Relationships between early growth traits in the Elsenburg Dormer sheep stud

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Received 19 March 1992; accepted 9 December 1992

Correlations were estimated from a total of 7 740 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) ($ADG/WW^{0.75}$). 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.

Korrelasies is bereken op 'n totaal van 7 740 lamrekords wat vanaf 1943 tot 1990 ingesamel is vanaf die nageslag van 215 ramme van die Elsenburg Dormerskaapstoet. Fenotipiese korrelasies was in die algemeen positief en matig tot hoog met die uitsondering van 'n lae negatiewe verwantskap (–0.06) tussen geboortegewig (GW) en Kleiberverhouding (KV) ($GDT/SW^{0.75}$). Insgelyks is 'n matig negatiewe genetiese korrelasie (–0.279) tussen GW en KV gevind. Genetiese korrelasies tussen speengewig (SW), gemiddelde daaglikse toename (GDT) en KV was baie hoog met lae standaardfoute. Verwagte gekorreleerde responsies in SW en GDT met 'n 10% verhoging in KV was 20.4% en 24.6%, onderskeidelik. Voorts word 'n afname van 7.5% in GW met 'n toename van 10% in KV verwag. 'n Kromlynige model is gepas om die verwantskap tussen SW en KL weer te gee. Die resultate dui daarop dat diere voorlopig op lae SW uitgeskot, en finale seleksie op belangrike na-speense eienskappe gedoen moet word.

Keywords: Dormer sheep, early growth traits, genetic and phenotypic correlations.

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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 7 740 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 $ADG/WW^{0.75}$.

Statistical analysis

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

$$Y_{ijklmn} = \mu + h_j + a_k + s_l + p_m + r_i + bX + e_{ijklmn}$$

where Y_{ijklmn} = an observation of a trait on the n^{th} individual of the i^{th} sire of the m^{th} birth status of the l^{th} sex of the k^{th} dam age group born in the j^{th} year–season,

μ = 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, ..., 9 and older),

s_l = fixed effect of the l^{th} sex (l = 1, 2),
p_m = fixed effect of the m^{th} birth status (m = 1, 2, 3),
r_i = random effect of the i^{th} sire with zero mean and variance $I\sigma^2_r$,
bX = linear regression of the appropriate deviation from the mean of individual inbreeding, and
e_{ijklmn} = random error with zero mean and variance $I\sigma^2_e$.

The expected (correlated) response (CR) in one trait (Y) when selection is applied to another trait (X) was calculated by the following formula as described by Falconer (1989) and further deduced by Bergh (1990) (the percentage change in one trait with an increase of 10% in the other is estimated):

$$CR_y/Y = 10 r_g \sigma_{gy} X / \sigma_{gx} Y$$

where r_g = genetic correlation between traits,
σ_{gx} and σ_{gy} = genetic standard deviation of traits X and Y, respectively, and
X and Y = least-squares mean of traits X and Y, respectively.

Results and Discussion

Phenotypic, genetic and environmental correlations are given in Table 1. Phenotypic correlations between live weights and average daily gain were positive and medium to high. A very small negative association between BW and KL was observed. These results correspond in both sign and magnitude to results reported for Afrino sheep (Badenhorst *et al.*, 1991).

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

Traits[a]	r_p	r_g (± *SE*)	r_e
BW × WW	0.356	0.163(0.140)	0.381
ADG	0.220	0.010(0.144)	0.249
KL	–0.060	–0.279(0.138)	0.030
WW × ADG	0.990	0.988(0.003)	0.990
KL	0.894	0.888(0.030)	0.895
ADG × KL	0.942	0.943(0.016)	0.942

[a] BW = birth weight; WW = weaning weight; ADG = average daily gain; KL = Kleiber ratio.

The genetic correlations estimates of BW with WW and ADG were found to be small. This result is in agreement with those of Chopra & Acharya (1971) and Mavrogenis *et al.* (1980). However, the result is unreliable because of the large standard errors (*SE*) of the estimates. Contrary to this, however, Martin *et al.* (1980), Boujenane & Kerfal (1990) and Badenhorst *et al.* (1991) reported high genetic correlations between BW and WW and BW and ADG. In a selection experiment for WW in Targhee sheep, a significant increase in BW over a period of 20 years was reported (Lasslo *et al.*, 1985). The moderate negative genetic correlation between BW and KL (–0.279) agrees with the negative relationship between these traits found by Bergh (1990) in beef cattle. These results generally imply that selection for KL would result in lower birth weights or would at least keep it from increasing.

The genetic correlations between WW, ADG and KL were close to unity and had small *SE* values (Table 1), which suggest that selection for one trait would be very similar to selection for the other. The high estimates further reflect the part–whole relationships among them. These results are in close agreement with those reported by Bergh (1990) for beef cattle and Badenhorst *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 of 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 (h^2) 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 2 Percentage change in one trait with an increase of 10% in another trait

	Increase of 10% in			
% Change in:	BW	WW	ADG	KL
Birth weight (BW)	–	1.91	0.10	–7.49
Weaning weight (WW)	1.39	–	8.70	20.38
Average daily gain (ADG)	1.58	11.23	–	24.60
Kleiber ratio (KL)	–1.04	3.87	3.62	–
CV (%)[a]	20.12	19.01	20.78	7.53
h^2 [b]	0.121	0.120	0.126	0.132

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

Acknowledgement

The authors thank the Director, Winter Rainfall Region, Department of Agricultural Development and the National Mutton Sheep Performance and Progeny Testing Scheme for kind permission to use the data.

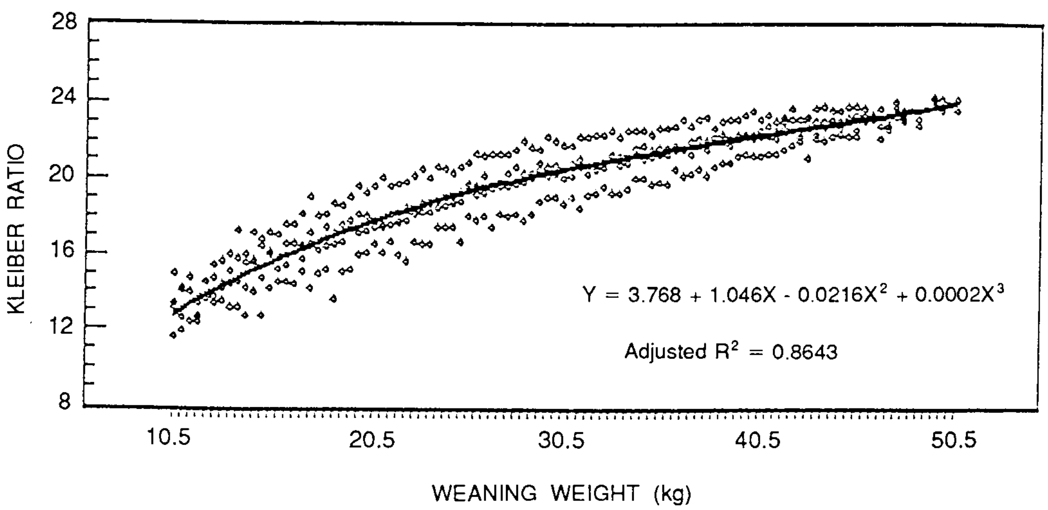

Figure 1 Relationship between Kleiber ratio and weaning weight.

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