained. With the improvements in animal evaluation procedures over the past few decades, there has been a consistent improvement in the genetic ability of the cow to produce more milk. Improvement in managerial techniques, better dairy equipment, improved feeding methods and more accurate record keeping have also led to improvements in the environmental or non-genetic effects on yields.

Unfortunately very little has been reported in the literature on trends in the Ayrshire breed and also very little published on the dairy breeds in South Africa. It was only recently that mixed model procedures, initially described by Henderson (1975), could determine what portion of the phenotypic change was, in fact, genetic. The animal model incorporates all known relationships in the population and is, in particular, an effective method of separating genetic and environmental effects (Henderson, 1975; Wiggans *et al.*, 1988).

Materials and Methods

The data used in this analysis were the first lactation 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. A total of 9 050 lactations were involved in the original analysis. The data have been described by Hallowell (1994).

BLUP breeding values were calculated for each animal by applying a single-trait animal model. A summary of the models fitted is given in Table 1. The breeding values were calculated with the DFREML programme of Meyer (1989) which was also used in the estimation of variance components. Annual genetic values were then calculated as the average estimated breeding values per year of calving. Genetic trends were calculated as the regression of mean annual genetic values on the year of calving.

Table 1 Effects included in models for different traits

	Trait				
	Yield			Percentage	
Effect	Milk	Fat	Protein	Fat	Protein
Year of calving	+	+	+	+	+
Month of calving	–	–	–	+	+
Herd	+	+	+	+	+
Times milked	+	+	+	+	–
Age at calving – linear	+	+	+	+	–
Age at calving – quadratic	+	+	+	–	–
Model	one	one	one	two	three

Taking the significant effects shown in the above table into consideration, Model one for first lactation milk, fat and protein yield is:

$$Y_{ijklm} = u + a_i + h_j + mk + b_1A + b_2A^2 + S_m + e_{ijklm}$$

where: Y_{ijklm} = an observation on the trait considered,
u = overall mean,
a_i = fixed effect of the i-th year of calving,
h_j = fixed effect of the j-th herd,
mk = fixed effect of the k-th times milked per day,
$b_1\, a$ = linear regression of the appropriate deviation from the mean age at first calving,
b_2A^2 = quadratic regression of the appropriate deviation from the mean age at first calving,
S_m = random effect of the m-th sire and
e_{ijklm} = random error

Models two and three were constructed using the significant effects described in Table 1.

Several methods of defining and computing environmental trends exist. The most common is to regress the year-season solution on the year-season number. This is, however, only the year-season effect and not the total environmental effect since adjustments are made only for the known environmental effects. The environmental value was therefore obtained by subtracting the genetic (breeding) value from the phenotypic value.

Results and Discussion

Genetic trends

The parameters of the linear regression, *b* and R^2, are presented with each graph. The linear regressions produced good fits as indicated by the high R^2 values obtained for the genetic trends for milk, fat and protein yields which ranged from 0.86 to 0.89, while the R^2 values for fat and protein percentages were somewhat lower (0.63 for fat and 0.80 for protein percentages). Because there was a marked change in the genetic trend after 1984 (Figures 1 to 5) two separate regressions were fitted for the periods 1977 to 1984 and 1985 to 1992.

The genetic trend for milk yield as illustrated in Figure 1 shows two distinct periods. Firstly the period 1977 to 1984, marked by a small increase of 48 kg (or 6.0 kg per year), with a negative trend in 1980. The second period from 1985 to 1992 shows a dramatic increase of 32 kg per year. Over the 19-year period the genetic potential for milk production for the Ayrshire breed in South Africa therefore increased by 414 kg (or 21.2 kg per year). In order to make the results more current, Figure 2 has been included which shows the genetic trend for the Ayrshire breed for the period 1978 to 1997. Similar trends are apparent despite differing models and datasets. Hintz *et al.* (1978) reported changes in the average genetic merit of the American Ayrshire breed of 345 kg (24.6 kg per year) over the period 1961 to 1974, while Powell *et al.* (1977) reported annual trends in sire breeding value of only 7 kg for the Ayrshire over the period 1968 to 1975.

The increased genetic gains from 1985 can be attributed directly to the greater importation of semen and bulls from Scotland and Canada in the late 1970s and early 1980s, and the use of locally bred, genetically superior bulls. Similar trends have been described by Blanchard *et al.* (1983) and Burnside *et al.* (1992) who found that the genetic change in milk yield increased substantially with the availability of more accurate breeding values. The accentuated genetic changes in 1991 and 1992 can be ascribed, firstly to the introduction of two bulls, *Langside Impact* and *Des Peupliers Rebel* (whose daughters increasingly came into production during this period), and secondly, to the introduction of modern breeding value estimations in 1989 and the increased awareness by dairy

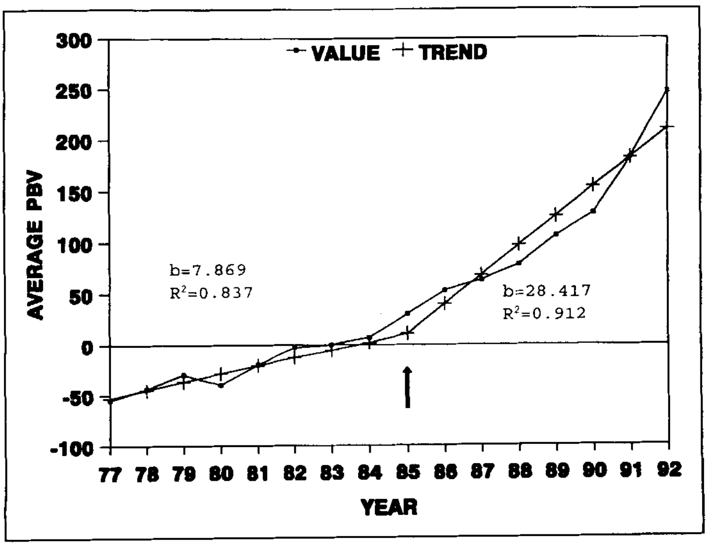

Figure 1 Genetic trend for mean annual breeding values for milk yield.

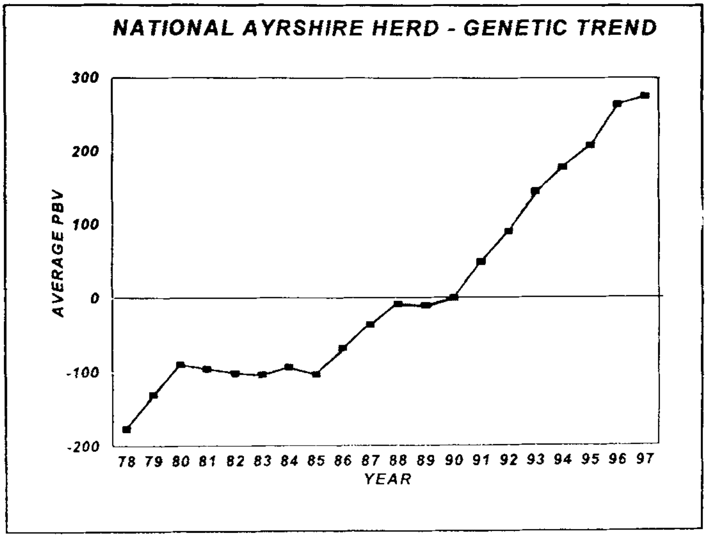

Figure 2 National Herd – Genetic trend for mean annual breeding values for milk yield.

farmers of the value of the National Dairy Performance Testing Scheme.

The genetic trends for fat and protein yields are presented in Figures 3 and 4. The trends are very similar to those for milk yield and the reasons given in the discussions of milk yield trends would apply to fat and protein yield, as there is a high positive genetic correlation between milk and composition yields (Simianer *et.al.*, 1991; Vermeulen, 1991).

The genetic trend for fat percentage is presented in Figure 5. There was no genetic trend in the

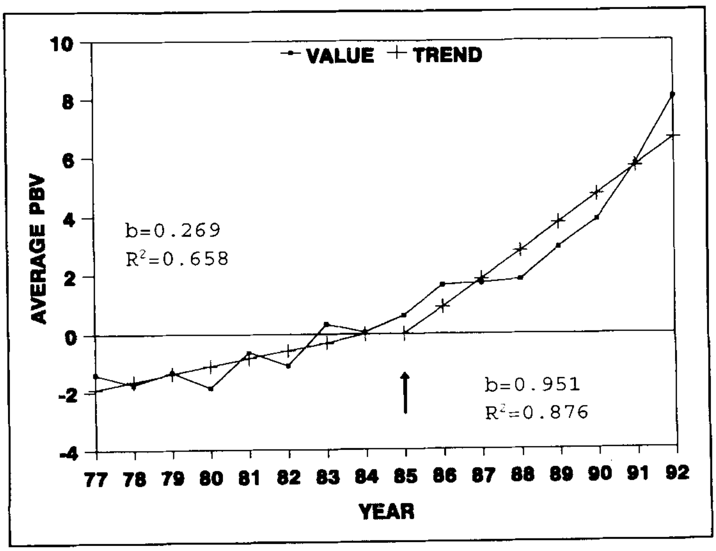

Figure 3 Genetic trend for mean annual breeding values for fat yield.

period 1977 to 1984, but a highly significant negative trend ($R^2 = 0.91$; $b = -0.003$) for the period 1985 to 1992 was evident. Lee *et al.* (1985) and Burnside *et al.* (1992) reported similar negative trends for fat percentage, which is a consequence of the selection for higher milk yield.

The genetic trend for protein percentage is presented in Figure 6. As was the case with fat percentage, there was no trend for protein percentage for the period 1977 to 1984, but a similar negative trend for the period 1985 to 1992. This is contrary to findings by Burnside *et al.* (1992) who

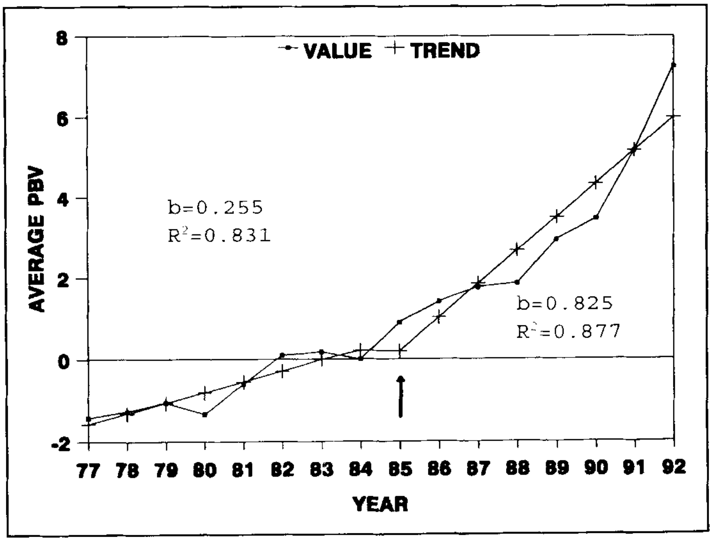

Figure 4 Genetic trend for mean annual breeding values for protein yield.

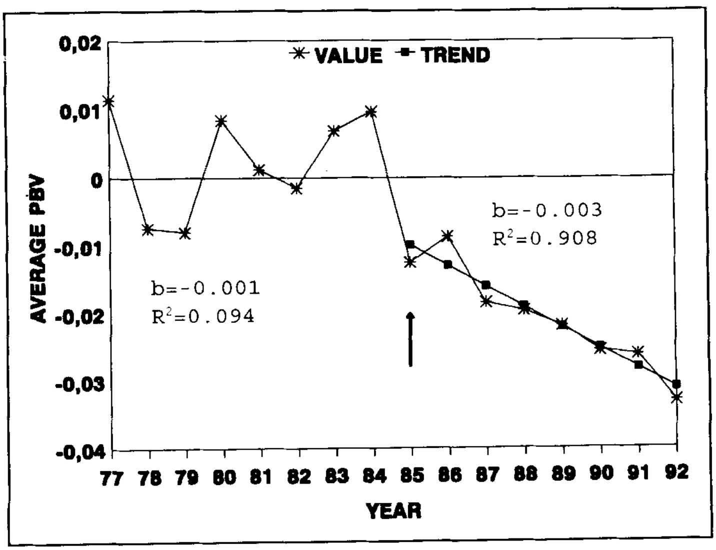

Figure 5 Genetic trend for mean annual breeding values for fat percentage.

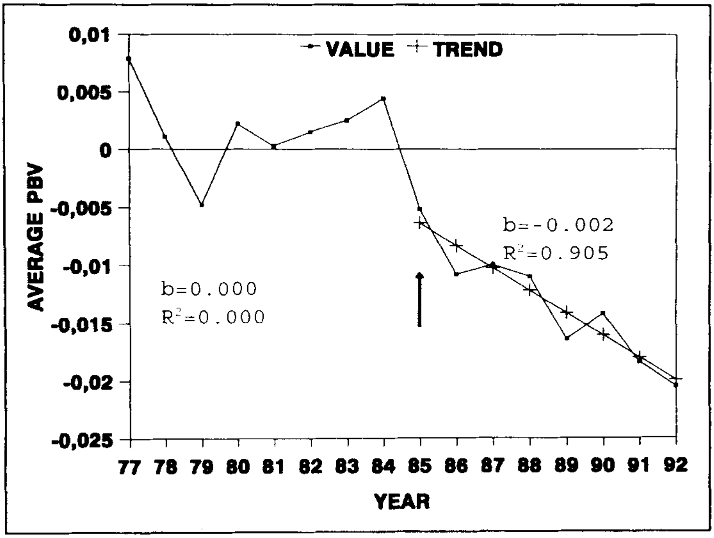

Figure 6 Genetic trend for mean annual breeding values for protein percentage.

reported a slight increase in protein percentage. It is assumed that no emphasis was placed on selection for milk fat and protein percentages of the bulls selected. Protein remains the most important constituent of milk and it should receive greater emphasis as a selection criterion in the future.

Environmental trends

Milk and protein yields have R^2 values over 0.90, while the fat yield R^2 value is somewhat lower (0.72). The low R^2 values for fat (0.0014) and protein (0.35) percentage indicate that no environmental trend for these two traits was apparent.

The mean environmental values for milk yield show some amount of annual variation as illustrated in Figure 7. From 1977 to 1979 there was a slight drop in production, followed by a period of steady increase (1980 to 1983), then a period of stagnation (1984 to 1987), and thereafter a period of steady increase through to 1992.

There are many compounding factors as far as the description of environmental trends is concerned. Firstly, the country has been in the grip of a drought for virtually the last decade which has affected certain areas more than others. Secondly, the introduction of the owner sampling scheme has made Milk Recording accessible to all farmers. In addition, there was a marked increase in the utilisation of the Scheme from 1984 onwards, which means that herds of all production levels participated in the Scheme. This could possibly account for the stagnation over the period 1984 to 1987. Thirdly, from 1989 onwards there was a marked decline in cows tested owing to several factors including the drought, which means that mainly the lower producing herds (both genetic and environmental) withdrew, resulting in the marked increases over the latter years. Fourthly, there was a marked increase in the number of cows milked three times per day in the last three years.

The environmental trends for fat and protein yields are presented in Figures 8 and 9. Owing to the similarity of the milk, fat and protein yield trends and the high correlations between the traits (Vermeulen, 1991) the reasons given for the trends observed in these two traits will be the same as those given for milk yield.

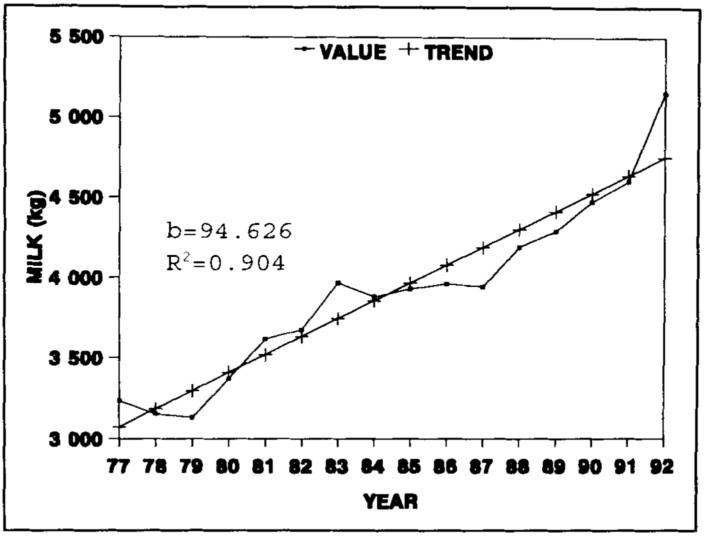

Figure 7 Environmental trend for mean annual environmental values for milk yield.

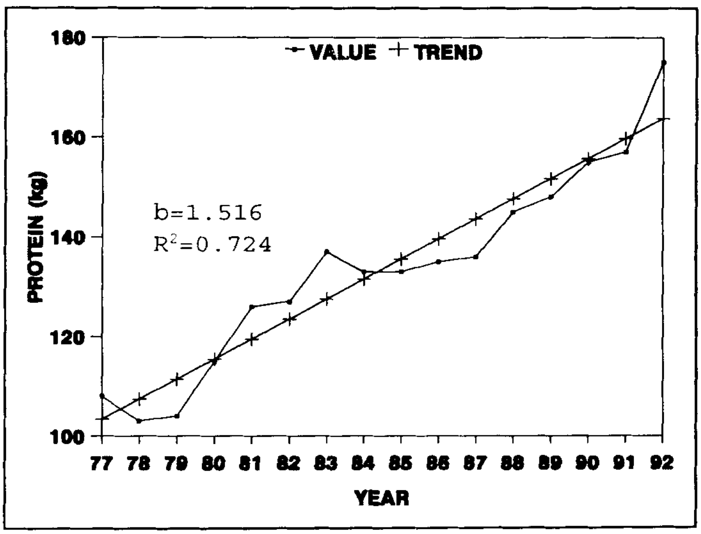

Figure 8 Environmental trend for annual environmental values for fat yield.

Conclusions

It is obvious from the positive trends obtained for the various yield traits that substantial advances owing to the application of the latest breeding techniques have been made, in spite of the small population of the Ayrshire in South Africa, especially over the past decade. Based on tendencies worldwide, greater strides could still be achieved in the future.

Over the past decade the emphasis has been placed on the improvement of milk production with

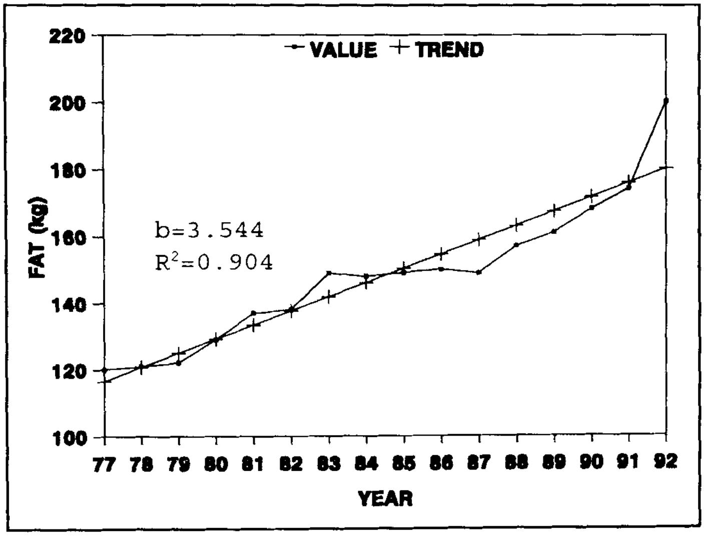

Figure 9 Environmental trend for environmental values for protein yield.

little attention given to fat and protein percentages. It is imperative that future selection of breeding sires be based on a monetary value index taking fat and protein into account.

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