EVALUATION OF YIELD TRAITS FOR THE DEVELOPMENT OF A UK FERTILITY INDEX FOR DAIRY CATTLE

S. Brotherstone[1], G. Banos[2] and M.P. Coffey[1]

[1] Scottish Agricultural College, West Mains Road, Edinburgh EH9 3JG, UK
[2] Aristotle University, Faculty of Veterinary Science, 54006 Thessaloniki, Greece

INTRODUCTION

Poor fertility of dairy cows has become a major cause of involuntary culling in many countries worldwide. Production costs and welfare related implications are of great concern to the industry. In the UK, there are no breeding tools available to help identify bulls that breed daughters with poor fertility. For this reason, a fertility index is being developed. The index includes insemination traits, which are directly linked to the cow's ability to conceive, and calving interval, which readily provides objective and reliable information. In addition, body condition is being considered as a useful tool in assessing the energy status of the cow, which is genetically correlated with reproductive performance (Harrison *et al*, 1990; Pryce *et al*, 2001). Finally, milk yield is also being considered in order to account for culling due to low production, because of its relationship with both calving interval and body condition, and to increase the predictive capacity of the fertility index.

The objective of this study was to evaluate different milk yield traits regarding their suitability for inclusion in a fertility index.

MATERIAL AND METHODS

Data description and edits. Insemination, calving, body condition and milk yield records of first parity Holstein cows were extracted from the databases of National Milk Records and Holstein UK and Ireland. All cows had calved between 1997 and 2000 and were required to have complete 305-d lactation yield records. Calving interval (CI) was calculated for cows that had calved for a second time in that period. Number of insemination (NINS) was also recorded for these cows. Furthermore, conception to first insemination (NR56) was included, coded 1 if a cow did not return to service 56 days after the first insemination and 0 otherwise. The following nine yield traits were considered: daily milk yield at 3rd test (DMK3), daily fat plus protein yield at 3rd test (DFP3), daily milk energy yield at 3rd test (DMJ3), daily milk yield at test nearest to body condition scoring (CS) date (DMKCS), daily fat plus protein yield at same test (DFPCS), daily milk energy yield at same test (DMJCS), 305-d lactation milk yield (MK305), 305-d fat plus protein yield (FP305) and 305-d milk energy yield (MJ305).

Records were excluded if age at calving was outside the 18-36 month range, daily milk yield was less than 3 kg or greater than 90 kg, lactation milk yield was less than 1000 kg, and milk recording test associated with CS was more than 20 days from scoring day. For cows that calved for a second time, records were removed if CI was outside the 300-600 days range, gestation length was less that 272 or greater than 292 days, and first insemination was before day 20 and last insemination after day 200. Further, herd-year combinations were required to have a minimum of 5 observations and sires had to have daughters in at least 10 herds. After these edits and some other quality tests, a total of 26875 cow records of 624 sires were kept.

Statistical analyses. Eighteen 4-variate analyses were performed, each including CI, CS, an insemination trait (NINS or NR56), and a yield trait. All models included the fixed effects of herd-by-year of calving interaction, month and age at calving (linear and quadratic regression), and the random effect of sire of cow (with sire relationships). For CS and daily yield traits, the model also included a second-degree regression on stage of lactation at classification and test, respectively. (Co)variance components were estimated with ASREML (Gilmour *et al*, 1995). Average reliability of sire genetic evaluations for CI, NINS and NR56 was also computed.

RESULTS AND DISCUSSION

Table 1 summarises the data and provides descriptive statistics of all traits considered in this study. Heritability estimates obtained from the statistical analyses are also shown. Results indicate that about 73% of the cows in this study had a second calving, with average CI of 386 days. For these cows, the average number of recorded services per conception was 1.65. Results also show that 64% of the cows conceived at the first insemination. Daily milk yield was slightly higher at 3rd test than at test closest to CS date, because, on average, it was closer to lactation peak (days in milk were 77 and 127, respectively). Heritability estimates for CI, CS, NINS and NR56 were similar to earlier estimates (Pryce *et al*, 2000; Kadarmideen *et al*, 2000; Pryce *et al*, 2001; Veerkamp *et al*, 2001).

Table 1. Mean, standard deviation (SD), coefficient of variation (CV) and heritability estimates (h^2) for all traits

Trait	No. records	Mean	SD	CV	h^2
CI (days)	19705	386.22	48.56	12.57	0.04±0.01
NINS (count)	19342	1.65	0.99	60.00	0.03±0.01
NR56 (0/1)	25859	0.64	0.48	75.05	0.03±0.01
CS (score)	8133	4.47	1.72	38.54	0.22±0.04
DMK3 (kg)	26875	24.97	5.47	21.89	0.22±0.02
DFP3 (kg)	26875	1.71	0.37	21.48	0.14±0.02
DMJ3 (MJ)	26875	99.47	21.16	21.27	0.15±0.02
DMKCS (kg)	8133	23.71	5.91	24.94	0.26±0.04
DFPCS (kg)	8133	1.67	0.39	23.31	0.16±0.04
DMJCS (MJ)	8133	96.25	22.53	23.41	0.18±0.04
MK305 (kg)	26875	6538.03	1401.86	21.44	0.31±0.03
FP305 (kg)	26875	466.18	93.03	19.96	0.22±0.02
MJ305 (MJ)	26875	26817.80	5363.41	20.00	0.22±0.02

Genetic correlation estimates among CI, CS, NINS and NR56 are shown in Table 2. As expected, the correlation between CI and NINS was positive, with long CI being linked to more recorded inseminations. The correlation between CI and NR56 was not significantly different from zero. The correlation between CS and CI was favourable, indicating that improved CS would be associated with shorter CI. Genetic correlations between CI and the two insemination traits (NINS and NR56) were not significantly different from zero.

Table 2. Estimates of genetic correlations among CI, CS, NINS and NR56

Trait	CI	NINS	NR56
CI		0.56±0.19	-0.18±0.25
CS	-0.23±0.19	0.19±0.23	0.04±0.21

Genetic correlation estimates between the 9 yield traits and CI, CS, NINS and NR56 are shown in Table 3. Correlations of the 9 traits with CI were unfavourable and did not statistically differ from each other. These correlations suggest that increased milk production is associated with longer CI, confirming earlier studies (e.g. Kadarmideen *et al*, 2000). In this case, selection bias due to milk production is, at least partially, accounted for by the multiple trait analysis, since at least some of the data on which selection had been based were included. Genetic correlation estimates between yield and NINS were not significantly different from zero, whereas correlations with NR56 were slightly unfavourable for 3rd test and lactation yield traits, with higher yield being associated with reduced success at conceiving at first insemination. Correlations with CS were also unfavourable for all yield traits.

Table 3. Estimates of genetic correlations between nine yield traits and CI, CS, NINS and NR56

Trait	CI	NINS	NR56	CS
DMK3	0.34±0.15	0.01±0.18	-0.19±0.15	-0.49±0.10
DFP3	0.33±0.16	0.10±0.19	-0.31±0.16	-0.40±0.12
DMJ3	0.33±0.16	0.07±0.19	-0.34+0.16	-0.45±0.11
DMKCS	0.29±0.19	-0.11±0.23	-0.04±0.20	-0.61±0.11
DFPCS	0.39±0.21	-0.02±0.23	-0.10±0.23	-0.68±0.13
DMJCS	0.39±0.21	-0.02±0.25	-0.12±0.23	-0.68±0.12
MK305	0.38±0.13	0.01±0.16	-0.21±0.14	-0.49±0.09
FP305	0.40±0.14	0.02±0.17	-0.29±0.15	-0.50±0.10
MJ305	0.43±0.13	0.03±0.17	-0.31±0.15	-0.51±0.10

Average reliability estimates of sire genetic evaluations for fertility traits (CI, NINS and NR56), computed in each multivariate analysis, are shown in Table 4. All nine yield traits were equally informative at predicting NINS, whereas 3rd test and lactation yield traits were better than yield at test near CS date at predicting NR56. For CI, the models including lactation yield resulted in slightly more accurate sire prediction compared to models including daily yield, but differences were modest. Between the two insemination traits, sire predictions for NR56 were more accurate than for NINS, because of higher genetic correlation estimates with the yield traits.

Table 4. Sire reliability estimates for CI, NINS and NR56, from nine models including nine different yield traits

Yield trait	CI	NINS	NR56
DMK3	0.202	0.131	0.169
DFP3	0.198	0.134	0.179
DMJ3	0.197	0.133	0.184
DMKCS	0.189	0.136	0.159
DFPCS	0.193	0.135	0.159
DMJCS	0.192	0.135	0.160
MK305	0.209	0.136	0.169
FP305	0.205	0.134	0.178
MJ305	0.208	0.134	0.181

CONCLUSION

All nine yield traits evaluated in this study had, generally, similar genetic correlation estimates with fertility. Further, all yield traits were equally informative, in a multivariate analysis context, at predicting sire evaluations for calving interval and insemination traits. Therefore, all yield traits studied here would be equally suitable for inclusion in a fertility index. The preferred trait would be daily yield at 3rd test because it is available earlier in lactation and can better account for selection bias. Based on results of this study, a fertility index for dairy cattle could include calving interval, rate of conception at first insemination, body condition score, and yield at 3rd test.

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