GENETIC PARAMETERS FOR FEED EFFICIENCY IN HOLSTEINS

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INTRODUCTION

One of the goals in dairy cattle breeding is to improve the economic efficiency and profitability of production. Feed intake and the biological efficiency with which it is converted into milk, fat and protein are important contributors to profitability. Several studies reported on heritabilities of feed intake and gross feed efficiency measures and their genetic correlations with milk, fat and protein yields (e.g. Van Arendonk *et al.*, 1991 ; Persaud *et al.*, 1991 ; Veerkamp, 1998). Reports on genetic parameters of net efficiency measures are fewer, partially because of the difficulty involved in their estimation(e.g. Veerkamp and Evans, 1995 ; Walter and Mao, 1989). Most of the reports on genetic parameters for feed efficiency in dairy cattle are based on data collected in institution herds and under experimental conditions. The present study reports on genetic parameters for feed efficiency measures in dairy cattle estimated from a large data set collected under normal field conditions in a milk recording program.

MATERIAL AND METHODS

Data and editing. A total of 568 266 first lactation records of production and feed intake on Holsteins in 5356 herds from September 1979 to January 1994 were obtained from the Quebec Dairy Herd Analysis Service (PATLQ). Each record contained information on cow identification, sire of cow, date of birth, date of calving, weight at calving, condition codes affecting the record, and 90-day and 305-day milk, fat and protein yields, total energy intakes, total protein intakes and total dry matter intakes. The numbers of 305-day records deleted for various editing criteria, and the final number of records are shown in table 1. The numbers were the same at 90-days except that an additional 148 records were deleted for missing feed data and missing body weights. The following measures of feed efficiency were derived from the data :

(1) Corrected milk yields (CMY) at 90 or 305 days were obtained by adjusting the actual yields to a constant total energy intake (TEI), a constant % energy from grain relative to total energy intake, and constant metabolic weight.
(2) Efficiency of fat-corrected milk (EFCM) where :
    EFCM = FCM/TEI, and FCM = .4 milk yield + 15 fat yield
(3) Efficiency of fat and protein corrected milk (EFPCM) where :
    EFPCM = FPCM/TEI, and FPCM = (.349 + .107 (% fat) + .067 % protein) x milk yield
(4) Efficiency of energy value of milk (EEVM), where (e.g. Mcdonald *et al.*, 1981)
    $EVM(M_j)$ = [(24.52 (% protein) + 16.54 (% lactose) + 38.12 (% fat) x 100] x (milk yield)/TEI
(5) Protein efficiency which was defined as lactation protein yield (kg) divided by lactation protein intake (kg).

Statistical methods. The data were analysed using the following statistical model :

$y_{ijklm} = \mu + hys_i + age_j + g_k + s_{kl} + e_{ijklm}$,

where y_{ijklm} = milk yield, measures of efficiency or intake at 90 or 305 days, μ = overall mean, hys_i = the fixed effect of herd-year-season, age_j = the fixed effect of age-at-calving, g_k = the fixed effect of genetic group, s_{kl} = the random effect of sire nested within genetic group (proven sires were fitted as a fixed effect and young sires as a random effect), and e_{ijklm} = the random residual term associated with each record.

There were 39 307 herd-year-seasons for the 305-day records and 39 284 for the 90-day records. Seasons were March to September and October to February. There were 21 age-at-calving classes and 18 genetic group levels. There were 472 young sires and 262 proven sires with data. The model was fitted by multitrait REML (Meyer, 1985) with the relationship matrix built up only on the male side (resulting in 862 male ancestors which did not have daughters in the data set). For the analysis to obtain the regression coefficients required to produce CMY, an additional analysis of milk yield was performed using the above model but within TEI, % energy from grain in the diet and $BW^{.75}$ added to the model as covariates.

Table 1. Numbers of records removed for various editing criteria, and final number of records at 305 days

Reason for removal	Number of records
Duplicate records	2 159
Missing sire registrations	49 940
Missing field data and body weight	299 915
Records with condition code[1] $\neq 0$	36 959
Cows sold, culled or died during lactation	24 625
Records of sires with $\leq$ 10 progeny in $\leq$ 5 herds	38 225
Records of sires not in pedigree	2 045
Age at calving < 20 months or > 40 months	23
Abnormal values for production or feed	22
Herd-year-seasons with only one record	2
Total deleted =	453 915
Initial total number of records	568 266
Records remaining for analysis	114 351

[1]records that were affected by abnormalities such as mastitis, sick, abortion, etc.

RESULTS AND DISCUSSION

Estimates of heritabilities for efficiency measures, as well as milk yield, FCM, FPCM and EVM are shown in table 2. EFCM, EFPCM, EEVM and protein efficiency are gross efficiency measures, and their heritability estimates are similar to those for the yield traits, especially at 305-days, in general agreement with other studies (e.g. see Veerkamp, 1998, for review). As discussed by many authors, gross efficiency measures are likely to be of less interest in the context of genetic improvement in dairy cattle (e.g. Blake and Custodio, 1983) than net efficiency measures. CMY is an attempt to obtain a net efficiency measure, as variation in CMY essentially represents variation in production among cows having the same weight and ingesting the same amount of total energy intake made up of a constant amount of energy from concentrate in the diet ; hence differences among cows in CMY would be an indication of differences in feed conversion ability (e.g. see Wang *et al.,*1992). The heritability estimates for CMY at 90 and 305 days were higher (.37 and .48, respectively) than those for the gross efficiency measures. Studies by Buttazzoni and Mao (1989) and Svendsen and Mao (1989) reported heritabilities of about 0.4 also for net efficiency measures derived from data collected under normal farm conditions.

Table 2. Heritability estimates for milk yield and efficiency measures at 90 and 305 days of lactation (± s.e.)

Trait	90-day	305-day
Milk yield	.38 ± .03	.45 ± .04
FCM	.31 ±. 03	.39 ± .03
FPCM	.31 ± .03	.39 ± .03
EVM	.18 ± .00	.25 ± .00
CMY	.37 ± .03	.48 ± .04
EFCM	.22 ± .00	.37 ± .00
EFPCM	.20 ± .00	.35 ± .00
EEVM	.18 ± .00	.25 ± .00
Protein efficiency	.10 ± .01	.31 ± .03

FCM = fat-corrected milk, FPCM = fat and protein corrected milk, EVM = energy value of milk, CMY = corrected milk yield, EFCM = efficiency of FCM, EFPCM = efficiency of FPCM, EEVM = efficiency of EVM

Genetic and phenotypic correlations of milk yield with efficiency traits are shown in table 3. Genetic correlations between milk yield and the gross efficiency measures (EFCM, EFCPM, EEVM and protein efficiency) were similar or slightly lower than most other estimates in the literature (e.g. Veerkamp, 1998). The genetic correlations between milk yield and CMY (.66 and .60 respectively) were higher than expected, but similar to the 0.56 estimate reported by Buttazzoni and Mao (1989) for a net feed efficiency measure derived from field data.

Table 3. Genetic and phenotypic correlations between efficiency traits and milk yield at 90 and 305 days of lactation (± s.e.)

Correlation	Genetic		Phenotypic	
	90-day	305-day	90-day	305-day
Milk yield and CMY	.66 ± .04	.60 ± .04	.59 ± .01	.58 ± .01
Milk yield and EFCM	.55 ± .05	.51 ± .05	.59 ± .00	.58 ± .00
Milk yield and EPCM	.64 ± .04	.60 ± .04	.61 ± .00	.62 ± .01
Milk yield and EEVM	.59 ± .05	.52 ± .05	.54 ± .00	.49 ± .00
Milk yield and protein efficiency	.68 ± .04	.79 ± .03	.37 ± .00	.53 ± .00

Based on the results from this study using data collected under normal farm conditions, and in agreement with other studies, it seems that selection for milk yield will result in a considerable correlated response in gross feed efficiency, and there is some evidence that net fee efficiency will also be improved.

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