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Genetic and Environmental Trends for Milk Traits in the Zimbabwean Holstein-Friesian Population

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Abstract: The data was obtained from the Zimbabwe Dairy Services Association. Genetic trends for milk yield, fat yield and protein yield were estimated using 30, 395 records of cows in parities 1 to 8 using AIREML procedures for cows born 1973 to 1994. Environmental trends were estimated as the difference between the phenotypic and genetic values. The heritabilities for milk yield, fat yield and protein yield was 0.23, 0.21 and 0.21, respectively. The annual genetic trends ranged from 8.72 to 14.40 kg for milk yield and 0.285 to 0.44 kg for fat yield. The annual genetic trends for cows born 1987 to 1994 were higher at 22.39 kg for milk yield, lower for fat yield at 0.127 and 0.39 kg for protein yield. The effects of the droughts were clear from the environmental trends obtained. Also the harsh economic climate in Zimbabwe has led to the negative environmental trends. There were positive genetic trends in milk yield traits that indicate that the dairy cattle genetic improvement strategies that were used in Zimbabwe in the last twenty years were effective.

Key words: Holstein-Friesian, fat yield, genetic trend, milk yield, protein yield

INTRODUCTION

The measurement of genetic capacity of the dairy cows is of economic importance and improvement in genetic capacity is measured by the genetic trend. There have been advancements in management techniques, improved dairy equipment, improved feeding techniques and more accurate recording. All these are expected to result in improvements in the environmental effects.

One way of evaluating breeding schemes (previous sire and cow selection strategies) is to analyse the phenotypic trends observed and separate it into its genetic and environmental components. This is the way to estimate genetic trends without the use of a controlled experiment. The strategies used in Zimbabwe included importation of semen and embryos from United State of America and Canada. The impact of this must be assessed using genetic trend analysis. These genetic trends measure the cumulative changes in a population and are the final indicator of sustainable genetic progress[1].

Mixed model methodology is used extensively because it has smaller sampling variances (PEV) and accounts for competition by adjusting for differences in herd mates of the daughters of the sires. This has further been refined to the animal model, which uses the additive numerator genetic relationships in the population. The animal model is known to be an effective way of separating genetic and environmental effects[2]. The animal model is also attractive as it accounts for changes in variances as a result of selection[3]. Average Information Restricted Maximum Likelihood (AIREML) is used to estimate both fixed effects and random effects at the same time, accounting for the losses of degrees of freedom in the simultaneous estimation. Musani and Mayer[1] described it to be robust against selection and non-random mating. The AIREML has the properties of Maximum Likelihood that the estimates obtained increase the chances of obtaining the phenotypic data used to estimate them.

MATERIALS AND METHODS

The environment: Zimbabwe is located in Southern Africa in the tropical savannah region. The total land area is

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Table 1: Effects included in models

	Traits		
Effects	Milk yield	Fat yield	Protein yield
Herd	+	+	+
Year of birth	+	+	+
Month of calving	+	+	+
Parity	+	+	+
Linear effect of days in milk	+	+	+
Quadratic effects of days in milk	+	+	+
R^2 value	0.63	0.60	0.62

390,759 sq. km. About 7.25% is arable, 0.25% is under permanent crops like coffee, 12.5% are meadows and pastures (veld) and 49% are forests and woodlands. A central plateau lying between 1200 and 1500 m above sea level dominates Zimbabwe's landscape. The climate is subtropical moderated by altitude. The rainy season is November to March with a dry cool season from May to August. The rainfall increases from southwest to northeast. The mean annual temperature range is 16 to 25°C. The dairy farms are located within 40 km of the major towns and cities.

The records: The milk production records were obtained from the Zimbabwe Dairy Services Association (ZDSA). Kunaka[4] described the dataset and the edits. This gave a dataset of 30,379 records. This was then split into three datasets EVNH73, ODNH73 and ALL87 for reasons given by Kunaka[4]. The animal model used had the fixed effects of herd, month of calving, year of birth for datasets EVNH73 and ODDNH73, the dataset ALL87 had these fixed effects plus the effects of parity, linear and quadratic functions of days in milk as shown in Table 1. The breeding values for each animal were estimated using AIREML of Gilmour[5] that was also used to estimate the variance components. Annual genetic values were calculated as the average estimated breeding values per year of birth. The genetic trends were calculated as the linear regression of mean genetic values on the year of birth.

There are many ways of defining and calculating environmental values. In order to take account of the total environmental effects, the environmental values were described as the differences between the genetic values from the phenotypic value for the year of birth[6].

RESULTS AND DISCUSSION

Genetic parameters: The heritabilities (h^2) for the parities studied were 0.23(0.07), 0.21(0.04) and 0.21(0.04) for milk yield, fat yield and protein yield, respectively. These heritabilities were similar to those reported by Makuza and McDaniel[7] (using daughter-dam regression analysis) in Zimbabwean Holsteins and other countries[8]. These heritabilities were lower than those reported for parity one[7]. This is expected because more environmental factors affect later parities. Powell *et al.*[9] reported that heritabilities decreased with age. Hill *et al.*[10] reported a slightly lower heritability for protein yield than fat yield in the British Holsteins. In this study, there were no differences in the heritabilities for protein and fat yields.

The repeatabilities were 0.42, 0.30 and 0.31 for milk yield, fat yield and protein yield. These repeatabilities were lower than those for temperate Holstein populations Makuza and McDaniel[11]. This could be due to the fact that the repeatability model used assumed that the dominance and epistatic variances were equal to zero. This assumption may not be true[12]. These values could also be lower because of large temporary environmental effects affecting milk production in Zimbabwe. Possibly, there is a lot of noise in the data.

Genetic trends: The regressions produced good fits as shown by the R^2 values (range 0.75 to 0.84) obtained for milk and fat yield. The R^2 value for protein yield was low at 0.56. It could be deduced that the linear regression model could not explain the 0.44 of the variation in the protein yield with changes in the years of birth. The low R^2 value could be due to a short testing period. The genetic analysis was done when ZDSA had only four years experience in milk protein measurement. The annual trends for milk were 14.40 kg for the ODNH73 (Fig. 1), 8.72 kg (Fig. 2) for the EVNH73 and 22.39 kg for ALL87 (Fig. 5), respectively. The same pattern was observed for fat yield, which were 0.44 kg (Fig. 4), 0.285 kg (Fig. 3) and 0.127 kg (Fig. 6) for EVNH73, ODNH73 and ALL87, respectively. There was significant genetic trend in the protein yield of 0.39 kg (Fig. 7).

The expectation was to get more accurate and predicted trends in protein yield as its measurement started with more modern Bentley 2000 machine. There was an increase in the importation of semen from USA and Canada from the late 1980s to early 1990s. This would mean that even the locally bred bulls would be genetically superior. It was expected that with the more accurate recording with the introduction of the Dairy Herd Improvement Association (DHIA) in Zimbabwe in 1994, genetic trends for milk yield, fat yield and protein yield would increase[13]. Fat and protein yield would follow the same trend as milk yield because of the high genetic correlation[14,15]. However the genetic trends observed were lower possibly because of lower heritabilities due to high environmental variation. Musani and Mayer[1] reported that extreme values of genetic parameters have little influence on the estimates of annual genetic trends, something that will need to be confirmed using larger

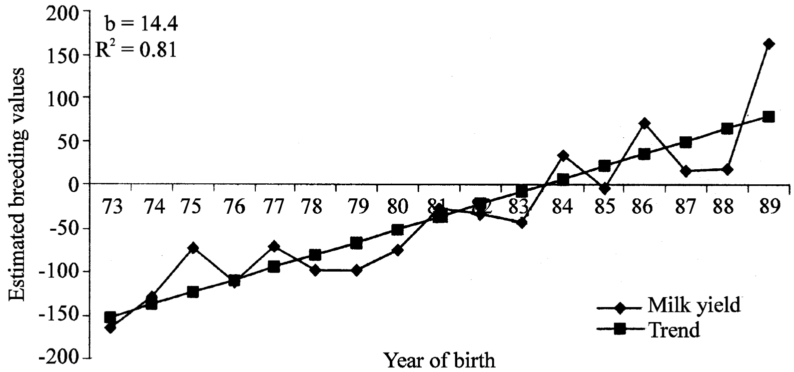

Fig. 1: Genetic trends of milk yield in ODNH73 data set (1973-1989)

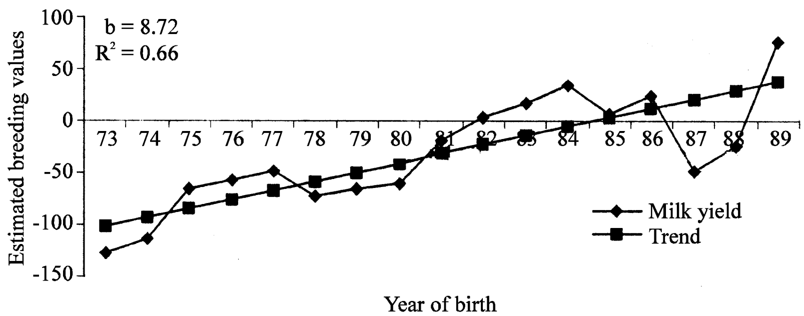

Fig. 2: Genetic trends of milk yield in EVNH73 data set (1973-1989)

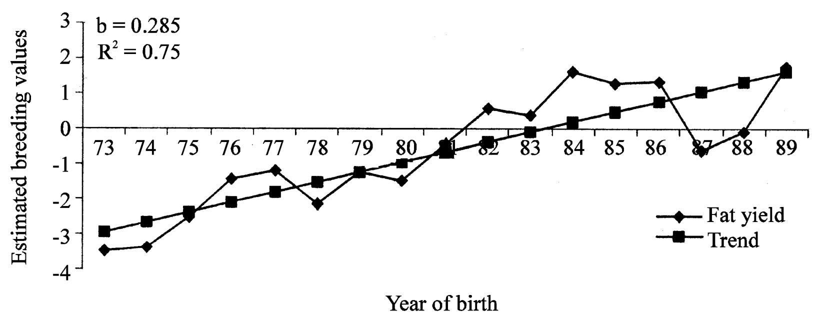

Fig. 3: Genetic trends of fat yield in EVNH73 data set (1973-1989)

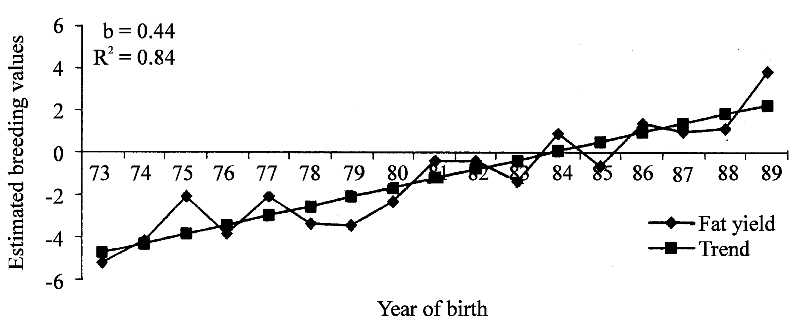

Fig. 4: Genetic trends of fat yield in ODNH73 data set (1973-1989)

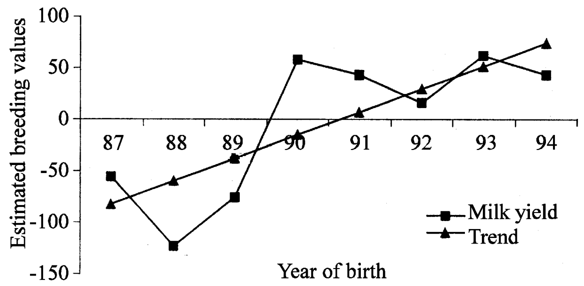

Fig. 5: Genetic trends of milk yield in ALL87 data set (1973-1994)

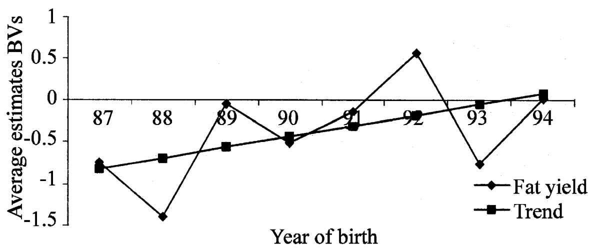

Fig. 6: The genetic trends of fat yield in ALL87 data set (1973-1994)

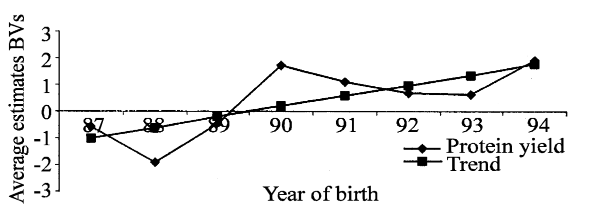

Fig. 7: The genetic trends of protein yield in ALL87 data set (1973-1994)

datasets. The low fat and protein yield trends may be an indication that much of the selection applied was aimed at increasing milk yield only.

Environmental trends: The effects of the droughts that have occurred in Zimbabwe over the years were clearly shown on the environmental trends observed. There was a marked decline from 1987 and thereafter the trends were negative. The effect of the droughts was to reduce the population size under selection resulting in reduced selection intensity. The economic situation has continued to decline from a situation of single digit inflation to triple figures. The price increases of inputs for example stockfeed increased by as much as 600% between 1990 and 1993 yet milk price increased by a mere 200% due to consumer resistance[16]. The expectation would be that these factors would have forced the mainly lower (less efficient) producing herds (both genetic and environmental) resulting in some marked increase over the years after. However, the trends were still low.

There have been some positive genetic trends in milk, fat and protein yields over the years in the Holstein-Friesians of Zimbabwe. The selection strategies have been effective. It is clear that the selection strategies used in Zimbabwe emphasized on milk yield almost neglecting the production of the other components. The production environment has been deteriorating over the years. Although there are many confounding factors constituting the environment, it remains the biggest challenge to the productivity of Holsteins in Zimbabwe. The same study should be done using the dominance and epistatic models as suggested by Mrode[17]. It is recommended that the effects of extreme genetic parameters on the estimates of annual genetic trends should be tested.

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