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Estimates of environmental effects and genetic parameters for live weights and fleece traits of Angora goats

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ABSTRACT

Three data sets comprising 2329, 2102 and 720 Angora goats sired by 30, 29 and 17 bucks used in the Land Corporation's Waitangi Angora flock, were used to obtain estimates of the effects of age of dam, sex, rearing rank and birth day (age). Characters studied (and years of birth) in the three data sets were: Set 1: weaning weight and 12- month fleece weight (1978-1986); Set 2: 6-month fleece weight and yearling fleece weight (the sum of both 6- and 12-month fleece weights; 1978-1985); Set 3: 12-month live weight and 12-month fibre measurements of fibre diameter, standard deviation of fibre diameter, percent medullation and percent kemp (1984-1986).

The weaning weights of kids out of dams aged 3, 4, 5 and 6+ years were heavier than those out of 2-year-old dams by 0.7, 1.0, 1.5 and 1.8 kg respectively ($P<0.001$). Corresponding differences in 6-month fleece weight were 0.01, 0.02, 0.03 and 0.03 kg ($P<0.05$). Age-of-dam effects were variable for 12-month live weight and arcsine-transformed percent kemp, and nonsignificant for the remaining traits studied. Males had heavier live weights and fleece weights than females ($P<0.001$), but differences between the sexes were generally small for the fibre measurement traits. Multiple-reared kids (and later-born kids) had significantly lighter live weights and fleece weights than single- reared kids (and earlier-born kids). Both rearing rank and birth day effects were generally small and not significant for the fibre measurement traits.

Heritability estimates for weaning weight, 6-, 12-month and yearling fleece weights, 12-month live weight, fibre diameter and standard deviation of fibre diameter were respectively 0.10, 0.24, 0.25, 0.36, 0.24, 0.51 and 0.21. Arcsine transformation of percent medullation and percent kemp data yielded heritabilities of 0.16 and 0.02 respectively. Subject to the limited number of sires represented in the data sets studied, genetic correlations between 12-month fleece weight and the two live weight traits were negative and of medium magnitude. There were also strong positive genetic correlations between 12-month fleece weight and both fibre diameter and arcsine- transformed percent kemp. Phenotypic correlations among live weight, fleece weight, and fibre diameter traits were all positive and of medium to high magnitude. Corresponding correlations with arcsine-transformed percents medullation and kemp were generally small and positive.

It was concluded that direct incorporation of the genetic and phenotypic parameter estimates obtained in this study into selection index calculations, could not be advocated without due attention to the limited sample sizes and associated errors of estimation.

Keywords Angora goats; environmental effects; heritabilities; genetic correlations; phenotypic correlations; live weights; fibre traits

INTRODUCTION

Only a limited amount of information on environmental effects and genetic parameters for traits of economic importance in the Angora goat industry exists in the New Zealand and overseas literature. Preliminary estimates of environmental effects and some genetic parameters for weaning weight and fleece weights of young Angora goats in a New Zealand flock were presented by Nicoll (1985).

The objective of this study was to update estimates of environmental effects and genetic parameters for the above traits, as well as to provide preliminary estimates for live weight and fibre measurements taken at 12 months of age.

MATERIALS AND METHODS

Data for the study came from the Waitangi Angora flock of the Land Corporation Limited. Statistical analyses used the Restricted Maximum Likelihood technique (Patterson and Thompson, 1971) to fit the fixed effects of year of birth, age of dam (2, 3, 4, 5, 6+ years), sex, rearing rank (single, multiple) and a covariate of birth day (age), as well as a random sire effect. Heritabilities were estimated by the paternal half-sib method.

Three data sets from the flock were used

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depending on the traits studied. In the first data set, 2072 and 2329 records for weaning weight and 12-month fleece weight respectively (representing 30 sires), were used from animals born 1978 to 1986 inclusive. Apart from estimates of environmental effects, the heritabilities and genetic and phenotypic correlations between these two traits were estimated.

The second data set involved 2102 animals born 1978 to 1985 inclusive (representing 29 sires), for 6-month fleece weight and yearling fleece weight (the sum of 6- and 12-month fleece weights). Heritabilities and genetic and phenotypic correlations between these two traits were estimated, as well as their correlations with weaning weight and 12-month fleece weight records present in this data set.

The third data set involved 720 animals (representing 17 sires), born 1984 to 1986 inclusive, with records on 12-month live weight, and measured mean fibre diameter, standard deviation of fibre diameter, percent medullation and percent kemp. Fleece samples were taken from the mid-side of each animal at the 12-month shearing, and analysed in the fibre laboratory of Whatawhata Hill Country Research Station. Percent medullation and percent kemp data exhibited skewed distributions which necessitated arcsine transformation. Heritabilities were calculated, and all genetic and phenotypic correlations among the paired combinations were estimated for the above traits, as well as for the corresponding weaning weight and 12-month fleece weight records in this data set. Insufficient records were available to estimate correlations with either 6-month or yearling fleece weights.

RESULTS

Relative to kids out of 2-year-old dams, those out of dams aged 3, 4, 5, and 6+ years had heavier weaning weights by 0.7, 1.0, 1.5, and 1.8 kg respectively ($P<0.001$) (Table 1). Corresponding differences in 6-month fleece weights were 0.01, 0.02, 0.03, and 0.03 kg ($P<0.05$). Kids out of 5-year and 6+ -year-old dams were also heavier at 12 months of age by 0.7 kg ($P<0.10$) and 1.7 kg ($P<0.001$) respectively, compared with kids out of 2-year-old dams (Table 1). Kids out of 4-year-old dams had greater arcsine-transformed percent kemp than those out of 2-year-old dams ($P<0.01$), but differences in the other age-of-dam classes were not significant. Age-of-dam effects were not significant for the other traits studied.

Males were 1.8 and 5.2 kg heavier at weaning and at 12 months of age respectively ($P<0.001$), and had heavier 6-month (0.06 kg), 12-month (0.08 kg) and yearling fleece weights (0.17 kg) compared with females ($P<0.001$) (Table 2). Arcsine-transformed percent kemp in males was significantly lower than that in females. Differences between the sexes in the other fibre

TABLE 1 Estimates of age-of-dam effects (relative to 2-year-old dams) for weaning weight (WW), 6-month (FW6), 12-month (FW12) and yearling (YFW) fleece weights, 12-month live weight (LW12), fibre diameter (FD), standard deviation of fibre diameter (SDFD), and arcsine-transformed percent medullation (AsM) and percent kemp (AsK).

Trait		Number animals	Mean	Age of dam (years) 3-2	4-2	5-2	>6-2	Av sed
WW	(kg)	2072	14.3	0.7***	1.0***	1.5***	1.8***	0.21
FW6	(kg)	2102	0.57	0.01*	0.02*	0.03***	0.03***	0.01
FW12	(kg)	2329	0.99	0.00	-0.01	-0.01	0.00	0.02
YFW[1]	(kg)	2102	1.57	0.01	0.00	0.01	0.02	0.02
LW12	(kg)	720	22.4	0.2	0.3	0.7+	1.7***	0.5
FD	(μm)	719	27.22	-0.26	0.03	0.23	-0.60	0.47
SDFD	(μm)	719	9.68	-0.02	0.09	-0.20	-0.13	0.19
AsM[2]	(°)	720	14.2	0.1	0.5	-0.6	-0.7	0.7
AsK[2]	(°)	720	4.4	0.3	0.9**	0.6	0.6	0.4

[1] YFW = (FW6 + FW12) in this and subsequent tables.
[2] Untransformed mean % medullation = 6.0 and % kemp = 0.6.

TABLE 2 Estimates (and standard errors) of sex, rearing rank and birth day effects for weaning weight (WW), 6-month (FW6), 12-month (FW12) and yearling (YFW) fleece weights, 12-month live weight (LW12), fibre diameter (FD), standard deviation of fibre diameter (SDFD), and arcsine-transformed percent medullation (AsM) and percent kemp (AsK).

Trait		Sex (Male - Female)		Rearing rank (Multiple - Single)		Birth day	
WW	(kg)	1.8	(0.2)***	-1.8	(0.1)***	-0.07	(0.004)***
FW6	(kg)	0.06	(0.01)***	-0.07	(0.01)***	-0.005	(0.0002)***
FW12	(kg)	0.08	(0.02)***	-0.01	(0.01)	-0.002	(0.0003)***
YFW	(kg)	0.17	(0.02)***	-0.07	(0.01)***	-0.007	(0.0004)***
LW12	(kg)	5.2	(0.3)***	-0.6	(0.3)+	-0.10	(0.01)***
FD	(μm)	-0.02	(0.23)	0.25	(0.25)	-0.012	(0.013)
SDFD	(μm)	-0.12	(0.10)	0.03	(0.10)	-0.009	(0.005)+
AsM	(°)	0.1	(0.3)	0.3	(0.4)	0.04	(0.02)+
AsK	(°)	-1.6	(0.2)***	-0.2	(0.2)	0.02	(0.01)

+ $P < 0.10$

measurement traits were not significant.

Relative to kids reared as singles, multiple-reared kids were 1.8 kg lighter at weaning ($P < 0.001$) and had significantly lighter 6-month (0.07 kg) and yearling fleece weights (0.07 kg) (Table 2). Differences in rearing rank approached significance for 12-month live weight (0.6 kg; $P < 0.10$), but were not significant for 12-month fleece weight or the remaining fibre measurements.

As expected, later-born (younger) kids had significantly lighter live weights and fleece weights than earlier-born (older) kids. The standard deviation of fibre diameter measurement was marginally lower (0.009 fm/day; $P < 0.10$), and arcsine-transformed percent medullation slightly higher (0.04 x/day; $P < 0.10$) for younger animals compared with older animals. Age effects were not significant for either fibre diameter or arcsine-transformed percent kemp.

The standard errors of the heritability estimates were large, reflecting the limited numbers of sires represented in the three data sets used in the analyses. Heritability estimates (Table 3) were in the medium to high category for fleece weights, 12-month live weight, fibre diameter and standard deviation of fibre diameter. Low estimates were obtained for weaning weight and arcsine-transformed percents medullation and kemp.

TABLE 3 Genetic and phenotypic standard deviations and heritabilities for weaning weight (WW), 6-month (FW6), 12-month (FW12) and yearling (YFW) fleece weights, 12-month live weight (LW12), fibre diameter (FD), standard deviation of fibre diameter (SDFD), and arcsine-transformed percent medullation (AsM) and percent kemp (AsK).

Trait		Standard deviation Genetic	Phenotypic	Heritability	(se)
WW	(kg)	0.75	2.43	0.10	(0.06)
FW6	(kg)	0.05	0.11	0.24	(0.11)
FW12	(kg)	0.11	0.22	0.25	(0.15)
YFW	(kg)	0.17	0.29	0.36	(0.14)
LW12	(kg)	1.78	3.63	0.24	(0.12)
FD	(μm)	2.34	3.28	0.51	(0.19)
SDFD	(μm)	0.59	1.29	0.21	(0.11)
AsM	(°)	1.90	4.75	0.16	(0.09)
AsK	(°)	0.36	2.86	0.02	(0.04)

Genetic and phenotypic correlation estimates between paired combinations of the traits are shown in Table 4. Correlations between 6-month fleece weight and either 12-month live weight or the four fibre measurement traits were not calculated due to the limited amount of data available (2 years of birth, representing only 9 sires). As a consequence, the corresponding correlations between yearling fleece weight and these same traits were also not calculated. Correlation estimates in excess of unity were obtained for 6-month/12-month fleece weights, 12-month fleece weight / arcsine-transformed

TABLE 4 Genetic (above diagonal) and phenotypic (below diagonal) correlations for weaning weight (WW), 6-month (FW6), 12-month (FW12) and yearling (YFW) fleece weights, 12-month live weight (LW12), fibre diameter (FD), standard deviation of fibre diameter (SDFD), and arcsine-transformed percent medullation (AsM) and percent kemp (AsK).

	WW	FW6	FW12	YFW	LW12	FD	SDFD	AsM	AsK
WW		0.08	-0.29	-0.05	0.53	-0.28	0.37	0.32	0.08
FW6	0.52		-	0.86	-	-	-	-	-
FW12	0.24	0.44		0.67	-0.24	0.98	0.73	-	0.49
YFW	0.40	0.53	0.55		-	-	-	-	-
LW12	0.63	-	0.54			0.19	0.36	0.35	-
FD	0.15	-	0.55	.	0.37		0.78	0.54	0.04
SDFD	0.04	-	0.28	-	0.17	0.50		0.93	0.50
AsM	0.08	-	-0.12	-	0.10	0.32	0.32		0.84
AsK	0.02	-	-0.04	-	0.11	-0.02	0.08	0.07	

percent medullation, and 12-month live weight/arcsine-transformed percent kemp.

DISCUSSION

Environmental Effect Estimates

As expected, age-of-dam effects were significant for those traits expressed at a young age (weaning weight and 6-month fleece weight). The remaining traits studied were based on recordings at 12-months of age, at which time age-of-dam effects would be expected to be of lesser importance. This was the case for all but 12-month live weight, where kids out of dams in the older two dam age classes retained an advantage over kids out of younger-aged dams. Using a subset of the same data in the present study, Nicoll (1985) reported larger estimates of age-of-dam effects for weaning weight and 6-month, 12-month and yearling fleece weights. For example, kids out of dams aged 3, 4, 5 and 6+ years were reported to be heavier at weaning than those out of 2-year-old dams by 1.9, 2.2, 2.0 and 2.5 kg respectively. The smaller age-of-dam differences in the present study probably reflected the lower kid weaning weights, since the mean weaning weight was 14.3 kg compared with 16.2 kg in the earlier study. This was not the case for the fleece weight traits however, where the means in the two data sets were similar.

The magnitudes of the sex-effect differences for live weights and fleece weights were similar to those in a Turkish study cited by Yalcin (1982). In our study, males had significantly heavier live weights and fleece weights than females, but differences between the sexes were small for the fibre measurement traits. Consequently, despite having heavier fleece weights, males did not have a larger fibre diameter than females, nor did they exhibit greater variation in this measurement. This might have been expected in view of the positive correlations observed between 12-month fleece weight and both fibre diameter and the standard deviation of fibre diameter. Sex differences however, would be unlikely to be of concern for traits recorded after weaning since from this time, performance comparisons would be expected to be conducted within (separately managed) sex classes.

In general, the results indicated the importance of adjusting for age of dam, sex, rearing rank and age when records of performance are collected at weaning, or around six months of age. For traits recorded at 12 months of age, assuming comparisons are conducted within sex classes, adjustment for rearing rank and age effects would be necessary for live weight, and for age effects for fleece weight, and (if required), standard deviation of fibre diameter and arcsine-transformed percent medullation.

Genetic Parameter Estimates

The limited number of sires represented in each ofthe traits studied reduces the reliability of the present estimates, as indicated for example by the high standard errors of the heritability estimates (Table 3). Nevertheless, the lack of published estimates of genetic parameters, particularly in the New Zealand literature, was considered justification in providing the results of the present analyses.

In his review, Yalcin (1982) cited Turkish estimates of the heritability of weaning weight and live weight of 0.17 and 0.24 respectively, both of which agreed with the present study (0.10 and 0.24 respectively). Heritability estimates reported for 12-month fleece weight were 0.40 and 0.14 in Texas (Shelton and Bassett, 1970; and Shelton and Snowder, 1983; paternal half-sib method), 0.13 in Turkey (Yalcin, 1982; assumed yearling fleece weight) and 0.45 in Australia (D.R. Gifford, 1988, personal communication). These estimates are variable, reflecting the limited nature of data on Angora goats internationally, but they remain within the standard error range of the estimate of 0.25 in the present study.

The heritability estimate of 0.51 for fibre diameter was larger than the estimates of Shelton and Bassett (1970; 0.11), Yalcin (1982; 0.19), Shelton and Snowder (1983; 0.24) and D.R. Gifford (1988, personal communication; 0.14). The estimate, however, was close to that recorded for down diameter in feral goats (Pattie and Restall, 1987; 0.47) and the average for fibre diameter in Romney and Merino sheep (Nicoll, 1987; 0.52 and 0.50 respectively).

No comparable estimates of the heritability of the standard deviation of fibre diameter, and arcsine-transformed percents medullation and kemp have been reported in the literature on Angora goats. An average heritability of 0.19 (four estimates) for visually-assessed kemp score was reported in the review of Nicoll (1987).

In general the magnitude of the present heritability estimates for 12-month live weight, fleece weight and fibre diameter indicated that these traits would respond to mass selection. Smaller responses to mass selection would be expected for weaning weight, standard deviation of fibre diameter and arcsine-transformed percent medullation. In view of the current emphasis for kemp-free mohair in the New Zealand industry, it was of interest to note that virtually no response would be expected from single-trait selection for freedom from arcsine-transformed percent kemp. There was little genetic variation evident for this trait in the data set analysed.

In view of the limited reliability of the data used in this study, discussion of the genetic and phenotypic correlations (Table 4) is confined to the general magnitude and direction of the estimates. Comparisons with other published estimates are similarly confined.

Negative and low to medium genetic correlations were observed between live weight and fleece weight traits, indicating that selection for heavier fleece weights would result in a marginal reduction in live weight. Phenotypically, live weight and fleece weight were highly positively correlated, in agreement with Shelton and Snowder (1983), Lewis and Shelton (1985) and R.L. Baker (1988, personal communication).

Medium positive genetic correlations were found between both live weight traits, and standard deviation of fibre diameter and arcsine-transformed percent medullation. However, the genetic correlations between the live weight traits, and fibre diameter and arcsine-transformed percent kemp were variable. The low positive genetic correlation and medium positive phenotypic correlation between 12-month live weight and fibre diameter supported the earlier results of Shelton and Bassett (1970), Yalcin (1982), Shelton and Snowder (1983), Gifford *et al.* (1984) and Lewis and Shelton (1985).

While accepting their low reliabilities, the high positive genetic correlations between 12-month fleece weight and the four fibre measurement traits give some cause for concern. The estimates indicated that selection for 12-month fleece weight would result in correlated increases in fibre diameter, variability in measured fibre diameter and arcsine-transformed percent kemp (and percent medullation?). Texan workers reported a positive genetic correlation between fleece weight and fibre diameter (Shelton and Bassett, 1970; Shelton and Snowder, 1983), but Turkish workers reported a negative correlation (Yalcin, 1982). The present study supported previous estimates of the magnitude and direction of the phenotypic correlations between 12-month fleece weight and fibre diameter and percent medullation.

Genetic and phenotypic correlations of fibre diameter with arcsine-transformed percent medullation (medium-high and positive), and with arcsine-transformed percent kemp (low), indicated that the degree of fibre medullation would be expected to decrease with increased selection pressure for finer fibre diameter, but that little change in the transformed percent kemp would occur.

The results of the present study indicate that 12-month fleece weight would respond to single-trait selection, but that this response may be achieved at the expense of improvements in 12-month live weight, fibre fineness, variability of fibre diameter measurement, and the percentages of medullated and kemp fibres. Single-trait selection for fibre fineness, on the other hand, would be likely to result in an improvement of this trait together with reductions in live weight, fleece weight, diameter measurement variability and percentage of medullated fibres. As a consequence, where single trait selection is to be applied in a breeding plan distinction would need to be made between overall animal production-type traits (eg, live weight and fleece weight), and fleece quality-type traits (eg, fibre diameter, medullation and kemp). The relative economic values of an extra kilogram of improvement in fleece weight versus an extra micron reduction in fibre diameter would determine the fleece trait to select for in such a simple breeding programme.

In practice, improvements in reproductive rate, live weight, fleece weight and fibre quality traits would be desirable within the New Zealand Angora Goat Industry, indicating a requirement for index-based selection. Unfortunately estimates of the heritability of female reproductive performance in Angora goats, and of its relationships with other productive traits have not been published to date. In addition, the direct incorporation of the live weight and fleece trait heritability and correlation estimates from this study in the calculation of a selection index cannot be advocated, in view of limited sample sizes and associated errors of estimation. For non-reproductive traits of economic interest (eg, weaning weight, 12-month live weight, 12-month fleece weight and fibre diameter), many of the genetic correlations between them in the present study were of medium to high magnitude. Inclusion of these estimates in index calculations could potentially place more emphasis on indirect selection pathways to predict the breeding objective, a situation that has been suggested by James (1982) to be risky.

In examining the effects of changes in economic weights on the efficiency of index selection, Smith (1983) noted that although both the phenotypic and genetic correlations affected efficiency of selection, the genetic correlations tended to have a more important role. Changes in efficiency were usually larger with unfavourable correlations among the traits. The genetic correlations between a potentially dominating trait such as 12-month fleece weight, and both fibre diameter and 12-month live weight, were medium to high and unfavourable in the present study. The use of such estimates in deriving an index may therefore make the efficiency of the index overly sensitive to changes in economic weightings. This would occur because the index would obtain its response by effectively balancing among the traits. Any upset of this balance, such as changing the economic weightings, would tend to alter the efficiency appreciably.

There is clearly a need for caution in incorporating genetic and phenotypic parameter estimates in selection indexes for Angora goats in New Zealand. The estimates in this study have been presented merely to augment the limited amount of information currently available.

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