Relationships between early growth traits in the Elsenburg Dormer sheep stud

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Correlations were estimated from a total of 7740 lamb records, collected from 1943 to 1990, from the progeny of 215 sires of the registered Elsenburg Dormer sheep stud. Phenotypic correlations were generally positive and medium to high except for a very small negative correlation (-0.06) between birth weight (BW) and Kleiber ratio (KL) (ADG/WW0.75). A moderate negative genetic correlation (-0.279) between BW and KL was obtained. The estimated genetic correlations between weaning weight (WW), average daily gain (ADG), and KL were close to unity and had small standard errors. Correlated responses in WW and ADG associated with a 10% increase in KL were 20.4% and 24.6%, respectively. Birth weight is also expected to decrease by 7.5% with an increase of 10% in KL. A curvilinear model was fitted to represent the relationship between WW and KL. The results suggest that animals should initially be culled on low WW and finally selected on important post-weaning traits.

Introduction
The first step in genetic improvement of production efficiency in a population is to identify suitable selection criteria. Apart from heritabilities and variation of each trait, knowledge of how selection for one trait will influence others is needed. This is important since unfavourable correlated responses could render improvement in a specific trait undesirable as far as total economic value is concerned. Also, if genetic improvement in a trait does not increase efficiency of production, this improvement is really of no economic consequence. Efficiency of feed conversion is difficult, if not impossible, to measure under range conditions. The Kleiber ratio (growth rate/metabolic weight) has been suggested as an approximation of feed conversion efficiency under these conditions (Kleiber, 1936; Roux & Scholtz, 1984; Scholtz, 1985; Scholtz & Roux, 1988).

The purpose of this study was to investigate phenotypic, genetic and environmental correlations among early growth traits, including the Kleiber ratio, in the Elsenburg Dormer sheep stud. It is also estimated how improvement in any one trait should affect others in an effort to suggest a suitable selection strategy.

Material and Methods
Data
After editing, a total of 7740 lamb records from the Elsenburg Dormer sheep stud, the progeny of 215 sires, born from 1943 to 1990 were available for analysis. The data were edited to exclude the following:
(i) sires with less than seven progeny,
(ii) records of stillborn lambs, and
(iii) incomplete records.

Details of the history, management and selection practices of the animals have been described by Van Wyk et al. (1993a). The data analysed consisted of records on birth weight (BW), weaning weight (WW), average daily gain (ADG) and Kleiber ratio (KL). WW was adjusted to a 100-day equivalent and ADG was calculated from birth to weaning (0—100 days). The KL was calculated as ADG/WW0.75.

Statistical analysis
Data were analysed using least-squares procedures as described by Harvey (1988). The following linear mixed model was fitted to the data:

\[ Y_{ijklmn} = \mu + h_j + a_k + s_t + p_m + r_i + bX + e_{ijklmn} \]

where \( Y_{ijklmn} \) = an observation of a trait on the \( n^{th} \) individual of the \( i^{th} \) sire of the \( m^{th} \) dam age group born in the \( j^{th} \) year—season, \( \mu \) = overall mean, \( h_j \) = fixed effect of the \( j^{th} \) year—season, \( a_k \) = fixed effect of the \( k^{th} \) age of dam (\( k = 2, \ldots, 9 \) and older),

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phenotypic, genetic and environmental correlations are given however, Martin BW over a period of 20 years was reported (Lasslo et al., 1991) for Afrino sheep. Since genetic correlations between WW, ADG and KL are very high, it seems advisable that only one of the traits should be included in a breeding programme.

Increased WW has been an important selection objective among many sheep meat producers since it is a reflection of the animal’s value at marketing age. In addition, it is relatively simple to measure and is positively correlated with efficiency of feed conversion (Scholtz & Roux, 1984). In spite of these advantages, selection for WW may result in unwanted correlated responses such as a decrease in lamb survival and ewe fertility (Lasslo et al., 1985) and an increase in fatness, especially at later ages (Roberts, 1979). Increases in the amount of food consumed, as an indirect consequence of direct selection for size and growth rate (Roberts, 1979), may result in the breeding of gluttons which become overfat as they grow older and this may adversely affect fertility (Scholtz & Roux, 1984).

From reports of long-term selection experiments in sheep, it is evident that, although direct selection for WW was successful, correlated increases in BW and mature body weights were unfortunately also observed (Pattie, 1965; Lasslo et al., 1985). When no correlated increase in total weight of lamb weaned occurred, the authors concluded that selection on WW alone was not likely to improve the production efficiency of a sheep breeding enterprise. If this is true for the Elsenburg Dormer stud, it necessitates investigation of alternative selection criteria. The KL as a possible measure of efficiency was therefore included as an additional trait in this study.

The use of the KL as indirect selection criterion for efficiency of feed conversion under field conditions has potential advantages as outlined by Roux & Scholtz (1984), Scholtz & Roux (1988) and Bergh (1990). As alternative to direct selection, substantial gains can be achieved by indirect selection for a correlated trait when the heritability of the trait under selection is higher than that of the trait to be improved and the genetic correlation between the two traits is high. From Table 1 it is clear that selection for KL is not likely to cause undesired correlated responses in early growth traits. In fact, the correlated responses in WW and ADG associated with an increase of 10% in KL are 20.4% and 24.6%, respectively (Table 2). Also, BW is expected to decrease by 7.5% with an increase of 10% in KL. These results are in accordance with the results obtained by Bergh (1990) in beef cattle. However, the final decision of including KL in a breeding programme also depends on its heritability (h2) and existing variation. With a heritability of 0.13 and a coefficient of variation (CV) of 7.5%, it is most unlikely that large improvements from selection on the animal’s own phenotype could be expected. Owing to the low heritability of KL, there could be distinct advantages in selection on breeding value based on performance of relatives. This forms part of

### Table 1 Phenotypic ($r_p$), genetic ($r_g$) and environmental ($r_e$) correlations between traits

<table>
<thead>
<tr>
<th>Traits</th>
<th>$r_p$</th>
<th>$r_g$ ($\pm$ SE)</th>
<th>$r_e$</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW × WW</td>
<td>0.356</td>
<td>0.163(0.140)</td>
<td>0.381</td>
</tr>
<tr>
<td>ADG</td>
<td>0.220</td>
<td>0.010(0.144)</td>
<td>0.249</td>
</tr>
<tr>
<td>KL</td>
<td>-0.060</td>
<td>-0.279(0.138)</td>
<td>0.030</td>
</tr>
<tr>
<td>WW × ADG</td>
<td>0.990</td>
<td>0.988(0.003)</td>
<td>0.990</td>
</tr>
<tr>
<td>KL</td>
<td>0.894</td>
<td>0.888(0.030)</td>
<td>0.895</td>
</tr>
<tr>
<td>ADG × KL</td>
<td>0.942</td>
<td>0.943(0.016)</td>
<td>0.942</td>
</tr>
</tbody>
</table>

* BW = birth weight; WW = weaning weight; ADG = average daily gain; KL = Kleiber ratio.
Table 2 Percentage change in one trait with an increase of 10% in another trait

<table>
<thead>
<tr>
<th>% Change in:</th>
<th>Increase of 10% in</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>BW</td>
</tr>
<tr>
<td>Birth weight (BW)</td>
<td>–</td>
</tr>
<tr>
<td>Weaning weight (WW)</td>
<td>1.39</td>
</tr>
<tr>
<td>Average daily gain (ADG)</td>
<td>1.58</td>
</tr>
<tr>
<td>Kleiber ratio (KL)</td>
<td>-1.04</td>
</tr>
<tr>
<td>CV (%)</td>
<td>20.12</td>
</tr>
<tr>
<td>$h^2$</td>
<td>0.121</td>
</tr>
</tbody>
</table>

* Van Wyk et al. (1993a).
* Van Wyk et al. (1993b).

the subject of a later study. Another practical disadvantage of KL, as with ADG, is that BW, which is seldomly recorded under commercial sheep farming conditions, is needed.

WW is, however, a simple measurement normally recorded and, to investigate its possible application in phenotypic selection, its relationship with KL was further investigated by calculating the regression of KL on WW. The results are presented in Figure 1.

Figure 1 illustrates how KL increased with an increase in WW but that the relationship was curvilinear. A third-order regression produced a good fit (adjusted $R^2 = 0.8643$). The lower weaning weights produced a steeper slope and were also associated with a larger variation in KL. This implies that selection pressure would be more effective in changing mean KL in the stud if it is merely directed at culling animals with low WW records rather than selection of animals with the highest possible WW. Setting an independent lower limit culling level for WW should be more effective than including it in a selection index when other traits are included in selection. If selection is to be made on WW alone, the selection intensity of especially sires can be decreased. This will inevitably decrease the rate of progress but could lead to higher total response by increasing effective population size (Falconer, 1989).

Conclusions
From the results obtained in this study, as well as from results reported in the literature, each of the early growth traits studied presents possible problems or limitations in selection if efficiency of production is defined as goal. If KL is accepted as a measure of efficiency, the most practical recommendation would seem that the animals should initially be culled on low WW, a trait normally recorded, and then finally selected on important post-weaning traits.

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References


