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ABSTRACT

Age-season adjusted records from five breeds of dairy goats on Dairy Herd Improvement test from 1965 to 1976 were used to estimate components of variance for milk yield, fat yield, and fat percentage. The data were 6,452 Alpine, 1,730 LaMancha, 6,897 Nubian, 2,759 Saanen, and 4,007 Toggenberg lactation records. Components of variance were estimated by Henderson's Method 1 with a four-way model that included random effects of herd, year-season, sire, and doe. Herd effects accounted for 22 to 31% of the total variation in milk and fat yields and 15 to 25% of the variation in fat percentage. These effects were large enough to indicate that they must be considered in genetic evaluations of milk and fat production. Sire components of variance were 8 to 10% of the total variation in milk yield, fat yield, and fat percentage. Does accounted for 16 to 25% of total variation in milk yield, fat yield, and fat percentage. Repeatabilities of milk yield, fat yield, and fat percentage varied from .39 to .55 whereas heritabilities also within herd-year-season ranged from .48 to .62. Heritabilities larger than repeatabilities indicate that confounding may have inflated sire effects. Phenotypic and genetic correlations between milk and fat yields averaged .94 and .86. Milk yield and fat percentage were correlated negatively both phenotypically and genetically, whereas genetic correlations between fat yield and fat percentage averaged .18.

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INTRODUCTION

Phenotypic and additive genetic variances as well as heritabilities and repeatabilities derived from variance components are needed for design of effective breeding programs. This report presents variances for herd, year-season, sire, doe, and residual necessary for buck and doe evaluation.

MATERIALS AND METHODS

Data were provided by the USDA Animal Improvement Programs Laboratory. Only normally terminated records of 305 days or less, initiated at 10 mo or more of age, having a herd code, kidding date, birth date, breed, and sire and doe identification were studied. Three seasons of freshening were defined (January through February, March through April, and May through December). Data comprised 6,452 Alpine, 1,730 LaMancha, 6,897 Nubian, 2,759 Saanen, and 4,007 Toggenburg records. These records were corrected to mature equivalent by adjustment for age-season of freshening with multiplicative factors (7). Numbers of records, herds, year-seasons, sires, and does are in Table 1. Components of variance were estimated by Henderson's Method 1. The model for the lactation record of the l^{th} doe, daughter of the k^{th} sire freshening in the j^{th} year-season in the i^{th} herd is

$$y_{ijkl} = \mu + h_i + ys_{ij} + s_{ik} + d_{ikl} + e_{ijkl}$$

where μ is an unknown constant common to all records; h_i is a random effect of the i^{th} herd with mean 0 and variance σ^2_h; ys_{ij} is a random effect associated with the j^{th} year-season within the i^{th} herd, mean 0 and variance σ^2_{ys}; s_{ik} is a random effect of the k^{th} sire in the i^{th} herd, mean 0 and variance σ^2_s; d_{ikl} is a random effect of the l^{th} daughter of the k^{th} sire in the i^{th} herd, mean 0 and variance σ^2_d; and e_{ijkl} is a random error associated with the record, mean

TABLE 1. No. of records, herds, year-seasons, sires, and does per breed.

No.	Alpine	LaMancha	Nubian	Saanen	Toggenburg
Records	6,452	1,730	6,897	2,759	4,007
Herds	745	279	977	417	456
Year-seasons	2,318	810	3,117	1,242	1,471
Sires	2,713	869	3,326	1,227	1,597
Does	4,663	1,333	4,878	2.017	2,690

0, and variance σ_e^2. Covariances between pairs of nonidentical random variables are zero.

Fewer than 8% of the bucks had progeny in more than one herd. Also, no does had more than one record in a year-season. Because of these conditions, random effects of year-seasons and sires were nested within herds.

Heritability, h^2, and repeatability, r, were estimated within herd-year-season by

$$\hat{h}^2 = (4\hat{\sigma}_s^2)/(\hat{\sigma}_s^2 + \hat{\sigma}_d^2 + \hat{\sigma}_e^2)$$

and

$$\hat{r} = (\hat{\sigma}_s^2 + \hat{\sigma}_d^2)/(\hat{\sigma}_s^2 + \hat{\sigma}_d^2 + \hat{\sigma}_e^2)$$

The relationship

$$\text{Var}(A+B) = \text{Var}(A) + \text{Var}(B) + 2\,\text{Cov}(A,B)$$

allows the covariance between any two traits, A and B, to be estimated with the same procedure that estimates variances. Covariances between milk and fat yields, milk and fat percentages, and fat yield and fat percentages were used to estimate genetic and phenotypic correlations.

RESULTS AND DISCUSSION

Components of variance are in Table 2. Herd effects accounted for 22 to 31, 24 to 25, and

TABLE 2. Estimated components of varience for herd, year-season, sire, doe, and residual effects, and total variances for fat fraction and fat and milk yield for five breeds.

	Percent of total					
	Herd	Year-season	Sire	Doe	Residual	Total
Alpine						
Milk (kg)	22.6	12.7	8.2	24.7	31.8	114630
Fat (kg)	24.6	13.8	8.8	25.2	27.6	151.7
Fat (fraction)	15.5	14.1	10.0	18.3	42.1	.290
La Mancha						
Milk (kg)	31.5	15.9	8.6	18.6	25.4	118992
Fat (kg)	24.6	11.0	9.6	22.0	32.8	218.5
Fat (fraction)	22.5	9.9	10.3	17.7	36.6	.514
Nubian						
Milk (kg)	22.7	8.4	10.2	24.0	34.7	89224
Fat (kg)	24.4	9.0	10.8	21.0	34.8	204.9
Fat (fraction)	24.8	10.2	10.8	17.4	36.8	.517
Saanen						
Milk (kg)	22.3	8.6	9.2	23.3	36.6	119315
Fat (kg)	25.2	8.0	8.1	22.4	36.3	163.2
Fat (fraction)	17.5	13.5	10.8	18.9	39.4	.297
Toggenburg						
Milk (kg)	22.3	11.4	9.9	17.9	38.4	96819
Fat (kg)	25.2	10.6	9.4	16.8	37.1	114.4
Fat (fraction)	20.5	13.2	8.9	16.6	40.7	.302

TABLE 3. Estimates of heritability and repeatability within herd and year-season for fat percentage, fat yield, and milk yield.

Breed	Trait	Heritability	Repeatability
Alpine	Milk yield	.49	.51
	Fat yield	.57	.55
	Fat %	.57	.40
LaMancha	Milk yield	.61	.52
	Fat yield	.59	.49
	Fat %	.63	.43
Nubian	Milk yield	.59	.50
	Fat yield	.64	.48
	Fat %	.66	.43
Saanen	Milk yield	.53	.47
	Fat yield	.48	.46
	Fat %	.62	.43
Toggenburg	Milk yield	.59	.42
	Fat yield	.59	.42
	Fat %	.54	.39

15 to 25% of the variation in milk yield, fat yield, and fat percentage. These percentages indicate large differences in production from feeding and overall herd management. Year-seasons accounted for 8 to 14% of the total variation in milk yield, fat yield, and fat percentage.

Sire components of variance were relatively larger than for dairy cattle and accounted for 8 to 11% of variation in milk yield, fat yield, and fat percentage. Goat herds are usually small so there may be little information to distinguish between effects of sire and year-season, and also there usually are only a few does per sire; therefore, some variation attributed to sire may be from confounding of sire effects with other effects. Contributions of the sire component to the total variance were consistently higher than some for dairy cattle (3, 6, 11), although other studies (1, 2, 5, 10) have reported that sires could contribute as much as 15% of the total variation in lactation milk yield for dairy cattle. Doe components of variance, however, were 16 to 25% of the total variation in milk yield, fat yield, and fat percentage, which suggests that sire components were overestimated. These estimates, however, indicate substantial potential for selection of does. Residual variances were about 34% of variation in milk and fat yields and 40% for fat percentage.

Repeatabilities and heritabilities within herd-year-season are in Table 3. Estimates may be unreliable because of difficulties related to sample size and biases from confounding. Repeatabilities are higher than those of about .33 obtained from paired records of does that had a first and a second record (7). Repeatabilities varied from .39 to .55, but heritabilities ranged from .48 to .62. Since heritability must be smaller than repeatability, the anomaly may result from confounding that inflated estimates of sire variance. Other workers (8) have reported heritabilities as high as .68 and .56 for milk and fat yield of dairy goats. Rønningen (9) obtained heritabilities of .55 and .22 and repeatabilities of .40 and .35 for milk and fat yields of Norwegian goats. Estimates as low as .17 have been reported (4) for French Alpine goats.

Genetic and phenotypic correlations are in Table 4. Phenotypic correlations averaged .94, and genetic correlations averaged .86 between milk and fat yields. Genetically and phenotypically, milk yield and fat percentage were correlated negatively, but for fat yield and fat percentage genetic correlations averaged .18.

CONCLUSIONS

Total variance of fat and milk records is composed of similar percentages of variance components. The relative importance of herd, year-season, sire, and doe effects is similar to those for dairy cattle. Sire evaluation programs for dairy goats should take into account these

TABLE 4. Genetic and phenotypic correlations between milk and fat yield, milk and fat percentage, and fat and fat percentage.

Breeds	Traits	Correlations	
		Genetic	Phenotypic
Alpine	Milk and fat	.85	.94
	Milk and fat %	−.24	−.04
	Fat and fat %	.14	.19
LaMancha	Milk and fat	.74	.75
	Milk and fat %	−.12	−.04
	Fat and fat %	.15	.19
Nubian	Milk and fat	.52	.94
	Milk and fat %	−.17	−.05
	Fat and fat %	.18	.19
Saanen	Milk and fat	.86	.94
	Milk and fat %	−.24	−.04
	Fat and fat %	.18	.18
Toggenburg	Milk and fat	.86	.94
	Milk and fat %	−.14	−.05
	Fat and fat %	.18	.18

sources of variation that might influence evaluation of sires when daughter records are represented unequally in herds and year-seasons.

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