Genetic Associations Amongst Health and Fertility Traits for Two UK Recording Schemes

J.E. Pryce[1], R.F. Veerkamp [1], R.J. Esslemont ,[2] M.A. Kossaibati [2] and G. Simm [1]

[1]Genetics and Behavioural Sciences Dept., Scottish Agricultural College, West Mains Road, Edinburgh, EH9 3JG, UK
[2]Department of Agriculture, Earley Gate, The University of Reading, Reading RG6 6AT, UK
j.pryce@ed.sac.ac.uk

Abstract

Genetic parameters for 305 day milk production, health disorders (mastitis, lameness and milk fever) and fertility traits (calving interval; days to first service and conception to first service) were estimated using data from two UK recording schemes. One was a National recording scheme operated by the Scottish Livestock Services Ltd. (SLS) and the other was a health and fertility management recording system, the Dairy Information System (DAISY). The datasets consisted of 33732 and 10569 records for the SLS and DAISY respectively. The heritability for somatic cell score was 0.15, heritabilities for all other health and fertility traits were less than 0.10. Heritability and correlation estimates agreed well in the two datasets. Genetic correlations with milk yield were in all cases antagonistic, suggesting that selection for milk yield has led to a deterioration in health and fertility.

1. Introduction

In the UK, there are three national recording agencies. By far the largest is the National Milk Records (NMR), responsible for recording herds mostly in England and Wales, next largest is the Scottish Livestock Services (SLS) recording predominantly in Scotland and the smallest is the United Dairy Farmers in Northern Ireland. These recording services are mainly concerned with milk production traits, although calving and insemination dates are usually also recorded. Some are now expanding to record health traits, SLS started recording health disorders in January 1994. Any farmer recording milk production has the option to record health disorders, service information and calving dates free of charge. All information is recorded in booklets designed for this purpose and collected monthly by the official SLS milk recorder.

In addition to the national recording agencies, the Dairy Information System (DAISY) operated by the University of Reading / National Milk Records, is designed specifically for recording of health disorders and fertility information. The recording scheme is nationwide, although most participating farms are in the South of England. Health disorders, fertility and in most cases production are recorded on farm, either independently or in conjunction with a veterinarian onto a personal computer. The main use of this data is as a management aid to farmers. However, data from individual sites is also collected into one large and comprehensive database. Most DAISY members have an interest in recording this sort of information as they use it to improve management strategies. As a consequence information is generally well recorded. The database was set up in the 1970's, however not until now were there sufficient herds using DAISY for long enough to enable estimation of genetic parameters of health and fertility traits.

The aims of this study were (i) to assess whether genetic parameters estimated from data collected from a scheme designed specifically for recording health and fertility differed to parameter estimates from a national scheme. This information may be useful to define which traits to improve through selection programmes in addition to aiding the design of future recording schemes; and (ii) to investigate the relationship between health and fertility traits. Most previous studies have concentrated on the relationship between milk production and fertility, or the relationship between milk production and health. In this paper, relationships between milk production, health and fertility traits were examined simultaneously.

2. Material and methods

Similar data editing and analysis procedures were applied to both datasets. In both datasets cows had a combination of health, fertility and 305 day milk production data. In all cases lactation lengths had to be over 200 days. Records from thirty three herds from DAISY were used. These herds were selected as they were known to have official NMR milk records. However, many SLS herds do not record health and service information, so criteria for selection of data had to be imposed. SLS herds were selected according to the completeness of their records, full details of editing procedures for SLS data are given in Pryce et al. (1997).

Health traits available from DAISY included mastitis, lameness and log 2 transformed somatic cell count (SCS). Other health traits are also recorded, but these were the only ones available from the summary data extracted from the database. The SLS record seven different health disorders (Table 1). However, analyses were restricted to mastitis, lameness and milk fever, as the other categories were either ambiguously defined (other and breeding problems) or the incidence was very low (staggers and ketosis). In both datasets all health disorders were coded as 0/1 traits ie. 0 for no observations of a disease in a lactation and 1 for 1 or more observations of disease in a lactation.

A successful insemination was determined by a subsequent calving date. Traits included: (i) calving interval; (ii) days to first service; (iii) the conception to first service coded as 1 or 0 for success or failure respectively. Fertility records were discarded if the days to first service were less than 20 or greater than 200 days, if the calving intervals were outwith the range 300 to 700 days and if the gestation length was over 20 days either side the mean value of 282 days.

The same statistical procedures were applied to both datasets. Observations were assigned to herd-year-season subclasses using four seasons at calving (January to March, April to June, July to September, and October to December). Cows in lactation five or above were grouped into the same lactation class.

Fixed effects and covariates in the analyses included (i) herd-year-season (ii) lactation number (iii) age at calving was fitted as a linear and quadratic covariate. A permanent environmental effect was included in the first data set (all lactations) to account for multiple lactation records.

The Variance Components and Estimation (VCE) restricted maximum likelihood (REML) programme written by Groeneveld (1996) was used to analyse the data. The DAISY dataset was analysed using a multivariate animal model, however computing limitations restricted the SLS data set analysis to bivariate animal models, although a multivariate approach would have been preferable. VCE was used in preference to a threshold model, which may have been more appropriate for 0/1 data, as an animal model with all known parents and grandparents could be fitted and VCE can make use of records where some of the traits are missing.

3. Results

In both the DAISY and SLS datasets, the editing procedures reduced the datasets to around 60% of the original number. The numbers of records in the final datasets are shown in Table 2.

Means corrected for fixed and random effects are shown in Table 3. Means for milk yield and calving interval were similar in the two datasets. However, the mean days to first service was longer and conception to first service higher in SLS than DAISY cows. The incidence of mastitis and lameness were also higher in DAISY than SLS cows. However, as the incidences of mastitis and lameness differed between the two studies it may be more informative to compare heritabilities after transformation from the observed to the underlying scale, using the conversion formula of Robertson and Lerner (1949). This is $p(1-p)/z^2$, where p is the population incidence and z is the height of the ordinate of a standardised normal at the threshold point corresponding to p. Heritabilities on this scale were 0.226 and 0.106 for mastitis for SLS and DAISY respectively and 0.114 and 0.110 for lameness for SLS and DAISY respectively.

The heritabilities of 305 day milk yield in the two datasets were very similar (0.34 and 0.33), the heritability of SCS was 0.15, heritabilities of other traits were all below 0.10. The permanent environmental effects were consistently lower in the

SLS than the DAISY data set. This could be because there were fewer repeated records in the SLS data than DAISY data, a cow could have a maximum of two lactations in the SLS data as there were only two years of data. Genetic correlations between traits are shown in Table 4. All genetic correlations with milk yield were antagonistic. Most of the correlations between the same traits agreed well between the two datasets.

4. Discussion

Conception to first service was lower in DAISY than SLS cows, however calving intervals were no better in DAISY than SLS herds. This may imply under-recording in some SLS herds. Similarly, the incidences of mastitis and lameness were lower. This may be expected, as the SLS scheme began more recently, and many of the participants of the SLS recording scheme may be more concerned with recording milk production traits than health and fertility traits. Furthermore, more information on fertility traits were available than health traits in SLS cows, which could be a reflection of the perceived value of the two types of information. Clearly, as health and fertility issues are becoming more important, there is a need to encourage more farmers of the value of collecting this type of data both from a farm management perspective and for sire evaluations.

Heritabilities of health and fertility traits (with the exception of somatic cell score) in both datasets ranged between 0.013 (for conception to first service) and 0.071 (for mastitis). Although the heritabilities of these traits were low, variation was high, as can be seen from the phenotypic SDs, consequently selection to improve these traits may be possible. The heritability for lameness was higher in DAISY than SLS, which could have been because of differences in the recording schemes. As DAISY is used by farmers interested in recording health, recording of these traits is likely to be better than SLS. However, heritabilities were generally lower for DAISY than SLS.

There was a moderately high correlation between mastitis and somatic cell score of 0.65 (Table 4) and the heritability of somatic cell score was substantially higher than mastitis. Thus, selection to improve mastitis via indirect selection using somatic cell score may be possible.

The genetic correlations between milk yield and health and fertility traits were antagonistic (Table 4). This indicates that selection for high milk yield leads to a deterioration in health and fertility. Similar results are found in the literature between milk yield and health traits (eg. Lyons et al., 1991; Uribe et al., 1995) and milk yield and fertility traits (e.g. Van Arendonk et al., 1989; Oltenacu et al., 1991; Hoekstra et al., 1994; Poso and Mantysaari, 1996).

One of the aims of this study was to investigate whether the (co)variances and means obtained from the two recording schemes differed substantially. Although all fertility traits were the same in the two studies, the only two health problems that were the same in the datasets were mastitis and lameness. However, there were no large differences in heritability estimates and correlations in DAISY and SLS recorded cows, as more data becomes available, then perhaps minor differences will be reduced. The SLS record information from herds mainly in Scotland, and the DAISY system was mainly in Southern England, it is possible that there were geographical and climatic differences which would be unaccounted for.

5. Conclusions

In order to make progress in selection programmes incorporating health and fertility, appropriate definitions of health disorders and fertility traits recorded in dairy recording schemes is of great importance. The heritabilities and genetic variances estimated in this study do seem to indicate that selection to improve some or all of these traits will be possible. The correlation between mastitis and somatic cell score and the relatively high heritability of SCS suggest that further improvements to mastitis may be achieved through indirect selection, using somatic cell score. The method of choice for improvement of health and fertility traits would be to include some of them in future versions of a selection index, for example, the UK index for total economic merit, ITEM (Veerkamp et al., 1995), with a weighting based on their economic values. Additional weighting on these traits should be considered to counter the apparent deterioration in health and fertility with rising milk yield and also because of ethical and economic reasons.

6. Acknowledgements

The authors wish to thank DAISY and SLS for provision of data. We thank Bill Hill, Brian McGuirk and Peter Visscher for useful comments on the manuscript. Jennie Pryce acknowledges funding from the Ministry of Agriculture, Fisheries and Food. SAC receives financial support from Scottish Office for Agriculture, the Environment and Fisheries Department.

References

Hoekstra, J. Van Der Lugt, A.W. Van Der Werf, J.H.J. and Oueweltjes, W. 1994. Genetic and phenotypic parameters for milk production and fertility traits in upgraded dairy cattle. *Livest. Prod. Sci. 40,* 225-232.

Lyons D.T., Freeman, A.E. and Kuck, A.L. 1991. Genetics of health traits. *J. Dairy Sci. 74(1),* 1092-1100.

Oltenacu, P.A., Frick, A. and Lindhe, B. 1991. Relationship of fertility to milk yield in Swedish cattle. *J. Dairy Sci. 71,* 264-268.

Poso, J. and Mantysaari, E.A. 1996. Relationships between clinical mastitis, somatic cell score, and the production for the first three lactations of Finnish Ayshires. *J. Dairy Sci. 79,* 1284-1291.

Pryce, J.E., Veerkamp, R.F., Thompson, R., Hill, W.G. and Simm, G. 1997. Genetic aspects of common health disorders and measures of fertility in Holstein Friesian dairy cattle. *Anim. Sci.* (submitted)

Robertson, A. and Lerner, I.M. 1949. The heritability of all-or-none traits: Liability of poultry. *Genetics* 34, 395-411.

Uribe, H.A., Kennedy, B.W., Martin, S.W. and Kelton, D.F. 1995. Genetic parameters for common health disorders of Holsteins. *J. Dairy Sci. 78,* 421-430.

Van Arendonk, J.A.M., Hovenier, R. and De Boer, W. 1989. Phenotypic and genetic associations between fertility and production in dairy cows. *Livest. Prod. Sci. 21,* 1-12.

Veerkamp, R.F. Hill, W.G., Stott, A.W., Brotherstone, S. and Simm, G. 1995. Selection for longevity and yield in dairy cows using transmitting abilities for type and yield. *Anim. Sci. 61,* 189-198.

Table 1. Health disorders recorded by members of the SLS recording system.

Disease code	Disorder
1	Breeding Problems
2	†Milk fever (hypocalcaemia)
3	†Mastitis
4	†Foot problems
5	Staggers (hypomagnesia)
6	Ketosis (acetonaemia)
7	Other

† health disorders used in the analyses

Table 2. Numbers of records in the final datasets after editing.

	SLS	DAISY
Records	33732	10569
Cows	27444	4571
Sires	2224	267
Years	2	6
Herds	410	33

Table 3. Numbers of records, means and phenotypic standard deviations (σ_p), heritabilities (h^2_{vce}) and permanent environmental effects (c^2) estimated with VCE and heritabilities transformed to the underlying scale ($h^2_{underlying}$) for 0/1 traits.

	Dataset	mean	σ_p	$h^2_{(vce)}$	$h^2_{(underlying)}$	$c^2_{(vce)}$
305 day milk yield	SLS	6455	1078	0.34"0.01	-	0.19"0.01
	DAISY	6733	1067	0.33"0.01	-	0.31"0.01
Calving interval	SLS	387	45	0.032"0.005	-	0.000"0.000
	DAISY	382	45	0.017"0.002	-	0.026"0.002
Days to 1st service	SLS	84	25	0.031"0.007	-	0.000"0.000
	DAISY	70	18	0.020"0.003	-	0.029"0.003
Conception	SLS	0.66	0.46	0.019"0.009	0.032	0.002"0.002
to 1st service	DAISY	0.51	0.49	0.013"0.002	0.020	0.027"0.003
Somatic cell score	SLS	-	-	-	-	-
	DAISY	3.25	1.07	0.15"0.01	-	0.28"0.01
Mastitis	SLS	0.09	0.26	0.071"0.009	0.226	0.002"0.001
	DAISY	0.15	0.34	0.045"0.006	0.106	0.049"0.004
Lameness	SLS	0.05	0.20	0.025"0.005	0.114	0.015"0.004
	DAISY	0.15	0.34	0.047"0.005	0.110	0.035"0.004
Milk fever	SLS	0.03	0.15	0.080"0.009	0.55	0.001"0.001
	DAISY	-	-	-	-	-

Table 4. Genetic (below diagonal) and phenotypic (above the diagonal) correlations between health and fertility traits and 305 day milk yield in all lactations.

Trait		1	2	3	4	5	6	7	8
1. Milk yield	SLS		0.22	0.16	-0.13	-	0.01	0.05	0.02
	DAISY		0.18	0.09	-0.13	-0.08	-0.03	0.03	-
2. Calving interval	SLS	0.50		0.50	-0.61	-	0.03	0.03	0.02
	DAISY	0.28		0.33	-0.59	0.12	0.04	0.05	-
3. Days to	SLS	0.43	0.93		0.08	-	0.004	0.02	0.02
1st service	DAISY	0.41	0.56		0.04	0.05	0.02	0.03	-
4. Conception	SLS	-0.19	-0.56	0.15		-	-0.02	-0.005	0.002
1st service	DAISY	-0.12	-0.81	-0.13		-0.08	-0.03	-0.03	-
5. Somatic cell	SLS	-	-	-	-		-	-	-
score	DAISY	0.16	0.28	0.16	-0.40		0.23	0.04	-
6. Mastitis	SLS	0.21	0.06	-0.18	-0.19	-		0.06	0.02
	DAISY	0.29	0.16	-0.14	-0.58	0.65		0.03	-
7. Lameness	SLS	0.29	0.07	0.18	0.70	-	0.17		0.02
	DAISY	0.13	0.33	-0.11	-0.65	0.26	0.48		-
8. Milk fever	SLS	0.19	0.03	0.25	0.03	-	0.64	0.21	
	DAISY	-	-	-	-	-	-	-	

Standard errors for genetic correlations between 0.05 and 0.21 in the SLS data set.
Standard errors for genetic correlations between 0.04 to 0.13 in the DAISY data set.