ESTIMATES OF GENETIC PARAMETERS FOR DAILY GAIN, FEED INTAKE, AND BEHAVIOR TRAITS IN RAM LAMBS OF A COMPOSITE POPULATION

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INTRODUCTION

Roughly one-half of the cost of ruminant production is associated with feed. James (1986) argued that feed intake should be considered in the selection objective for sheep even if feed intake is not recorded and included in the selection criterion. Electronic collection of feed data in a group setting is becoming more feasible and permits examination of feed behavior traits as well as feed intake. Complex genetic models can now be used to estimate genetic parameters from large data sets. However, precise estimates of genetic and phenotypic parameters for feed intake of sheep have not been published, and development of breeds has not directly considered effects on feed intake and efficiency. The objective of the study was to estimate genetic parameters for daily gain, feed intake, and feeding behavior traits recorded on ram lambs of a terminal sire composite population.

MATERIALS AND METHODS

Population and management. A terminal sire composite population was created in 1980 by mating Columbia rams to Hampshire-Suffolk crossbred ewes (Leymaster, 1991). A relatively large effective population size was maintained thereafter by use of at least 24 sires per year and avoidance of matings among paternal half-sibs. Data were collected on ram lambs managed in Pinpointer units at the USDA Meat Animal Research Center in Clay Center, Nebraska, USA. Eight Pinpointer units were located within an enclosed building. Each unit consisted of an elevated pen with a woven-wire floor, an entrance chute, a scale-feeder unit, and a microprocessor. The entrance chute limited access to the scale-feeder unit to one lamb at a time. Each lamb was electronically identified, allowing measurement of individual feeding events (length and intake) of each lamb in a group situation. An event had to be at least 15 s in length to be recorded.

Ram lambs were weaned at 7 wk of age and randomly sampled within sire groups to be placed into Pinpointer units at 10 wk of age. From 1986 through 1989, ram lambs were grouped 11 per pen, whereas pens contained 9 ram lambs each from 1990 through 1997. These numbers of ram lambs per pen allowed full expression of daily feed intake per ram lamb in previous research (Jenkins and Leymaster, 1987). Pinpointer units were used in two successive periods per year from 1986 through 1989 and once per year thereafter. Ram lambs were offered a pelleted, total-mixed creep diet (2.90 Mcal ME per kg DM with 17.5 % CP) to ensure that protein availability would not limit muscle development. Following 1-wk adaptation to Pinpointer units, weight and feed data were recorded from 11 to 17 wk of age. Ram lambs were weighed on a weekly basis. Data recorded on 1 241 ram lambs by 149 sires were analyzed.

Data editing. A total of 864,960 feeding records were collected. All data recorded on unhealthy animals (3 % of ram lambs), as determined by shepherd's observations and statistical detection of outliers, were deleted. Feeding records that could not be associated with a specific ram lamb were deleted as were records with intake values less that 4.54 g or greater than 1,361 g. It was assumed that the maximum rate of feed consumption was 1.51 g per s (454 g per 5 min). Feeding events with rates of consumption greater than 1.51 g per s were deleted, however, this edit affected less than 0.2 % of data. Likewise, feeding events greater than 40 min in length were set to 40 min, but this editing affected less than 0.3 % of data. Editing decisions deleted about 20 % of the data, leaving 692 027 records.
Records collected on each ram lamb were summarized within each available day. Due to numerous problems associated with electronic collection of data, every ram lamb was missing some daily records during the period from 11 to 17 wk of age. The frequency of missing records and their occurrence during the period varied widely among ram lambs. To address these issues, the 42-d period was divided into three 14-d intervals from d 1 to 14, d 15 to 28, and d 29 to 42. Means of traits were then calculated within each interval using available data and the three interval means then averaged to represent performance over the entire period. Feed and behavior traits were daily feed intake (DFI), event feed intake (EFI), daily time (DT), event time (ET), and daily number of events (DNE). Average daily gain (ADG) of each ram lamb was estimated by regression of weekly weight on weigh date.

Statistical analyses. Fixed effects of age of dam (1, 2, and greater than 2 yr) and type of birth (single, twin, and greater than twin) were investigated in preliminary analyses using the GLM procedure in SAS (SAS Institute, Inc., 1999). These fixed effects remained in the model, regardless of significance, if the residual error variance was reduced relative to exclusion of effects. Estimates of variance and covariance components were obtained by REML using a derivative-free algorithm with the MTDFREML software (Boldman *et al.*, 1995). Random effects were direct genetic, maternal genetic, contemporary group, and residual. There were 124 contemporary groups, defined as ram lambs within a Pinpointer unit. Maternal genetic effects were insignificant for all traits in preliminary analyses and therefore deleted. The final model included fixed effects of age of dam and type of birth and random effects of direct genetic, contemporary group, and residual with the exception that fixed effects were not fitted for DT. Standard errors for single-trait estimates of genetic parameters were calculated using the inverse of the information matrix as described by Dodenhoff *et al.* (1998). Two-trait analyses were done to estimate genetic and phenotypic correlations among DFI, DT, DNE, and ADG.

RESULTS AND DISCUSSION

Table 1 presents means of traits and fractions of phenotypic variance due to direct genetic (heritability), contemporary group (pen), and residual effects. On average, ram lambs ate 16.6 meals per day, lasting 8.54 min per meal, and consuming 124 g of feed per meal. On a daily basis, ram lambs ate 1.69 kg of feed in 1.96 h to gain 0.42 kg of weight. The mean for daily number of meals was similar to values reported for pigs, but pigs spent about half as much time eating as the sheep reported herein, both on a daily and meal basis (e.g. de Haer and de Vries, 1993).
Estimates of heritability were consistent among traits, ranging from 0.25 to 0.33. Standard

errors of heritability estimates were 0.07 or less for each trait. The heritability estimate for feed intake (0.25) tended to be lower than most estimates for cattle but similar to estimates for pigs. Cameron (1988) used several procedures to estimate heritability of feed intake in Texel-Oxford rams, with values ranging from 0.14 to 0.59. The heritability estimate for average daily gain (0.27) was less than most estimates reported for postweaning growth of sheep.

Table 1. Parameter estimates from single-trait analyses [A]

Statistics [B]	DFI(kg)	EFI(g)	DT(h)	ET(min)	DNE	ADG(kg)
$\bar{x}$,	1.69	124	1.96	8.54	16.6	0.42
h^2	0.25	0.33	0.24	0.29	0.33	0.27
c^2	0.14	0.20	0.07	0.31	0.23	0.32
e^2	0.61	0.47	0.69	0.40	0.44	0.42

[A] DFI = daily feed intake, EFI = event feed intake, DT = daily time, ET = event time, DNE = daily number of events, ADG = average daily gain.
[B] $\bar{x}$, = mean, h^2 = direct heritability, c^2 = proportion of phenotypic variance due to contemporary group (pen) effects, e^2 = proportion of phenotypic variance due to residual effects.

Contemporary groups accounted for 7 to 32 % of phenotypic variances with average daily gain and event time influenced more than other traits. Daily traits of feed intake and time were affected less by contemporary group than the corresponding event traits.
Ram lambs produced by older ewes had significantly increased daily and event feed intakes, but age of dam effects on other traits were not significant (results not tabulated). Relative to multiple-born rams, single-born ram lambs ate less often per day but spent more time eating per meal and consumed more feed per meal and per day. Effects of type of birth on daily time and average daily gain were not detected.
The estimate of the genetic correlation between DFI and ADG was 0.80 (table 2), in agreement with estimates of 0.73, 0.70, and 0.71 reported for beef cattle by MacNeil *et al.* (1991), Archer *et al.* (1998), and Jensen *et al.* (1992), respectively. This estimate implies that genetic opportunities to improve efficiency by jointly manipulating feed intake and daily gain are limited and therefore development of effective selection strategies will require use of insightful approaches. Remaining genetic correlations ranged from 0.19 to 0.55, indicating that selection for one or more of these traits is expected to change means of all traits.

Table 2. Estimates of genetic and phenotypic correlations [A]

Trait [B]	DFI	DT	DNE	ADG
DFI		0.27	0.30	0.80
DT	0.09		0.55	0.19
DNE	0.14	0.20		0.34
ADG	0.50	0.09	0.22	

[A] Genetic and phenotypic correlations above and below the diagonal, respectively.
[B] DFI = daily feed intake, DT = daily time, DNE = daily no. of events, ADG = average daily gain.

CONCLUSION

Estimates of direct heritabilities for daily gain, feed intake, and feed behavior traits ranged from 0.24 to 0.33 and all genetic correlations among traits were positive. The genetic correlation of 0.80 between daily gain and feed intake implies limited opportunity to select for improved efficiency. Selection for daily gain and/or feed intake is expected to change feeding behavior.

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