ISSN 0370-2731/2000 *Proceedings of the New Zealand Society of Animal Production* **60:** 318-319

BRIEF COMMUNICATION

Genetics of milk characteristics in New Zealand dairy cattle

D.L. JOHNSON, S.F. PETCH[1], A.M. WINKELMAN AND M. BRYANT [1]

Livestock Improvement Corporation, Private Bag 3016, Hamilton, New Zealand.

INTRODUCTION

The milk casein proteins represent a significant proportion of the total nitrogen-containing components of milk and are, on average, more valuable (per kg) than the non-casein components. Total protein, as measured by the Livestock Improvement Corporation (LIC) herd testing service, is a function of total milk nitrogen and, thus, represents the sum of the nitrogen-containing components. The primary objective of this study was to investigate the extent to which genes control the variation in the components that make up total milk protein, as there is little information on this in New Zealand.

The lactose in milk requires a considerable amount of energy for its production. A secondary objective of this study was to obtain information on the relative importance of genetic and environmental factors on lactose yield and its covariation with other production traits.

MATERIALS AND METHODS

Data collection was integrated with LIC's herd testing service using a sample of 102 herds involved in LIC's Sire Proving Scheme (SPS) in 1995. In addition to milk volume from herd testing, the concentrations of fat, crude protein (total nitrogen), casein, whey and lactose were determined. The data was collected from over 3,000 cows born in 1996 and first calving in the 1998 spring season, these being predominantly the daughters of approximately 220 SPS bulls. The milk characteristics were measured at three herd tests on each cow, with each herd having a herd test in each of the Sept/Oct, Nov/Dec and Jan/Feb periods. Hereafter, we refer to these three periods as stages of lactation.

The Milkoscan FT120, which employs Fourier transform infrared spectrophotometry with enhanced milk calibrations (Foss Electric Application Note Nos. 95, P/N 492280 and 102, P/N 578377), was used to determine the milk component concentrations.

Variance components were estimated using Restricted Maximum Likelihood (REML) and the average information algorithm (Johnson and Thompson, 1995).The linear model included the fixed effects of herd, period of calving (early, mid, late), calving age (≤23,24,25,≥26months), two covariates corresponding to the proportions of Jersey and Holstein-Friesian genes, a covariate for heterosis, and covariates corresponding to days in milk (DIM) and log(DIM). The random effect was sire with a relationship matrix based on sire and maternal grandsire, giving 787 sires in total. An additional trait, which represents the proportion of casein in crude protein (casein ratio), was calculated as log (casein/(protein-casein)), using a logratio transformation (Aitchison, 1982).

RESULTS AND DISCUSSION

Table 1 gives the means for the milk components. The average percentages of Holstein-Friesian and Jersey genes in the cow population were 64.5% and 33.9% respectively. Average DIM was 52, 101 and 183 days at each stage of lactation respectively.

TABLE 1. Raw means of milk components by stage of lactation.

	stage of lactation		
trait	1 (n=3306)	2 (n=3304)	3 (n=2965)
milk (l)	14.9	13.4	9.8
fat (kg)	0.659	0.605	0.475
protein (kg)	0.512	0.473	0.353
casein (kg)	0.396	0.366	0.277
whey (kg)	0.081	0.081	0.053
lactose (kg)	0.772	0.692	0.502
casein/protein	0.773	0.775	0.786

Table 2 presents the heritabilities and standard deviations for yields. The heritabilities for milk, fat and protein compare well with previous New Zealand estimates based on test day yields except that the values for fat are higher for the first two stages of lactation. The heritabilities for protein and casein are the same throughout lactation and the coefficients of variation for these two traits (~14%) show little variation across stages. A similar pattern is observed for milk volume and lactose (CV~15%). The heritability of the non-protein nitrogen component (not shown in Table 2) was of similar magnitude to the casein component.

TABLE 2. Heritability and phenotypic standard deviation of milk component yields by stage of lactation.

	stage of lactation					
trait	1		2		3	
	h^2	σ_p	h^2	σ_p	h^2	σ_p
milk (l)	0.27	2.3	0.32	2.0	0.22	1.5
fat (kg)	0.29	0.114	0.30	0.092	0.20	0.070
protein (kg)	0.22	0.074	0.22	0.065	0.18	0.048
casein (kg)	0.22	0.058	0.22	0.051	0.18	0.038
whey (kg)	0.33	0.014	0.29	0.013	0.24	0.009
lactose (kg)	0.27	0.117	0.31	0.103	0.21	0.076
casein ratio[1]	0.46	0.071	0.40	0.077	0.31	0.078

[1]log(casein/(protein-casein))

Table 3 presents correlations averaged over stages of lactation. Both the genetic and phenotypic correlations between protein and casein are very close to unity, indicating that the two traits are tightly linked. These estimates are a little higher than those obtained in the Canadian study of Hayes *et al.* (1984) (r_g=0.95, r_p=0.91), but similar to those

[1]Dairying Research Corporation, Private Bag 3123, Hamilton, New Zealand.

quoted in the literature summary of Graml *et al.* (1989). The relationships between casein ratio and yield traits indicate that selection for an increase in the casein content of protein would result in an increase in casein yield and a decrease in whey yield at double that rate, resulting in an overall decrease in protein yield.

TABLE 3. Correlations averaged over stages of lactation - genetic below diagonal and phenotypic above.

	milk (l)	fat (kg)	protein (kg)	casein (kg)	whey (kg)	lactose (kg)	casein ratio
milk		0.66	0.89	0.87	0.77	0.98	-0.10
fat	0.16		0.77	0.77	0.64	0.65	0.06
protein	0.72	0.58		0.99	0.87	0.88	-0.01
casein	0.69	0.60	0.99		0.81	0.87	0.11
whey	0.48	0.44	0.78	0.68		0.72	-0.39
lactose	0.95	0.15	0.70	0.69	0.43		-0.04
casein ratio[1]	-0.12	0.10	-0.05	0.10	-0.60	-0.06	

[1]log(casein/(protein-casein))

Selection theory was used to predict the responses in component traits due to selection on Breeding Worth (BW), the national dairy cattle breeding objective. The predicted responses in protein, casein and whey are the same on a percentage basis, thus, one would not expect current selection practices to change casein as a proportion of total protein.

The correlations between lactose and volume also reinforce the close association between these two traits and are similar to estimates from the study of Welper & Freeman (1992), (r_g=0.92, r_p=0.96) and the literature summary of Gibson (1987), (r_g=0.96, r_p=0.96).

CONCLUSION

Preliminary analyses of the first lactation data from this study indicates that casein yield is closely linked with crude protein yield and that there is little room to change the casein content of protein. Data on the economic returns for casein and whey protein will be required for proper assessment, but it would seem that unless the costs of casein and protein measurement are similar, there is little advantage in substituting casein for protein in the national breeding objective. This study also confirms the tight association between lactose and milk volume.

REFERENCES

Aitchison, J. 1982. The statistical analysis of compositional data. *Journal Royal Stat. Society. B*, **44:**139-177.

Gibson, J.P. 1987. The options and prospects for genetically altering milk composition in dairy cattle. *Animal Breeding Abstracts* **55:** 231-243.

Graml, Von R.; Buchberger, J.; Klostermeyer, H.; Pirchner, F. 1989. Marker-assozuerte und polygene korrelationen zwischen casein-, molkeneiweib- und fettgehalt und –mengen bei Fleckveih und Braunveih. *Journal Animal Breeding & Genetics* **106:** 96-109.

Hayes, J.F.; Ng-Kwai-Hang, K.F.; Moxley, J.E. 1984. Heritability of milk casein and genetic and phenotypic correlations with production traits. *Journal of Dairy Science* **67:** 841-846.

Johnson, D.L.; Thompson, R. 1995. Restricted maximum likelihood estimation of variance components for univariate animal models using sparse matrix techniques and average information. *Journal of Dairy Science* **78:** 449-456.

Welper, R.D.; Freeman, A.E. 1992. Genetic parameters for yield traits of Holsteins, including lactose and somatic cell score. *Journal of Dairy Science* **75:** 1342-1348.