Across-breed genetic evaluation of New Zealand dairy goats

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ABSTRACT

The New Zealand dairy goat industry consists of some 187 herds (33,500 does), from which 60 (12,600 does) supply milk for the New Zealand Dairy Goat Co-operative which manufactures whole milk powder for niche markets. Economically efficient progress of the industry requires identification of superior animals for traits of financial importance such as milk yield. The objective of this study was to develop a prototype method for routine genetic evaluation of does and bucks.

Across-breed estimated breeding values (EBVs) for total lactation milk yield adjusted for days in milk (MYA), unadjusted milk yield (MYU) and days in milk (DIM) of Saanen, Nubian, British, Toggenburg and crossbred dairy goats spread across 20 herds were estimated by Best Linear Unbiased Prediction (BLUP) procedures. A repeatability model was used to analyse lactation yields and included effects of herd-year-month, age, additive genetic merit and permanent environment. Coefficients of breed composition and heterosis (assuming equal heterosis among any of the breeds) and days in milk (MYA only) were considered as covariables. Heritability and repeatability assumed were 0.25 and 0.55. Evaluations were based on 6,517 lactation records of 3,856 does and 83 sires.

Average milk production was 548 *l* from an average of 200 DIM. Two year old does produced an extra 150 *l* of milk compared to one year old does. Peak production was at 5 years of age then production declined gradually with age. Young does had longer lactations than old does. Pure-bred Saanen does had more DIM and out-produced other breeds in MYA and MYU. Average EBVs (including breed group effects) for different breeds compared to a Saanen base were for MYU Nubian -291, British -242 and Toggenburg -106 *l*, MYA -177, -193 and -51 *l* and DIM -40, -17 and -19 days for each breed respectively. First cross heterosis was 105 *l* (19%) for MYU, 52 *l* (9.5%) for MYA and 18 days (9%) for DIM.

This prototype evaluation allows the selection of animals to be used as parents based on their estimated genetic merit and culling of lactating does based on producing ability.

Keywords: dairy goats; milk yield; genetic evaluation; heterosis.

INTRODUCTION

The New Zealand dairy goat industry is an emerging dairy production system. The industry comprises some 187 herds with a population of 33,500 does, from which 60 herds with 12,600 does supply milk for the New Zealand Dairy Goat Co-operative mostly to produce whole milk powder for niche markets (Livestock Improvement Corporation, personal communication).

A performance recording and evaluation scheme should be implemented such that economically efficient genetic progress of the industry can be achieved. This involves processing and using information for timely identification of animals of high genetic and phenotypic merit to improve the net financial return to the farm business. Identification of high merit animals can be achieved through the application of Best Linear Unbiased Prediction (BLUP; Henderson, 1973). In New Zealand, this technique has been applied to the genetic evaluation of sheep (Blair and Pollak, 1984), dairy cattle (Anderson, 1974; Garrick *et al.,* 1993) but can be applied to any livestock industry (Garrick, 1991). Currently, New Zealand dairy cattle are evaluated by BLUP across breeds (Harris *et al.,* 1996).

Genetic evaluations for milk, fat and protein yields of straight- and crossbred dairy goats by BLUP using an animal model have been reported in the United States by Wiggans (1989). The objective of this study was to develop a prototype method for routine genetic evaluation of animals in the New Zealand dairy goat industry.

MATERIALS AND METHODS

Pedigree information and lactation records from dairy goats kidding between 1990 and 1996 were obtained from the Livestock Improvement Corporation database. The data were spread across 20 herds of the New Zealand Dairy Goat Co-operative. Total lactation yields had been calculated from test-day records using methodologies previously applied to dairy cattle (Livestock Improvement Corporation, personal communication). After editing for incomplete information, there were 6,517 lactation records representing 3,856 does and 83 bucks.

Contemporary groups were defined as does kidding in the same herd, year and month. A total of 242 groups were formed. Age of the doe was included as a fixed effect in the model and calculated as the difference between date of kidding and date of birth. Most lactation records pertained to does kidding in 1993, 1994 and 1995 such that individual does had, at most 3 lactation yields.

The proportion of genes from Saanen, Nubian, British, Toggenburg and "unknown" breeds was calculated for each animal. Coefficients of expected heterosis were cal-

culated assuming equal heterosis among any pair of the breeds because the numbers of crossbred animals were insufficient to determine heterosis for specific crosses.

Estimated breeding values (EBV) for lactation milk yield (MYU) and days in milk (DIM) were obtained using the software package PEST (Groeneveld *et al.,* 1990) under the following repeatability model:

$$y_{ijkl} = c_i + m_j + \sum_{q=1}^{4} b_q a_q + b_5 h + g_k + p_k + e_{ijkl}$$

where

y_{ijkl}	is the *lth* lactation milk yield (or days in milk) of animal k, of age j and contemporary group i;
c_i	is the fixed effect of contemporary group i;
m_j	is the fixed effect of age class j;
a_1, a_2, a_3 and a_4	are coefficients of additive genetic breed effects for Nubian, British, Toggenburg and "unknown", respectively. This results in the Saanen breed effect being set equal to zero;
b_1, b_2, b_3 and b_4	are regression coefficients of milk yield on a_1, a_2, a_3 and a_4 ;
h	is coefficient of expected general heterosis effects;
b_5	are regression coefficients of milk yield on h;
g_k	is the random genetic effect (breeding value) of animal k;
p_k	is the random permanent environmental effect of animal k; and
e_{ijkl}	is the random residual effect unique to observation y_{ijkl}.

It was assumed that the random effects, g_k, p_k and e_{ijk} have zero means and are mutually uncorrelated. Genetic effects g_k, are correlated between relatives and have variance $\mathbf{A}\sigma_g^2$ where $\mathbf{A}$ defines the matrix of additive relationships between the animals. Non-genetic effects p_k and e_{ijkl}, are uncorrelated between animals, with variances σ_p^2 and σ_e^2 , respectively. Values of heritability and repeatability were assumed in 0.25 and 0.55, respectively.

Estimated breeding values for lactation milk yield adjusted for lactation length (MYA) were obtained using the same model but including days in milk as an additional covariable. Estimated producing values (EPV) for DIM, MYA and MYU were calculated for does as the sum of their breeding value plus permanent environment and heterosis effects.

RESULTS AND DISCUSSION

Average milk production was 548 *l* from an average of 200 DIM. Effects of age of does on DIM, lactation MYU and MYA are shown in Table 1. Young does had more DIM and higher milk yields than old does. The regression coefficient of milk yield on DIM was estimated

TABLE 1: Effect of age of lactating goats on days in milk (DIM), milk production unadjusted (MYU) or adjusted (MYA) for days in milk.

Age of doe (year)	DIM (days)	MYU (*l*)	MYA (*l*)
1	4	-136	-148
2	6	2	-16
3	6	75	59
4	0	79	78
5	1	85	83
6	-2	58	64
7	-8	17	39
8	-12	-18	18
9	-12	-77	-43
10	-32	-152	-61
11	-36	-219	-116

at 2.9 *l*/day. Milk yield increased with age until 5 years, then production declined gradually.

An understanding of the particular performance abilities of various goat breeds and the need to improve productivity can only be built on comprehensive breed information. Breed and heterosis effects for the traits evaluated are shown in Table 2. Pure-bred Saanen does had more DIM and out-produced other breeds in MYA and MYU. First cross heterosis was 105 *l* (19%) for MYU, 52 *l* (9.5%) for MYA and 18 days (9%) for DIM.

TABLE 2: Breed[a] and heterosis effects for days in milk (DIM), milk production unadjusted (MYU) or adjusted (MYA) for days in milk of lactating goats.

	DIM (days)	MYU (*l*)	MYA (*l*)
Breed effects			
Saanen	0	0	0
Nubian	-40	-291	-177
British	-17	-242	-193
Toggenburg	-19	-106	-51
"Unknown"	-43	-164	-39
Heterosis effects	18	105	52

[a] Breed effects of Saanen were set to zero for comparison.

Heterosis effects are of similar magnitude to the breed differences relative to Saanen base, indicating that first cross Saanen-Toggenburg does had similar performance to straightbred Saanen does. Subsequent crosses would be inferior due to heterosis losses.

Access to genetic evaluations may enable breeders to improve the genetic merit of animals. Estimated breeding values can be used to select the animals as parents for the next generation and estimated producing values can be used in culling decisions. Many dairy goat farmers milk herds of mixed breed does. Simultaneous evaluation of does and bucks across breed as described in this paper, allows comparison of animals on a common basis. Saanen

had the highest EBVs for days in milk and milk yield whether adjusted for lactation length or not. Similar results were reported by Wiggans (1989) for the genetic evaluation of US dairy goats of different breeds.

At present, dairy goat farmers are paid on the basis of kg milk solids. Evaluation for this trait can be easily accomplished using the prototype method described here, although milk solids yield can only be estimated cost effectively by summing fat and protein yield measures.

CONCLUSIONS

Estimates of genetic breed effects for DIM, MYU and MYA suggest that considerable genetic variation exists among breeds and that the Saanen is the breed of choice for milk production.

Genetic evaluation of dairy goats across breed, as described in this paper, will allow comparison of animals on a common basis. New Zealand dairy goat producers can use estimated breeding and producing values for making selection and culling decisions. Genetic progress resulting from these decisions can enhance profitability for these producers.

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