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Genetic and environmental sources of variation in hogget fleece weight and live weight in Coopworth sheep

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ABSTRACT

Hogget fleece weight (HFW) (n=10376) and live weight (HLW) records (n=5930) from a highly fecund Coopworth flock were analysed by least squares methods to obtain estimates of environmental effects, heritabilities and genetic and phenotypic correlations.

Single-born ewe hoggets were 2.7kg heavier than twins and 4.0kg heavier than triplets, and HFW differences were 0.07kg and 0.13kg respectively. Single-born ram hoggets were 2.9kg heavier than twins and 4.3kg heavier than triplets, HFW differences being 0.04kg and 0.10kg, respectively. Ewe hoggets reared by 3, 4 and 5 year old dams were 0.7, 1.2 and 1.4kg heavier than those reared by 2 year old dams, and the corresponding estimates for ram hoggets were 0.6, 1.8 and 1.3kg. Dam age did not significantly affect HFW; linear regression coefficients of the traits on age were 0.003kgd⁻¹ (ewes) and 0.006kgd⁻¹ (rams) for HFW, and 0.04kgd⁻¹ and 0.08kgd⁻¹ for HLW. The regression of HFW and HLW was 0.02kgkg⁻¹.

Heritability estimates (from paternal half-sib analyses) for HFW were 0.52±0.05 (ewes) and 0.22±0.04 (rams), while HLW heritability estimates were 0.26±0.05 and 0.21±0.06. Genetic correlation estimates were 0.21±0.15 (ewes), -0.33±0.18 (rams) and 0.03±0.14 (combined-sex), while phenotypic correlation estimates ranged from 0.27 to 0.40.

Keywords Fleece weight; live weight; Coopworth; heritability; genetic correlation; environmental effects; sheep; wool.

INTRODUCTION

Hogget fleece weight (HFW) and hogget live weight (HLW) are important selection criteria, and as such have been included in selection indices for dual-purpose sheep breeds (Elliott and Johnson, 1976; Clarke and Rae, 1977). HFW has a relatively high heritability, and repeatability estimates have ranged from 0.4 to 0.7 (Rae, 1982), so that selection for high HFW can lead to improved lifetime fleece production from both the selection individuals themselves and their progeny. Selection for high HLW can improve weaning weight, through positive genetic correlations, and improve ewe fertility through positive (but low) genetic and phenotypic correlations (Ch'ang and Rae, 1970, 1972; Baker *et al.*, 1979).

In order to maximise genetic progress from selection, the phenotypic records of animals must reflect their underlying genotypic values as accurately as possible. This is the reasoning behind correction for identifiable non-genetic effects. Accurate estimates of heritabilities, phenotypic and genetic correlations are also essential in order that genetic progress from index selection is maximised (Eikje, 1975).

Most published estimates of the above parameters for New Zealand breeds have originated from Romney sheep (Rae, 1958; Tripathy, 1966; Ch'ang and Rae, 1970, 1972; Baker *et al.*, 1974; Baker *et al.*, 1979). A few studies have provided data from Perendale sheep (Elliott, 1975; Elliott *et al.*, 1979), while only one major study (Hight and Jury, 1971) has presented estimates of environmental correction factors and genetic and phenotypic parameters for HFW and HLW in Border

Leicester x Romney and Coopworth sheep which comprise approximately 15% of New Zealand's sheep numbers. This paper discusses the magnitudes of environmental effects on HFW and HLW in a highly fecund Coopworth flock, and genetic and phenotypic parameters relating to these 2 traits.

MATERIALS AND METHODS

Animals

The records analysed were from animals born between 1963 and 1983 inclusively in the Lincoln College Coopworth flock, this being one of the breed's foundation flocks. Selection has been primarily for high fecundity, with some emphasis on fleece weight and grade (I.E. Coop, personal communication).

Records were available for varying numbers of years, depending on the trait and sex being considered. Ewe HFW data were available for 20 years (6491 animals), ram HFW data for 8 years (3885 animals), ewe HLW data for 10 years (3624 animals) and ram HLW data for 5 years (2306 animals). Seventy one % of the animals in this study were born as twins, and 12% as triplets. In addition to birth rank, each animal's birthdate, sire and dam were recorded, but rearing rank data were not available.

Measurements

HFW was measured as the total weight of greasy fleece wool (less belly wool and pieces) grown between 4 months and 11 months for rams, and between 4

months and 13 months for ewes. HLW was usually recorded within a week prior to hogget shearing.

Analysis

The data were analysed by least squares methods (Harvey, 1977). The linear models included a random effect, sires, with heritabilities and genetic and phenotypic correlations being estimated from variance and covariance components due to sires (paternal half-sib analysis). Fixed effects (year of birth, birth rank, dam age, regression on birthday) were included in the models if they proved significant at the 5% level. HLW was included as a covariate for HFW in some models. Interactions between main effects were included when significant at the 1% level.

RESULTS AND DISCUSSION

Environmental Effects

Hogget fleece weight

Mean HFW was 0.78kg greater in ewes than in rams (Table 1). However, this was probably a reflection of shearing date, ewes being shorn later, and of grazing mob.

Birth rank accounted for only 0.2 to 0.4% of the total sums of squares for HFW in across-year models, but within individual years accounted for 1 to 2% of variation. Fleeces from triplets were, on average, 0.13kg (ewes) and 0.10kg (rams) lighter than those from singles. These correspond to differences in expected breeding value for HFW of 0.04kg and 0.03kg, assuming a heritability of 0.30. Removal of this source of bias through use of correction factors would increase accuracy of selection, and hence the rate of genetic progress in HFW. It is likely that correction factors would increase accuracy of selection, and hence the rate of genetic progress in HFW. It is likely that correction factors even greater than those presented here would be necessary for animals which are reared, as well as born, as triplets—many of the triplet-born animals in this study may actually have been reared as twins or singles, which would be expected to reduce their birth handicap.

Dam age did not significantly affect HFW in this flock. Although other authors have found significant effects of dam age (Tripathy, 1966; Elliott *et al.*, 1979; McCall and Hight, 1981), the effects have generally been small except when due to yearling dams.

About 1% of within-year variation in HFW was accounted for by regression on birthday. The coefficients presented here are somewhat smaller than published estimates, which have been about 0.01kgd⁻¹ (Tripathy, 1966; Hight and Jury, 1971; Baker *et al.*, 1974). The coefficients also differed significantly between years, so that within-year estimation might be necessary.

The regression of HFW on HLW was similar for both sexes, at 0.02kgkg⁻¹. When this effect was included

in the model, the birth rank effect became non-significant, and year and regression on birthday became less significant sources of variation in HFW. Consequently, correcting for HLW could be an alternative to correcting HFW for non-genetic effects. Such a method of correction might also lead to increased wool growth efficiency, through selection of animals which have a high wool production/unit body weight. However, long-term effects on HLW are difficult to predict. Elliott and Johnson (1976) suggested that corrections should only be made for effects which are completely environmental in origin. Nevertheless, if HFW is the sole or major selection objective, and changes in HLW are considered unimportant, then animals could justifiably be selected for live weight-corrected HFW. A very important consideration is that this correction method could be used by all commercial farmers to effect improvement in fleece weight whereas correction for birthday and birth rank is generally restricted to recorded stud flocks.

Hogget live weight

Ram hoggets were heavier than ewes (Table 1), although they were weighed 2 months earlier. This was probably due in part to their higher growth potential, but also to preferential feeding of rams to prepare them for sale. Birth rank affected HLW of rams and ewes similarly, and accounted for 3 to 5% of within-year HLW variation. Dam age significantly affected HLW, the correction factors being generally similar in magnitude to those found by other authors (Tripathy, 1966; Ch'ang and Rae, 1970; Hight and Jury, 1971; Baker *et al.*, 1974; Elliott *et al.*, 1979). However, the dam age correction factors differed between sexes (Table 1), and there was a significant interaction between dam age and year for ewe HLW. Regression coefficients of HLW on age also differed between sexes, and differed significantly between years. These observations suggest that within-year correction may be necessary in order to increase the accuracy of breeding value estimation. Such specific corrections are likely to be used in Sheepplan (the New Zealand national sheep recording scheme) when BLUP techniques become available (STG Subcommittee, 1985).

As for HFW, the regression of HLW on age was twice as great for rams as for ewes, the coefficient of 0.04kgd⁻¹ for ewe HLW being slightly lower than other estimates in the literature. The higher coefficient for rams would be expected because of their greater growth potential, and indicates that separate corrections of HLW for age should be used for rams and ewes.

Heritabilities, Genetic and Phenotypic Correlations

Heritabilities of both HFW and HLW were higher in ewes than rams (Table 2) because of a higher genetic variance component (VG) in ewe HLW. Higher heritabilities for HFW and HLW in ewes have also

TABLE 1 Least squares estimates of environmental effects on hogget fleece weight (kg) and hogget live weight (kg).

	Hogget fleece weight		Hogget live weight	
	Ewe	Ram	Ewe	Ram
Mean	2.94	2.16	45.4	54.3
Standard deviation)	(0.80)	(0.44)	(7.4)	(11.0)
Year—range (number)	2.44 (20)	0.82 (8)	14.9 (10)	21.5 (5)
Birth rank 1-2	0.07	0.04	2.66	2.87
3-2	-0.06	-0.06	-1.31	-1.38
Dam age 3-2	-0.01 NS	0.03 NS	0.69	0.64
4-2	0.00 NS	0.04 NS	1.16	1.79
5-2	0.00 NS	0.03 NS	1.39	1.27
Birthday regression (kgd ⁻¹)	-0.003	-0.006	-0.04	-0.08
HLW regression* (kg kg ⁻¹)	0.023	0.021		

$P < 0.001$ for all effects except: NS non-significant

* From models which included only those environmental effects which were significant following inclusion of HLW as a covariate.

been reported by Kyle and Terrill (1953), Young *et al.*, (1960), Baker *et al.*, (1979) and Blair (1981). Baker *et al.* (1979) attributed the higher heritabilities in ewes to higher VG and lower VE for both HLW and HFW. Blair *et al.* (1985) calculated higher realised heritabilities of HFW in ewes than rams.

Realised heritabilities for HFW have tended to be lower than those estimated by analysis of covariance between relatives with values for Romneys being 0.10 to 0.17 (Blair *et al.*, 1985) and 0.19 (Johnson, 1981). Estimates from analysis of covariance have ranged from 0.04 (McMahon, 1943) to 0.61 (Chopra, 1978), and the estimates from this analysis fall within this range. Dalton and Rae (1978) suggested that the median value was about 0.30, which is the value currently used in Sheeplan (Clarke and Rae, 1977).

HLW heritability estimates have generally been greater than those presented in Table 2 and range from 0.22 (Baker *et al.*, 1974) to 0.51 (Ch'ang and Rae, 1970), while Sheeplan uses a value of 0.35 for the heritability of spring live weight (Clarke and Rae, 1977). Johnson (1981) calculated a realised heritability of 0.23.

The combined-sex estimate of the genetic correlation between HFW and HLW was effectively

zero (Table 3). However, the within-sex estimates were significantly different from one another, and opposite in sign. The negative estimate for rams was consistent over most years, and is difficult to interpret. No comparisons of within-sex estimates exist in the literature, although Baker *et al.*, (1979) stated that genetic correlations were generally higher in ewes than rams. Combined-sex estimates have ranged from -0.07 (Elliott *et al.*, 1979) to 0.54 (Tripathy, 1966) for New Zealand crossbreds.

Positive correlated responses in HLW following selection for HFW, ranging from 0.2 to 0.7%/year, were observed by Johnson (1982), Clarke (1982) and Blair *et al.* (1985). Johnson (1981) calculated a realised genetic correlation of 0.24. The Sheeplan dual-purpose breed selection index incorporates a genetic correlation estimate of 0.30 (Clarke and Rae, 1977).

Phenotypic correlations between HFW and HLW were positive for both sexes (Tables 3), in agreement with other studies, and the combined-sex estimate of 0.40 is the same as that used in Sheeplan (Clarke and Rae, 1977). Estimates in the literature have been more consistent than genetic correlation estimates, ranging from 0.39 (Elliott *et al.*, 1979) to 0.61 (Tripathy, 1966).

TABLE 2 Estimates of the genetic (VG), environment (VE) and phenotypic (Vp) components of variance and heritabilities (h²) for hogget fleece weight and hogget live weight.

Trait	Sex	d.f.	VG	VE	Vp	h ² ± SE
HFW	Ewe	200	0.095	0.088	0.183	0.52 ± 0.05
	Ram	105	0.023	0.084	0.107	0.22 ± 0.04
HLW	Ewe	104	6.2	17.8	24.0	0.26 ± 0.05
	Ram	70	6.6	25.3	31.9	0.21 ± 0.05

TABLE 3 Estimates of genetic and phenotypic correlations between hogget fleece weight and hogget live weight.

Sex	Genetic correlation \pm SE	Phenotypic correlation
Ewe	0.21 \pm 0.15	0.27
Ram	-0.33 \pm 0.18	0.27
Combined	0.03 \pm 0.14	0.40

CONCLUSIONS

Environmental effects can reduce the accuracy of selection based on HFW and HLW records, and can therefore reduce rates of genetic progress in fleece production, live weight and possibly ewe fertility. Gains are possible through correcting HFW and HLW for birth rank and birthday, and correcting HLW for dam age. Correction of HFW and HLW records for birth rank may also increase genetic progress in fertility under index selection: twins and triplets have high breeding values for fertility, but their overall index rankings tend to be lowered by birth rank effects on HFW and HLW. Environmental effects were not always consistent across sex and birth year classes, and differed from some of those found in other studies. It is suggested that flock \times year \times sex specific adjustments would be advantageous when numbers of animals are sufficient to allow accurate estimation of correction factors.

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