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Phenotypic and genetic parameters of reproductive traits for Ayrshire cattle on large-scale farms in Kenya

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Abstract

Data consisting of 2757 records from ten Kenyan Ayrshire herds made between 1980 and 2005 were used to examine environmental factors affecting age at first calving (AFC) and calving intervals (CI) and consequently estimate genetic and phenotypic parameters and trends.

The overall means and standard errors for AFC and CI were 39.4 ± 7.2 months and 487.5 ± 151.6 days respectively. The respective heritability estimates were 0.091 ± 0.05 and 0.044 ± 0.032, while the repeatability estimate for CI was 0.096 ± 0.001. The genetic trends for CI and AFC were -0.6d/yr and -0.01mo/yr respectively and were both significant ($P<0.001$), indicating a decrease in mean breeding value over the study period. Phenotypic trends were -0.31 mo/yr and -0.35 d/yr for AFC and CI respectively though non-significant ($P>0.05$).

The low heritability for CI and AFC indicated that temporary environmental influences were much greater than genetic influences or permanent environmental influences on these traits.

Key words: Age at first calving, Ayrshire, calving interval, genetic parameters and trends

Introduction

Most of the current breeding programs globally use indices that give more weight to yield and type traits than reproductive traits (Lucy 2001). This practice has resulted in substantial genetic progress for yield, but is likely to cause reduced fertility given the reported positive genetic correlation between fertility and yield (Hansen et al 1983; Raheja et al 1989; Oltenacu et al 1991). Several studies demonstrated an inverse relationship between reproductive efficiency and milk yield especially in the tropics (Lucy 2001, Ojango and Pollot 2001, Roth 2004). Management can enhance reproductive efficiency, even though reproduction has some genetic variation (Lucy 2001; Biffani et al 2003).

Low fertility is of economic importance in dairy enterprises especially in tropics, because it results in higher levels of involuntary replacement, slippage in calving pattern, veterinary intervention and reduced annual milk production (Esslemont and Peeler 1993). Improving fertility also increases effectiveness of treatments or vaccinations and also reduces breeding costs because of isolation, treatment, culling and replacement of problem cows (Campos et al 1994, Damatawewa and Berger 1998).

Evidence in literature (Njubi 1990; Rege 1991; Lucy 2001; Biffani et al 2003) shows that heritabilities of reproductive traits in dairy cattle are generally low, making selection for those traits difficult. However there is sufficient variation to permit genetic improvement of reproductive performance.

Thus incorporation of measures of cow (daughter) reproduction into sire selection decisions has been recommended (Clay et al 2000; Weigel and Rekaya 2000).

The low heritability was interpreted by Hansen et al (1983) to mean that natural selection has reduced the additive genetic variance and little improvement through selection can be expected. Phillipson (1981) and Raheja et al (1989) on the other hand, inferred that considerable additive genetic variation is associated with fertility traits. Hansen et al (1983) pointed out that although selection for reproduction is possible, it would lead to loss in production and the only best economic alternative to apply selection for fertility would be to hold days open constant in cows.

A significant increase to productivity could therefore be feasible by paying attention to problems of reproductive inefficiency (Mukasa-Mugerwa et al 1992). Hence, Mukasa-Mugerwa et al 1992 reported that an important starting point in any animal improvement package is to assess the reproductive performance of the herd. The objectives of this study were to determine the environmental factors limiting reproductive traits in Kenya Ayrshire cattle and to estimate phenotypic and genetic parameters and trends for CI and AFC over recent years.

Materials and methods

Data Source and preparation

Data comprising of 8301 lactation records were sourced from 10 large-scale Ayrshire herds covered by the Dairy Record Services of Kenya (DRSK) and the Kenya Stud Book (KSB). Herds were located in the Rift Valley and Central Provinces of Kenya, which are classified as high and medium potential for agricultural production. The management system of the herds differed but generally animals were managed according to their age groups i.e. calves, weaners and mature stock. From the age of 14 months heifers coming on oestrus regularly were served through artificial Insemination. On average, most of the farms tried to have their heifers inseminated at 18 months of age. Calving occurred all year round but most cows were planned to calve towards end of the year when demand for milk was high and to capitalize on the long rains in early part of the subsequent year.

Rainfall data for different study areas were obtained from the Meteorological Department in Nairobi. Monthly rainfall totals over study period (1980-2005) were used to determine the rainfall pattern to define the three seasons. The seasons in the country were generally classified into three based on rainfall pattern (Rege ad Mosi 1989): Long rains, (March to May), Short rains (October to November) and Dry seasons (June -September and December-February).

Records of animals without pedigree information and dates of birth and calving were excluded. All cows with AFC earlier than 23 months and records of calving intervals shorter than 300 days were also omitted. This ensured that records that were wrongly entered at the farms resulting in impractically early AFC and short CI were not included in the analysis. The records were edited down to 2674 records of 1151 cows sired by 171 bulls. Pedigree records for individual cows were verified with records from KSB, which issues certificate of registration showing dates of birth, sire, dam and grandparents.

The age at the first calving was derived from the dates of birth and first calving, while the calving interval was derived from the dates of consecutive calvings i.e. current and previous calvings.

Statistical data analyses

The data were first analysed by the least squares techniques using the general linear models procedure of SAS (SAS 1989) to determine the effects of the various factors on reproductive traits. CI and AFC were analysed using models 1 and 2 respectively;

$$Y_{ijkbn} = \mu + p_i + h_j + y_k + s_l + e_{ijkbn} \quad (1)$$

where Y_{ijklm}- the observations on Calving interval,

μ = the underlying constant,

p_i = the fixed effect of the i^{th} parity (I= 1,2,.........5),
h_j = the fixed effect of j^{th} herd (j=1,2,........10),
y_k= the fixed effect of k^{th} year of calving (k=1986,1987…2005),
s_l = the fixed effect of l^{th} season of calving (l=1,2,3),
e_{ikllm} = the random residual NID $(0,\sigma^2_e)$

$$Y_{jkbn} = \mu + h_j + y_k + s_l + e_{ijkbn} \quad (2)$$

where Y_{jklm} = the observations age at first calving in the months.

μ, h_j , e_{ikllm} = as described in model 1,

From the preliminary analysis a suitable model was identified for the final estimation of the genetic parameters. The final statistical analyses were performed with DF-REML procedure (Meyer 1989) and animal model to obtain variance components for calving interval and age at first calving. The animal model included additive genetic merit of each cow as the only random effect. To estimate repeatability for calving interval, an animal model was used to account for permanent environmental effects common to the repeated records on the same animal.

Estimation of phenotypic, genetic and environmental trends was done for CI and AFC. The mean additive genotype in a particular year of birth was defined as the mean predicted breeding values of cows born in that year. Consequently, changes of mean additive genotype between the years reflected additive genotypic differences. The overall additive genetic trend in a trait was estimated by regressing the mean predicted breeding values on the respective year of birth in that trait. For phenotypic trends, the adjusted performance records were averaged within year of birth and then regressed on years of birth (Wakhungu 1988; Rege and Mosi 1989). The within year difference between the mean predicted breeding value and the mean of the adjusted phenotypic records reflected the component due to the non-additive genetic and the environment. These were also regressed on year of birth for the period of study to reflect the environmental trend.

Result and discussion

Means and variations

From the analysis with model 1 and 2 showed that herd, parity, year of birth/calving had significant effects (P<0.01) on CI and AFC. This reflects the importance influence of management and nutrition on the fertility traits. The overall means of AFC and CI were 39.4 ± 7.2 months and 487.5 ± 151.6 days respectively (Table 1).

Table 1. Data structure and means and standard deviations for fertility traits

Data structure	Number	
	CI	**AFC**
Records	2674	1544
Cows	1151	1499
Sires with progeny	171	189
Traits Mean	487.5 ±151.6	39.4 ±7.2
Coefficient of variation, %	29.7	15.5

CI had a moderate coefficient of variation (29.6%), even though the mean was longer than the biologically ideal CI of about 365 days, while AFC had low coefficient of variation (15.4%). These results were in agreement with the earlier reports in literature (Campos et al 1994; Okeyo and Mosi 1999; Ojango 2000). Early age at first calving (22 - 23 months) followed by minimum calving interval has been reported to increase the productive life of a cow this has the added effect of shortening the generation interval thereby improving the annual genetic gain.

Effects of non-genetic factors on reproductive traits

Herd had a significant influence (p<0.001) on calving interval. Similar results have been reported in literature (Rege 1991; Campos et al 1994; Kaya 1996). The variation of CI from one herd to another could be attributed to differences in skills of heat detection. Therefore, an intensive program of heat detection and practices of insemination may significantly shorten CI by shortening days open. Age at first calving, which is an indicator for age at sexual maturity and age at first service, was significantly affected by herd (p<0.01). Ojango and Pollot (2001) have reported similar results.

Effects of year of calving on CI were significant (p<0.001), similarly significant effect of year of birth on AFC was reported in this study. The year of birth/calving effects are the result of the interaction of a set of environmental, technical and administrative management practices makes its interpretation difficult, however, it is important source of variation that must be considered in the statistical analysis in order to get clear interpretation of results. Significant year of calving effects on CI have been reported in several studies made in Kenya (Rege and Mosi 1989, Rege 1991; Musani 1995; Muasya 2005).

The parity had a significant influence on CI (p<0.05). The first parity cow had the longest CI, and a declining trend with advancing parity was observed. This was due to the increase in the body weight combined with advancing age when body is fully developed followed by increase in function of most body systems including reproductive system. These results were in agreement with other earlier reports (Lusweti and Mpofu 1989; Chagunda et al 2004; Muasya 2005).

Heritability and repeatability

The estimated additive genetic, residual and phenotypic variances, heritability and standard errors for CI and AFC are presented in Table 2.

Table 2. Additive genetic, phenotypic and relative permanent environmental variances, heritability and repeatability for CI and AFC

Parameter	AFC	CI
Additive-genetic variance	2.96	898
Variance due to permanent cow effect	-	1128
Error variance	33.59	19113
Phenotypic variance	36.55	21140
Phenotypic CVs, %	15.5	29.7
Heritability	0.09± 0.05	0.04 ±0.03
C-squared value	-	0.05
Repeatability	-	0.09 ± 0.001

The heritability estimates for CI and AFC were consistent with those reported in other studies (Rege 1991; Makuza and McDaniel 1996; Baco et al 1998; Ojango and Pollot 2001) despite the differences in data, cattle populations and estimation procedures used. Reproductive traits general have low heritabilities than production traits. Other workers have reported high heritabilities (as high as 0.47) for some reproductive traits like AFC (Chagunda et al 2004, Ojango and Pollot 2001; Makuza and McDaniel 1996; Baco et al 1998).

The low heritability estimates obtained in this study for CI and AFC were due to low additive genetic variance attributable to long term natural selection in the breed. The effect of large environmental variance on the phenotypic variance also led to low heritability. Poor heat detection and insemination techniques are important contributors to increased phenotypic variance of these traits. The effect of nutrition on heifer's growth rate and silent heat, hence increased number of insemination per conception and insemination period, has been reported (Harrison et al 1990, Dechow et al *200*4). The low heritability estimates for CI and AFC obtained in this study indicates that little genetic improvement would be expected from selection for such traits. Although the heritabilities were low, there was exploitable genetic variance in these traits as observed in variance component estimation (Table 2) Therefore, improving managerial techniques such as feeding, heat detection, insemination services and use of high quality semen, should lead to considerable decrease in length of CI and AFC.

Phenotypic and genetic trends

The overall genetic trend in CI and AFC were as desired negative and significant ($P<0.001$), indicating a decrease in calving interval and age at first calving over time (Figure 1 and 2).

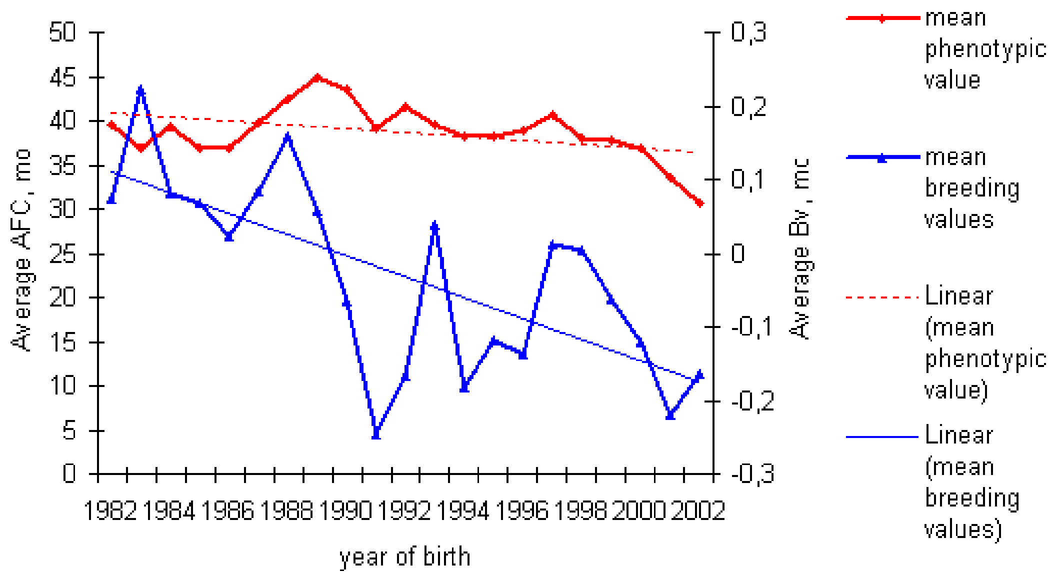

Figure 1. Phenotypic and genetic trends for age at first calving (months) [Y = -0.223x + 41.2], genetic trend: [y =-0.0143x+0.0125]

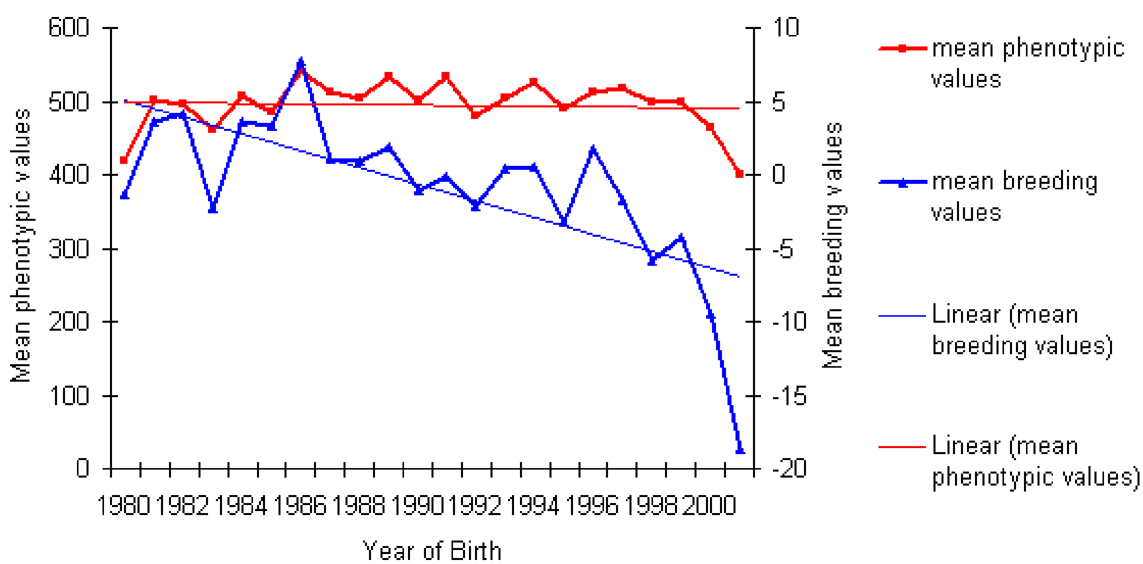

Figure 2. Phenotypic and genetic trends for calving interval (days) [Y= -0.276x + 497.9], genetic trend: [y =-0.569x+5.57].

The regression coefficients of mean breeding value for CI and AFC on year of birth were -0.57 d/yr and -0.01 mo/yr respectively. Thus, this means that breeding values for CI and AFC decreased during the study period at the rate of 0.6 d/yr and 0.01 mo/yr respectively. The corresponding phenotypic trends too were also negative but non-significant (P>0.05). These results are consistent with other reports in literature (Rege 1991; Ojango and Pollot 2001), but were not in agreement with reports by Njubi et al (1992) and Musani (1995) who reported positive genetic and phenotypic trends.

Within year difference between the mean predicted breeding value and the mean of the adjusted phenotypic records reflected the component that was attributed to the non-additive genetic component and the environment. The environmental trends for CI and AFC obtained in this study were 0.29 d/yr and -0.21, which were statistically not significantly different from zero.

Conclusions

- The genetic parameter estimates for calving interval and age at first calving obtained for the Kenyan Ayrshire cattle are comparable to those obtained in other regions. Despite relatively small heritabilities obtained, genetic coefficients of variation were large and selection for reproductive traits may be possible. The low heritability for CI indicated that temporary environmental influences were much greater than genetic influences or permanent environmental influences. Makuza and McDaniel (1996) also came to the same conclusion for days open.
- The genetic and phenotypic trends for calving interval and age at first calving obtained were in a favourable direction, even though the mean AFC and CI were longer than the biologically ideal.
- The results of this study indicate that the management influence reproductive traits of Ayrshire herds performing in a tropical climate of Kenya more than additive genetic factors. It would thus be possible to reduce CI and AFC through improvement in management of reproduction. Therefore, incorporation of fertility traits into a total genetic merit index might abate the decline in reproductive performance that would otherwise occur with selection for milk production.

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