Genetic parameters for milk yield, persistency, conductivity and milking efficiency in first lactation Jersey cows in Sri Lanka

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

[1] Animal Genetics & Breeding Unit, a joint venture between NSW Department of Agriculture and University of New England, University of New England, Armidale 2351, NSW, Australia
asamaraw@myune.edu.au (Corresponding Author)
[2] School of Environmental and Rural Science, University of New England, Armidale 2351, NSW, Australia
[3] Uva Wellassa University, Badulla 90000, Sri Lanka
[4]National Livestock Development Board, Narahenpita 00500, Sri Lanka

Summary

Dairy production in Sri Lanka is slowly changing from a small-scale extensive system within mixed farms to larger specialized units with intensive management based on temperate breeds and modern milking systems. The country's tropical climate may require a special breeding program for imported breeds to enhance adaptability to local conditions which could be based on data automatically recorded at the parlour. Therefore, the objective of this study was to estimate genetic parameters for milk persistency, milk electrical conductivity, flow rate, 305-day milk yield and daily am/pm milk yield using data collected automatically from November 2015 to March 2016 for imported first-lactation Jersey cows (826 cows) under an intensive management system in a single farm. Variance components and variance ratios were estimated as posterior means from a Bayesian Gibbs sampling analysis. As expected from the data structure, heritabilities were low to medium for all analysed traits and genetic correlations were all in the expected direction. Therefore, even in Sri Lanka's tropical conditions the genetic component of the phenotypic variation is sufficient to establish a breeding program based on imported Jersey cows to breed a locally adapted dairy cow.

Keywords: dairy cattle, milk yield traits, milk yield persistency, milk electrical conductivity, milk flow rate

Introduction

Milk yield is the primary trait of importance in dairy cattle production and the most important trait in a dairy breeding objective. Due to intense selection for milk yield and the unfavourable genetic correlation between milk yield and most of the functional and fitness traits, intensely selected cows have a decreased fitness performance (Veerkamp *et al.*, 2009). Regardless of this, improved dairy breeds are widely used either as purebreds or crossbreds to improve the local milk production in tropical climates where fitness traits are essential (Ojango & Pollott, 2002). This generates problems of poor survival and reproduction. A possible solution to these problems is to develop a locally adapted dairy breed based on a foundation stock of imported temperate dairy cattle. However, a precondition for the efficient implementation of breeding programs is the availability of reliable phenotypic data and pedigrees, enabling estimation of genetic parameters. In developing countries this precondition is often not met. With a slow but ongoing change of Sri Lanka's dairy production from small-holder extensive system embedded in a mixed farm operation to larger, more specialized units intensively managed using modern milking systems such breeding programs may be based on traits which are automatically recorded in the milking parlour.

Modern milking systems with more intensive management in developing countries provide potential to use data such as daily milk records, milking duration and milk electrical conductivity. Milk electrical conductivity has been used as a measure of udder health, especially mastitis, along with incorporation of other information sources such as milk flow (Khatun *et al.*, 2017). Daily records allow evaluation of cows' ability to maintain production after peak yield or the milk yield persistency (Jakobsen *et al.*, 2002). In terms of the number of cows milked per hour or the milk parlour efficiency and milk flow rate are important (Zwald *et al.*, 2005).

Therefore, the objective of this study was to estimate genetic parameters for milk yield persistency, milk electrical conductivity and flow rate along with 305-day milk yield and daily am/pm milk yield under an intensive management system of first lactation Jersey cows in Sri Lanka.

Material and Methods

Data

Data were obtained from a single dairy farm in Sri Lanka which uses only imported Jersey and Jersey-Friesian cross cows for milk production. All cows were imported from Australia as heifers and had calved between November 2015 and March 2016. The farm is located at 22 meters above sea level. The local climate is characterized by a distinct wet season, a mean annual temperature of 27 degrees Celsius, an average relative humidity between 70 and 80% and a total annual rainfall between 1000 and 2500 mm. Management is characterized by non-grazing, feed supplementation, artificial shed cooling, artificial insemination, mechanical milk extraction every 12 hours in a DeLaval™ parlour (thus two milk sessions per day) and automatic data collection by the parlour. Data collected by the parlour at every session were milk yield, milk flow rate and milk electrical conductivity. From the parlour data, traits were calculated as follows:

- Daily milk production records with 305 days in milk were aggregated and used as the 305-day milk yield for each cow. Cows with more than 50 missing records were excluded from the analyses. The final analysis included 200,605 daily records from 665 cows aggregated to 305-day (301.7 records per cow).
- Milk yield persistency (MP) was defined as the regression slope of daily milk yield on day of lactation. Only lactations with at least 150 non-zero daily milk records collected from 80 to 305 days in milk were used to derive milk persistency.
- Session milk production records were used to estimate session means for milk yield (SM), electrical conductivity (SC) and flow rate (SF). An average conductivity measure was available per session from all quarters of the udder, hence mean average conductivity was obtained per cow per session. Any sessions with zero milk yield were excluded from analysis. For SC, records with zero average electrical conductivity were removed from the analyses.
- Based on the availability of daily session records, daily means from late lactation (260 to 305 days in milk) were selected from cows with at least 30 records per cow to get means for each trait (SM, SC, & SF). After the traits were formed, outliers that differed more than four standard deviations from the mean were excluded from the

analyses.

The total number of animals in the pedigree was 1313. The average numbers of daughters per sire and maternal grand sire were 21.2 (range: 13 to 31) and 3.9 (range 0 to 17) where only 403 had maternal grand-sires. No maternal grand-sires were used as sires. Since the dams were all unknown, maternal-grand sires were fitted into the pedigree using dummy dams assuming a unique dam for each offspring.

Fixed effects and covariates were identified by least square estimation as year-month (MP) or the month of calving (305d, SM, SC) to define contemporary groups as well as time from arrival to farm till calving (SF) and days in milk (SD). For fixed effects, the minimum size of the contemporary group was ten. Variance components were estimated by BESSiE software (Boerner & Tier, 2016) using a Bayesian approach fitting an animal model. A blocked Gibbs sampler implemented in BESSiE was run for 50,000 cycles, and the additive genetic and phenotypic variance and covariance were calculated as posterior means by averaging the sum of every 100th cycle omitting the first 1000 cycles as burn-in.

Results and Discussion

Descriptive statistics of the six traits, 305-day milk yield, milk yield persistency, session milk yield, milk electrical conductivity and flow rate are given in Table 1. The coefficient of variation of all traits was high indicating considerable individual variation in selected traits except for SC. First lactation 305d milk yield and a daily average of 10.9 kg reported in this study were considerably higher than the average milk yield of Jersey cows reported earlier in Sri Lanka (Kollalpitiya *et al.*, 2012). Selection of cows with flatter lactation curves ensures stable milk production even after the peak milk yield, and potentially reduces the physiological stress due to peak yield in high yielding cows. The observed maximum value for milk persistency indicates the promising cows for selection whose milk yield decline is less than average cows after day 80. The observed phenotypic variation in MP indicates that conditional on existing genetic variation selection for increased persistency is feasible.

Since milk Na^+ and Cl^- concentrations increase in mastitis infected cows, electrical conductivity has been used as an indirect trait to detect mastitis (Norberg *et al.*, 2004). Mean electrical conductivity reported for dairy cows in the literature are 4.90 mS/cm (Vilas Boas *et al.*, 2017) and 4.8 ± 0.01 mS/cm (Norberg, *et al.*, 2004) where the latter found an increased mean of 5.37 ± 0.02 mS/cm in animals with subclinical mastitis. Comparatively high electrical conductivity of 6.2 ± 0.38 mS/cm in this study is expected since there is an increased probability of cows with mastitis at the end rather than the beginning of lactation. The trait was formed from parlour data obtained after the 260th milking day.

Table 1. Descriptive statistics of the selected traits.

Trait[1]	Units	n	Mean	SD	CV	Min	Max
305d	kg	665	4240.18	646.46	15	2224.09	6078.22
MP	kg/day	813	-0.028	0.013	46	-0.079	-0.0002
SM	kg	595	5.45	1.38	25	2.05	9.13
SC	mS/cm	488	6.16	0.38	6	4.98	7.44
SF	kg/min	611	1.18	0.26	22	0.52	2.15

[1]305d-305-day milk yield; MP-milk yield persistency; 260 to 305 days in milk - SM-mean session milk yield: SC-mean session milk electrical conductivity; SF-mean session milk flow rate

Variance components were estimated using a Gibbs Sampling approach which was found to be more suitable than REML for a data set characterized by a small sample size and a shallow pedigree. Heritability estimates and phenotypic variances obtained from univariate and multivariate analyses for the selected traits are given in Table 2. Table 3 shows the genetic correlations and their standard errors for the selected traits.

Table 2. Heritability ± standard errors (se) from univariate (h^2_u) and multivariate (h^2_m) analyses and phenotypic variance from univariate ($\sigma^2_{p,u}$) and multivariate ($\sigma^2_{p,m}$) analyses for the selected traits.

Traits[1]	h^2_u/se	h^2_m/se	$\sigma^2_{p,u}$	$\sigma^2_{p,m}$
305d	0.06 ± *0.02*	0.14 ± *0.08*	407221.7	431343.7
MP	0.07 ± *0.02*	0.14 ± *0.07*	0.00016	0.00016
SM	0.06 ± *0.03*	0.13 ± *0.07*	1.909	2.027
SC	0.12 ± *0.04*	0.24 ± *0.14*	0.148	0.158
SF	0.13 ± *0.04*	0.19 ± *0.09*	0.094	0.071

[1]305-day milk yield (305d), milk yield persistency after 80th day in milk (MP), mean session milk yield (SM), mean session milk electrical conductivity (SC), mean session milk flow rate (SF) from 260 to 305 days in milk.

Table 3. Genetic correlations (above the diagonal), standard errors (se) of genetic correlations (below the diagonal) for the selected traits.

Traits[1]	305d	MP	SM	SC	SF
305d		-0.14	0.61	0.09	0.44
MP	*0.37*		0.54	-0.09	0.42
SM	*0.26*	*0.29*		-0.05	0.73
SC	*0.38*	*0.35*	*0.33*		0.29
SF	*0.31*	*0.32*	*0.18*	*0.29*	

[1]305-day milk yield (305d), milk yield persistency after 80th day in milk (MP), mean session milk yield (SM), mean session milk electrical conductivity (SC), mean session milk flow rate (SF) from 260 to 305 days in milk.

Heritability estimates were different for univariate and multivariate analyses for traits (Table 2). Estimates were higher for all traits based on the multivariate analyses. However, estimates were not significantly different between univariate and multivariate analyses given the higher standard errors for estimates from the multivariate analyses. In comparison, the heritability estimate for 305-day milk yield was lower than in the literature (0.32 ± 0.02) for Holstein-Friesian cows in Australia (Haile-Mariam *et al.*, 2003). As anticipated, a positive genetic correlation was observed for 305-day milk yield with mean session milk yield (0.61 ± 0.26) and session flow rate (0.44 ± 0.31), indicating that the increased 305-day milk yield will increase the daily milk yield and milk flow rates. Moreover, milk flow rate was moderately heritable (0.19 ± 0.07) and our estimate was consistent with Zwald*, et al.* 2005 (milking speed, 0.11).

In terms of milking parlour efficiency, faster milking is important. However, considering the udder health, moderate milking speed is vital. Fast milking is associated with wider teat canal, which facilitates entry of pathogens, and increased somatic cell score (Carlström *et al.*, 2016). The indirect measure used in the study for udder health is milk electrical conductivity. Electrical conductivity was moderately heritable (0.24 ± 0.14) and showed no significant genetic correlations with 305-day milk yield, session milk yield and milk flow rate (range: -0.09 to 0.09). These weak genetic correlations indicate no significant trade-off between the daily performance level and udder health in late lactation in these cows, which should be taken care of in breeding programs in humid tropical conditions.

Milk yield persistency has been measured by a number of traits. In this study, milk yield persistency was estimated taking the slope of daily milk yield on day after day 80. The heritability estimate for milk persistency was 0.14 ± 0.08, with a weak negative genetic correlation with 305-day milk yield of -0.14 ± 0.37. A separate study, where the slope of the individual lactation was taken after day 150, reported a heritability estimate of 0.10 ± 0.10 for persistency with a -0.58 ± 0.05 genetic correlation between mean milk yield and slope (Haile-Mariam*, et al.*, 2003). The difference in genetic correlation might be due to the days of lactation selected for the persistency estimate, but could be also reflect the structure of the data used in this study. However, genetic progress in persistency has to be addressed with care, since persistency interferes with drying off at the end of 305-day milk yield if the target is one calf per cow per year. Further, incorporation of reproductive traits in breeding goals has to be considered because often longer lactations are a result of poor conception rates.

Conclusions

Our results show that automatic recording in modern parlour systems can be used for obtaining phenotypic observations which can enable evaluation for breeding programs. This is especially relevant for developing countries where on-farm innovations may be not accompanied by a laboratory infrastructure for milk analysis. The results also show that the genetic component of the performance variation of Jersey cows kept under tropical conditions is sufficient to establish a breeding program which if implemented appropriately should result in a dairy cow better adopted to local tropical conditions and with improved performance.

Acknowledgements

The authors thank National Livestock Development Board (NLDB), Sri Lanka for supplying the data. The first author received an International Postgraduate Research Award from the University of New England.

List of References

Boerner, V. & B. Tier, 2016. BESSiE: a software for linear model BLUP and Bayesian MCMC analysis of large-scale genomic data. Genet. Select. Evol. 48 (1): 63.

Carlström, C., E. Strandberg, K. Johansson, G. Pettersson, H. Stålhammar & J. Philipsson, 2016. Genetic associations of in-line recorded milkability traits and udder conformation with udder health. Acta Agric. Scand. A. 66 (2): 84-91.

Haile-Mariam, M., P. Bowman & M. Goddard, 2003. Genetic and environmental relationship among calving interval, survival, persistency of milk yield and somatic cell count in dairy cattle. Livest. Prod. Sci. 80 (3): 189-200.

Jakobsen, J.H., P. Madsen, J. Jensen, J. Pedersen, L. Christensen & D. Sorensen, 2002. Genetic parameters for milk production and persistency for Danish Holsteins estimated in random regression models using REML. J. Dairy Sci. 85 (6): 1607-1616.

Khatun, M., C.E. Clark, N.A. Lyons, P.C. Thomson, K.L. Kerrisk & S.C. García, 2017. Early detection of clinical mastitis from electrical conductivity data in an automatic milking system. Anim. Prod. Sci. 57 (7): 1226-1232.

Kollalpitiya, K., S. Premaratne & B. Peiris, 2012. Reproductive and productive performance of up-country exotic dairy cattle breeds of Sri Lanka. Trop. Agric. Res. 23 (4): 319-326.

Norberg, E., H. Hogeveen, I.R. Korsgaard, N. Friggens, K. Sloth & P. Løvendahl, 2004. Electrical conductivity of milk: ability to predict mastitis status. J. Dairy Sci. 87 (4): 1099-1107.

Ojango, J. & G. Pollott, 2002. The relationship between Holstein bull breeding values for milk yield derived in both the UK and Kenya. Livest. Prod. Sci. 74 (1): 1-12.

Vilas Boas, D.F., A.E. Vercesi Filho, M.A. Pereira, L.C. Roma Junior & L. El Faro, 2017. Association between electrical conductivity and milk production traits in Dairy Gyr cows. J. Appl. Anim. Res. 45 (1): 227-233.

Zwald, N., K. Weigel, Y. Chang, R. Welper & J. Clay, 2005. Genetic evaluation of dairy sires for milking duration using electronically recorded milking times of their daughters. J. Dairy Sci. 88 (3): 1192-1198.