Proc. Assoc. Advmt. Anim. Breed. Genet. 23:135-138

GENETIC PARAMETERS FOR MILK YIELD, MILK ELECTRICAL CONDUCTIVITY AND MILK FLOW RATE IN FIRST-LACTATION JERSEY COWS IN SRI LANKA

A.M. Samaraweera[1,3], V. Boerner[1], S. Disnaka[4], J.H.J. van der Werf[2] and S. Hermesch[1]

[1]Animal Genetics & Breeding Unit*, University of New England, Armidale, NSW, 2351 Australia
[2]School of Environmental & Rural Science, University of New England, Armidale, NSW, 2351
[3]Uva Wellassa University, Badulla, 90000 Sri Lanka
[4]National Livestock Development Board, Narahenpita, 00500 Sri Lanka

SUMMARY

Milk electrical conductivity is an indicator trait for mastitis, and for maintaining udder health, moderate milking speed is important. The heritabilities of sum of daily milk yields, mean milk electrical conductivity and mean milk flow rate for each 30-day period along the lactation trajectory in Jersey cows milking in their first lactation in Sri Lanka were estimated. The data included 248,854 daily records and 362,754 morning and evening records from 991 cows that calved from 2015 to 2018. Variance components and variance ratios were estimated from posterior means obtained from a Gibbs sampler. The heritability as estimated by univariate analyses for milk yield, milk electrical conductivity and milk flow rate ranged from 0.04 ± 0.01 to 0.13 ± 0.03, from 0.06 ± 0.02 to 0.09 ± 0.02, and from 0.06 ± 0.02 to 0.18 ± 0.05, respectively. Additive genetic correlations between milk yield and milk electrical conductivity or milk flow rate along the lactation ranged from -0.31 ± 0.49 to 0.77 ± 0.19 and from 0.46 ± 0.29 to 0.89 ± 0.12, respectively. Present heritability estimates were sufficiently high for milk electrical conductivity and flow rate to be used in a selection index. However, these estimates should be confirmed with more data.

INTRODUCTION

Mastitis is an important disease among dairy cows in the tropics which causes substantial economic losses (Bangar *et al.* 2015). Selective breeding against mastitis susceptibility is important to increase mastitis resistance in dairy cows. Milk electrical conductivity has been used as an indirect trait to reflect mastitis incidence (Norberg 2005). Fast milking is associated with a wider teat canal, which could lead to the entry of pathogens, and increased somatic cell score (Carlström *et al.* 2016). Therefore, moderate milk flow rate is important for udder health. The increasing use of modern milking systems in developing countries provides an opportunity to use automatically recorded data such as daily milk yield and milk electrical conductivity in genetic evaluation (Samaraweera *et al.* 2018). In Sri Lanka, milking systems with automatic recording are becoming popular, alongside recent importation of dairy cows to large-scale farms. The aim of this study was to estimate genetic parameters for milk yield, milk electrical conductivity and milk flow rate in first-lactation Jersey cows in an intensive dairy farm in Sri Lanka.

MATERIALS AND METHODS

Data. Milk yield records were obtained from a dairy farm located 37 meters above sea level of Sri Lanka, using Jersey cows imported from Australia as pregnant heifers. Milk yield, milk electrical conductivity and milking duration were recorded automatically in a DeLaval™ milking parlour. Daily milk yield and milking duration data were available from 248,854 daily records and milk electrical conductivity was available from 362,754 morning and evening (session) records from days five to 305

---

* A joint venture of NSW Department of Primary Industries and the University of New England

in first lactation. Data were available for 991 Jersey cows that calved from July 2015 to January 2018.

Data cleaning. Any negative milking durations for daily milk yields were removed and assumed to be an error in recording. Milking duration (measured in sec) was used to calculate milk flow rate (as kg/min). Any records with zero milk electrical conductivity were removed assuming a failure to record the milk electrical conductivity. Daily averages for the milk electrical conductivity (mS/cm) were calculated. The lactation length was divided into ten, 30-day periods starting from day five and going through to day 305. The total milk yield (MY), mean milk electrical conductivity (EC) and mean milk flow rate (FR) were calculated for each period. Outliers that differed by more than four standard deviations from the mean were excluded from the analyses.

Genetic parameter estimation. For each 30-day period, MY, EC and FR were considered as separate traits. The univariate animal model fitted was $\boldsymbol{y} = \boldsymbol{Xb} + \boldsymbol{Za} + \boldsymbol{e}$, where $\boldsymbol{y}$ is the vector of observations, $\boldsymbol{b}$ is the vector of estimates for fixed effects of year-season of calving (YS, for all traits) and lactation length as a covariate (for milk yield), $\boldsymbol{a}$ is the vector of random animal additive genetic effects estimates, $\boldsymbol{X}$ and $\boldsymbol{Z}$, the incidence matrices relating records to the fixed effects and random animal effects, and $\boldsymbol{e}$, the vector of random residual effects. The YS was used as the contemporary group and any contemporary groups with less than eight cows were discarded. There were two seasons as dry (from Dec to April next year) and wet (from May to Nov) and five YS combinations. The total number of animals in the pedigree was 1572 with information up to 3 generations. Cows with phenotypic records (991) descended from 39 sires and 521 cows out of total cows with phenotypes were related to one of 38 maternal grandsires. No maternal grandsires were used as sires. All sires for cows with data were known, but all dams were unknown. Therefore, maternal grandsires were fitted into the pedigree using dummy dams assuming a unique dam for each offspring.

Variance components for the three traits were estimated via the univariate model described above, using a Bayesian approach implemented in the BESSiE software (Boerner and Tier 2016). A blocked Gibbs sampler was run for 50,000 cycles, with scaled inverted Wishart distributions assigned as prior processes to the residual and additive genetic co-variance matrices with parameter “$\boldsymbol{\nu}$” set to “x” and “y”, respectively (see Sorensen and Gianola (2002, pp. 576-588) for further details). The additive genetic and residual variances were calculated as posterior means by averaging the sum of every 100th iteration omitting the first 1000 iterations as burn-in. The additive genetic correlations between MY and EC and MY and FR for each period were estimated with bivariate animal models. The additive genetic correlations between periods within the same traits were estimated with ten-trait animal model.

RESULTS AND DISCUSSION

Milk yield (MY) was highest in the second and third 30-day periods, close to the peak milk production (around 60 days in milk) (Table 1). The coefficient of variation (CV) for MY was highest at the beginning (0.32) and at the end of lactation (0.35) whereas in the middle of the lactation the CV was around 0.22.

Mean EC across the whole lactation was 6.2 mS/cm and EC was highest at the beginning of lactation (6.4 mS/cm) and slightly decreased towards the end of lactation (6.2 mS/cm) (Table 1), with little variation in EC over the lactation. Similar ECs were observed in the literature for mastitis-infected cows, e.g. Norberg *et al.* (2004) found healthy, sub-clinically infected and cows with clinical mastitis had ECs (mS/cm) of 5.30 ± 0.03, 5.75 ± 0.04 and 6.73 ± 0.06, respectively ($P<0.001$). Therefore, the relatively high EC values in this study suggests that some cows had mastitis. However, there are a number of other factors that affect the milk EC such as milk temperature, bacterial strain, milk fat content etc. (Nielen *et al.* 1992; Woolford *et al.* 1998; Mabrook and Petty 2003). Therefore, changes in milk EC need to be validated with mastitis incidences.

Mean FR for 30-day milking periods throughout the lactation ranged from 1.08 to 1.41 kg/min (Table 1) and minimum and maximum values ranged from 0.40 to 2.30 kg/min, respectively. A study with higher mean MY (30 kg/d) than this study (14 kg/d) reported higher mean (2.2 ± 0.5 kg/min) and variation (from 0.3 to 8.2 kg/min) for FR (Firk *et al.* 2002).

Table 1. Descriptive statistics of milk yield (kg), milk electrical conductivity (mS/cm) & milk flow rate (kg/min) in each 30-day days in milk class

Days in	Milk yield			Milk electrical conductivity			Milk flow rate		
milk	# cows	Mean	SD	# cows	Mean	SD	# cows	Mean	SD
5-34	967	408	131	961	6.40	0.36	966	1.26	0.23
35-64	944	469	113	944	6.31	0.34	831	1.17	0.27
65-94	929	459	96	931	6.26	0.35	728	1.08	0.27
95-124	919	431	89	923	6.23	0.35	945	1.41	0.25
125-154	914	409	85	917	6.21	0.33	932	1.40	0.25
155-184	914	388	87	912	6.18	0.33	924	1.36	0.25
185-214	896	370	86	901	6.18	0.35	918	1.35	0.24
215-244	891	344	88	889	6.16	0.36	917	1.35	0.24
245-274	880	315	88	877	6.20	0.37	898	1.30	0.25
275-305	831	285	100	819	6.19	0.37	891	1.25	0.25

The heritability estimates for MY and EC were low compared to literature (Table 2). For example, moderate and high heritability for EC (ranged from 0.15 to 0.39) has been reported in Norberg (2005). FR was moderately heritable (0.10) and our estimates were consistent with Zwald *et al.* (2005) (milking duration, 0.17 ± 0.03). The phenotypic variance for EC and FR (Table 1) was close to the observed variance (Table 2) indicating that the YS did not explain much of the variance of EC and FR. Heritability estimates were slightly higher for all traits in the bivariate and multivariate analyses but differences from those from the univariate analysis were small.

Table 2. Heritability ± standard errors ($\mathbf{h^2 \pm seh^2 \pm se}$) & phenotypic variance ($\boldsymbol{\sigma_p^2\sigma_p^2}$) from univariate analyses for milk yield, milk electrical conductivity and milk flow rate in Jersey cows

Days in	Milk yield		Milk electrical conductivity		Milk flow rate	
milk	$h^2 \pm se$	σ_p^2	$h^2 \pm se$	σ_p^2	$h^2 \pm se$	σ_p^2
5-34	0.08 ± 0.03	5099	0.09 ± 0.02	0.13	0.06 ± 0.02	0.05
35-64	0.13 ± 0.03	5675	0.06 ± 0.02	0.12	0.09 ± 0.03	0.07
65-94	0.08 ± 0.02	5196	0.08 ± 0.03	0.12	0.07 ± 0.02	0.07
95-124	0.12 ± 0.03	5385	0.09 ± 0.02	0.12	0.09 ± 0.03	0.06
125-154	0.11 ± 0.03	4809	0.06 ± 0.02	0.11	0.13 ± 0.04	0.06
155-184	0.10 ± 0.03	5067	0.08 ± 0.02	0.11	0.18 ± 0.05	0.06
185-214	0.08 ± 0.02	5564	0.08 ± 0.03	0.12	0.15 ± 0.04	0.05
215-244	0.04 ± 0.01	5593	0.08 ± 0.02	0.13	0.10 ± 0.03	0.06
245-274	0.04 ± 0.02	5138	0.06 ± 0.02	0.14	0.11 ± 0.03	0.07
275-305	0.06 ± 0.02	5443	0.06 ± 0.02	0.14	0.07 ± 0.02	0.06

The low additive genetic correlations (<0.30, results not shown) within the same trait across 30-day periods of lactation show that they were independent traits. Additive genetic correlations between MY and EC ranged from -0.31 ± 0.49 to 0.77 ± 0.19 with high standard errors (Table 3). The additive genetic correlation between MY and EC was higher and positive around peak milk production (from 65 to 94 days). Significant positive additive genetic correlations between MY and FR were also observed, and additive genetic correlations ranged from 0.46 ± 0.29 to 0.89 ± 0.12 (Table 3). Therefore, selecting cows solely for high milk yield would lead to a correlated response of increased FR and EC. Therefore, selection emphasis would need to balance the value of increasing milk yield with electrical conductivity and an intermediate optimum for milk flow rate.

Table 3. Additive genetic ($r_a r_a$) and phenotypic ($r_p r_p$) correlations between milk yield (1), milk electrical conductivity (2) & milk flow rate (3) for each days in milk class in Jersey cows

	Days in milk									
	5-34	35-64	65-94	95-124	125-154	155-184	185-214	215-244	245-274	275-305
$r_{a,12}$	-.11±.40	.25±.46	.77±.19	.44±.32	-.03±.49	.26±.49	.03±.45	.02±.60	-.31±.49	-.31±.48
$r_{p,12}$	-.04±.03	.08±.04	.12±0.03	.09±.03	.09±.03	.08±.03	-.01±.04	-.05±.04	-.09±.05	-.19±.04
$r_{a,13}$	.89±.12	.46±.29	.54±.35	.54±.33	.78±.22	.53±.36	.79±.20	.66±.33	.53±.39	.81±.19
$r_{p,13}$	.69±.02	.50±.03	.48±.03	.51±.03	.56±.02	.64±.02	.63±.02	.65±.02	.67±.02	.67±.02

CONCLUSIONS

A significant positive additive genetic correlation between MY and EC was found around peak milk production and the same between MY and FR was positive. The heritabilities for MY and EC from this data were lower than anticipated. However, present heritability estimates were adequate to use EC and FR in a selection index. The genetic parameters for MY, EC and FR should be confirmed with more data.

ACKNOWLEDGMENTS

The authors thank the University of New England for providing the PhD Research Award (UNE IPRA) for the first author and National Livestock Development Board (NLDB), Sri Lanka for supplying the data.

REFERENCES

Bangar Y.C., Singh B., Dohare A.K., and Verma M.R. (2015) *Trop. Anim. Health Prod.* **47:** 291.

Boerner V. and Tier B. (2016) *Genet. Sel. Evol.* **48:** 63.

Carlström C., Strandberg E., Johansson K., Pettersson G., Stålhammar H. and Philipsson J. (2016) *Acta Agric. Scand. A.* **66:** 84.

Firk R., Stamer E., Junge W. and Krieter J. (2002) *Archiv fur Tierzucht* **45:** 213.

Mabrook M. and Petty M. (2003) *J. Food Eng.* **60:** 321.

Nielen M., Deluyker H., Schukken Y. and Brand A. (1992) *J. Dairy Sci.* **75:** 606.

Norberg E. (2005) *Livest. Prod. Sci.* **96:** 129.

Norberg E., Hogeveen H., Korsgaard I.R., Friggens N., Sloth K. and Løvendahl P. (2004) *J. Dairy Sci.* **87:** 1099.

Samaraweera M., Boerner V., Cyril H.W., van der Werf J. and Hermesch S. (2018) *Proc. World Congr. Genet. App. Livest. Breed.* **11**:741.

Sorensen D., and Gianola D. (2002) In 'Likelihood, Bayesian, and MCMC methods in quantitative genetics.' pp. 576-588, Springer Science & Business Media: New York.

Woolford M.W., Williamson J.H. and Henderson H.V. (1998) *J. of Dairy Res.* **65:** 187.

Zwald N., Weigel K., Chang Y., Welper R. and Clay J. (2005) *J. Dairy Sci.* **88:** 1192.