Heritabilities of reproductive traits in a beef cattle herd using multtrait analysis

R.R. van der Westhuizen, S.J. Schoeman, G.F. Jordaan and J.B. van Wyk

1Dept of Animal Science, University of Stellenbosch, P Bag X1, Matieland, 7602
2Dept of Animal Science, University of Orange Free State; P O Box 339,Bloemfontein, 9300

Introduction
Reproduction is a critically important aspect of overall efficiency in the livestock industry. However, reproduction is a complex process with many components. Several such components have been used as measures of reproductive performance. Calving interval (CI), calving rate, services per conception, age at first calving (AFC), days to calving and calving date (CD) are some of the components of the female “reproductive complex” that have been considered. Animal geneticists are beginning to explore the possibility of separating components of the female “reproductive complex” into subsets that are both relatively easy to measure and have higher heritabilities. CI has traditionally been the predominant measure of reproduction during the productive life of the animal, particularly in dairy cattle (Rege & Famula, 1993). However, in beef operations, a relatively short breeding season is usually employed, so CI does not provide any additional information to CD and has lower repeatability and heritability (Bourdon & Brinks, 1983). Beef cattle in South Africa, as in other countries, are mated during a limited breeding season. Bourdon & Brinks (1983), Marshall et al. (1990) and MacGregor (1995) have found CI to be a biased measure of reproductive performance, due to its negative association with CD, which results in cows calving early having the longest CI. Direct selection for shorter CI could also result in indirect selection for later age at puberty, since cows with the shortest CI are often those whose calves were born late in calving seasons. Bourdon & Brinks (1983), Buddenberg et al. (1990), Lopez de Torre & Brinks (1990), Marshall et al. (1990), and MacGregor (1995) suggested CD as the preferred reproduction measurement for numerous reasons applicable to a restricted breeding season. These include lower birth weights, reduced incidence of dystocia, higher weaning and yearling weights and higher reconception rates. The objectives of this study were to obtain heritabilities (for CI, CD and AFC) and genetic correlations between these three traits.

Materials and Methods
Data used in this study were obtained from the multibreed synthetic beef cattle herd of the Johannesburg Metropolitan Council. After incomplete and biased records were removed, the data set contained 41 849 observations of 13 049 reproductive animals (dams and heifers) between 1979 and 1993. There were 25 684 base animals in the pedigree file. Paterson (1978; 1981) and MacGregor (1999) described the conditions under which these animals were kept and the management practices applied. Three traits were evaluated, namely calving interval (CI), calving date (CD), and age of first calving (AFC). CI was calculated as the interval in days between the subsequent and previous calving dates. CD was coded as the number of days from the onset of the calving season (1 June i.e.) until the dam calved. A penalty score for CD was given to those animals that did not calf during a particular year. The cow having the highest calving date value in a year was identified and 21 days were added to her CD value. This value was assigned to all non-calvers for that particular year (Johnson & Bunter (1996); MacGregor (1999)). A restricted maximum likelihood procedure with a multivariate animal model (using REML VCE 4.2.5 package of Groeneveld, 1998) was used to analyse the data. All traits were considered as a trait of the calf. The following effects were included in the model: year of birth (15 levels), month of birth (12 levels) and genotype (352 levels) as fixed effects and dam age as a covariate of CI and AFC. For CD, dam age was not significant in the initial analysis, therefore the rest of the effects were included in the operational model. Interactions were not significant in the initial analysis and therefore were ignored in the operational model.

Results and Discussion
Table 1 presents the heritabilities ($h^2$) and genetic correlations ($r_{g}$). Above the diagonal are the genetic correlations between traits and on the diagonal are the heritabilities.

<table>
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<tr>
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<th>CI</th>
<th>CD</th>
<th>AFC</th>
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<tbody>
<tr>
<td>CI</td>
<td>0.016 ± 0.002</td>
<td>0.025 ± 0.134</td>
<td>0.468 ± 0.089</td>
</tr>
<tr>
<td>CD</td>
<td>0.442 ± 0.008</td>
<td>0.600 ± 0.019</td>
<td></td>
</tr>
<tr>
<td>AFC</td>
<td>0.464 ± 0.012</td>
<td></td>
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The heritability of CI corresponds with that found in the literature. Koots et al. (1994a) reported in his review a $h^2$ of 0.01 for CI (based on three estimates). López de Torre & Brinks (1990) found a $h^2$ of 0.02. The $h^2$ for CD, on the other hand, is unexpectedly high and may be biased. Koots et al. (1994a) reported a mean $h^2$ of 0.08 for CD (based on seven estimates). However, Meacham & Notter (1987), López de Torre & Brinks (1990) and Rege & Famula (1993) also obtained higher $h^2$ values of 0.16, 0.17 and 0.16, respectively. Buddenberg et al. (1990), assigned a penalty score for CD to all non-calvers and obtained a $h^2$ value for CD in first calvers of 0.39. Thus, the penalty score effect may be the reason for the higher $h^2$ value for CD obtained in this study. Rege & Famula (1993), found a low negative $r_g$ of $-0.06$ between CI and CD while Koots et al. (1994b) reported a $r_g$ of $-0.83$ between CI and CD. The $r_g$ between CI and CD in this study was not significant. AFC’s $h^2$ of 0.464 also corresponds with some of the $h^2$ values found in the literature. Kassab (1995), Singh et al. (1996) and Magana & Segura (1997) obtained $h^2$ values of 0.46, 0.36 and 0.46, respectively for AFC. Singh et al. (1996) also found a $r_g$ of 0.68 between AFC and CI. The $h^2$ values for AFC and CD are both high and thus the preferred traits to use in a selection programme, rather than CI. The $r_g$ between AFC and CI, and AFC and CD are moderate. Thus, selection for AFC could lead to an improvement in both CD and CI. Selection for CD could also lead to an improvement in AFC. AFC and CD are both traits that are easy to measure and both can be measured early in an animal’s productive life. Selection for CD does have additional advantages over CI and AFC, as was discussed by Bourdon & Brinks (1983), Buddenberg et al. (1990), López de Torre & Brinks (1990), Marshall et al. (1990) and MacGregor (1995).

**Conclusions**

The $h^2$ of CD and the $r_g$ between CD and AFC found in this study, and the additional advantages of CD, suggest that CD is the preferable trait to include in a reproduction selection programme rather than AFC and CI.

**References**