EXPLORING FERTILITY TRAITS OTHER THAN CALVING INTERVAL FOR INCLUSION IN A NATIONAL GENETIC EVALUATION FOR SOUTH AFRICAN HOLSTEIN COWS

J.P. Potgieter[1], C.J.C. Muller[2], S.W.P. Cloete[1,2], O.T. Zishiri[1] and K. Dzama[1]

[1]Department of Animal Sciences, University of Stellenbosch, Stellenbosch 7600. South Africa
[2]Western Cape Department of Agriculture, Institute for Animal Production, Private bag X1, Elsenburg 7607, South Africa

SUMMARY

Poor fertility has become a major reason for the involuntary culling of dairy cows in South Africa. Routine analyses for fertility traits for Holstein cows in South Africa are at present based on calving interval (CI). Artificial insemination (AI) records were used to estimate genetic parameters for fertility traits for dairy cows in this study, using bivariate models (Linear-linear and threshold-linear). Traits analyzed were the interval from calving to first service (CFS), interval from calving to conception (DO), number of services per conception (SPC), (all linear), whether cows were inseminated for the first time within 80d postpartum (FS80d), whether cows were confirmed pregnant within 100d postpartum (PD100d) and whether cows were confirmed pregnant within 200d postpartum (PD200d) (as binary threshold traits, coded as 0=no and 1=yes) Estimates of heritability for these fertility traits were low and ranged from 0.04 to 0.09.

INTRODUCTION

Fertility is an important trait for profitable dairy cattle production, since a fertile herd means fewer services to conception, lower veterinary and replacement costs, and a reduction in the length of expensive dry periods. Breeding and selection programmes in South African Holstein herds have for many years focused on milk yield and conformation traits. Over the last decade there has been a growing interest in broadening selection programmes to include functional traits such as reproduction and health. Several studies worldwide have reported declines in the reproductive performance of dairy cows (Royal *et al*. 2002; Berry *et al*. 2003). Similarly, in South African Holsteins, calving interval (CI) increased from 386 days in 1986 to 412 days in 2004 (Makgahlela 2008). Limited research in this regard has been conducted for the South African dairy industry. Genetic parameters for some fertility traits have been estimated for small data sets for Jersey (Potgieter *et al*. 2004) and Holstein (Muller *et al*. 2006) cows. The number of lactation records used was 2639 and 3642 for 751 Jersey and 1375 Holstein cows respectively. Heritability estimates for key fertility traits were within the range of estimates from overseas studies.

Recently, estimated breeding values for CI have been estimated for South African Holstein and Jersey cows and are presented in herd profiles to dairy farmers (Mostert. 2009). However, alternative traits to CI could be used to better indicate fertility in dairy cows. Three options exist to measure fertility in dairy cows, i.e (1) physiological indicators, (2) time intervals and (3) success or failure of insemination or pregnancy. Physiological indicators include quality of semen and hormone levels of the cow. Time intervals relates to time periods, assuming that the main objective of the dairy farmer is to achieve conception within the shortest time physiologically possible after calving. Calving interval, the interval between calving and first insemination, and days open are generally considered in this category. The third group of fertility indicators indicates the probability of a cow becoming pregnant after insemination. As farmers routinely record insemination dates and pregnancy examination results for management purposes, it is possible to determine these traits. Genetic parameters for alternative reproduction traits to CI are therefore presented in this study.

MATERIAL AND METHODS

Data. All artificial insemination (AI) records (n = 69 181) of cows that had calved down in the period between 1991 and 2007 in 14 South African Holstein herds were used. A total of 24 646 lactation records from 9 046 individual cows was available. The outcome of each AI event was known. Insemination records were linked to the calving date of each cow, lactation number, dam and sire identification numbers. By using this information, fertility traits that measure the ability to show heat early in the breeding period and the probability of success of insemination and confirmation of pregnancy were derived. Before analyses, records with missing sire and dam identification numbers were removed from the data set. After further edits, a data set of 16 648 records, representing 6 164 cows and 738 sires was suitable for analyses. Several authors (Pryce *et al*. 1998) have required that all cows have a subsequent calving date. This restriction was not implemented in the present study, because including only those cows that eventually became pregnant could introduce selection bias.

Statistical analyses. The data were analysed using bivariate linear-linear and linear-threshold animal models. The fixed effects fitted were herd (14 levels), year (17 levels), season (4 levels) and lactation number (6 levels). The traits analysed were interval from calving to first service (CFS), interval from calving to conception (DO), number of services per conception (SPC), (all linear), whether cows were inseminated for the first time within 80d postpartum (FS80d), whether cows were confirmed pregnant within 100d postpartum (PD100d) and whether cows were confirmed pregnant within 200d postpartum (PD200d) (as binary threshold traits, coded as 0=no and 1=yes). The model included the random effects of animal and animal permanent environment (PE). The software used was THRGIBBS1F90 (Misztal 2008). Single chains of 250 000 cycles were run, with the first 50 000 cycles used as the burn-in period. This was followed by post Gibbs analysis, using POSTGIBBSF90 (Misztal *et al*. 2002). Posterior means were used to calculate the heritability and animal PE variance ratios for each trait. Genetic, animal PE and residual correlations were calculated accordingly.

RESULTS AND DISCUSSION

The interval from calving to conception (DO) was high and variable at 133.89±74.33 days (Table 1). Only 36 and 71% of all cows were confirmed pregnant within 100 and 200 days postpartum.

Table 1. Descriptive statistics for the raw data analysed for the interval from calving to first service (CFS), interval from calving to conception (DO), number of services per conception (SPC), whether cows were inseminated for the first time within 80d postpartum (FS80d), whether cows were confirmed pregnant within 100d postpartum (PD100d) and whether cows were confirmed pregnant within 200d postpartum (PD200d)

Variable	CFS	DO	SPC	FS80d	PD100d	PD200d
Number of records	16605	14255	14255	16648	16648	16648
Mean	77.3[a]	133.9[a]	2.55	0.64	0.36	0.71
Standard Deviation	29.9	74.3	1.79	0.48	0.48	0.45
Coefficient of variation (%)	38.7	55.5	70.2	75.2	133.7	64.0
Min	21	21	1	0	0	0
Max	250	435	8	1	1	1

[a]In days

The number of services per conception for all cows was 2.55±1.79 indicating an insemination efficiency of 0.39. The number of services per conception is significantly higher (1.85) than SPC values reported by Haile-Mariam *et al. (*2004). According to Gonzales *et al*. (2006) the number of services per conception (SPC) measures female fertility directly and indicates the probability of conception when a cow is given the opportunity to get pregnant. The interval from calving to first service was 77.33±29.93 days with 64% of animals being inseminated for the first time within 80 days postpartum. Days from calving to first service (CFS) can be utilized as it is an indicator of the postpartum return to reproductive function when estrus synchronization is not a common practice.

Estimates of (co)variances and genetic parameters using a set of bivariate models are presented in Table 2. Heritability (h^2) estimates of reproductive traits were low ranging from 0.04 to 0.09. Estimated heritability of SPC was similar to values in other studies (Veerkamp *et al*. 2001; Kadarmideen *et al*. 2003; González-Recio *et al*. 2005). This indicates that genetic progress for the trait is quite feasible although progress is likely to be slow. However, it is noteworthy that the the genetic coefficient of variation of 6-week pregnancy rate in dairy cattle equals that of milk yield (Goddard 2009). The heritability of CFS was higher than that reported by González-Recio & Alenda (2005) as well as the estimate (0.03) that was reported by Anderson-Ranberg *et al*. (2005). This low value suggests that it will be difficult to achieve genetic progress by selecting for the trait. More emphasis should be placed on improving different aspects of dairy herd management. The range of heritability estimates for DO (0.05 to 0.08) was slightly higher than estimates (0.01 to 0.03) obtained by Van Arendonk *et al*. (1989), using a linear sire model.

Table 2: Estimates of heritabilities (h^2), animal permanent environmental effects (pe^2), and residual variances and direct additive, permanent environmental and residual correlations for the fertility traits defined in Table 1

Trait	CFS	DO	SPC	FS80d	PD100d	PD200d
			Additive genetic correlations (h^2 in bold)			
CFS	**0.08±0.02**	0.55±0.11	-0.10±0.01	0.03±0.01	0.64±0.01	-0.36±0.01
DO	-	**0.06±0.02**	0.72±0.01	-0.50±0.01	0.99±0.00	-0.98±0.02
SPC	-	-	**0.06±0.02**	-0.88±0.15	-0.88±0.16	-0.90±0.14
FS80d	-	-	-	**0.06±0.02**	0.54±0.16	0.36±0.15
PD100d	-	-	-	-	**0.07±0.02**	0.96±0.20
PD200d	-	-	-	-	-	**0.07±0.04**
			Permanent environmental correlations (pe^2 in bold)			
CFS	**0.03±0.02**	0.30±0.10	0.05±0.04	0.12±0.01	0.43±0.03	-0.19±0.02
DO	-	**0.08±0.05**	0.88±0.01	-0.34±0.02	0.99±0.00	-0.99±0.01
SPC	-	-	**0.06±0.02**	-0.93±0.17	-0.93±0.17	-0.93±0.16
FS80d	-	-	-	**0.05±0.03**	0.34±0.27	0.15±0.20
PD100d	-	-	-	-	**0.07±0.04**	0.94±0.17
PD200d	-	-	-	-	-	**0.10±0.05**
			Residual correlations (σ^2_e in bold)			
CFS	**662.3**	0.28±0.01	-0.10±0.00	0.04±0.00	0.49±0.00	-0.15±0.00
DO	-	**4665.6**	0.78±0.00	-0.24±0.01	0.97±0.00	-0.99±0.00
SPC	-	-	**2.75**	-0.91±0.01	-0.91±0.01	-0.77±0.01
FS80d	-	-	-	**1.00**	0.42±0.02	0.11±0.02
PD100d	-	-	-	-	**1.00**	0.97±0.02
PD200d	-	-	-	-	-	**1.00**

Genetic correlations among most fertility traits were high, as would be expected from the close link between various fertility measurements (Table 2). Estimates ranged from -0.88 to 0.99. Due to the high genetic correlation between some of the fertility traits most of the traits could be expressed as a function of another trait. In this study DO, PD100d and PD200d effectively have a genetic correlation of unity. CFS had a favourable genetic correlation (0.55) with DO, indicating cows inseminated later into the lactation had a longer interval from calving to conception. The genetic correlation between DO and SPC was 0.72, indicating that cows with longer DO needed more services per conception. Results derived for the PE effect (Table 2) indicated positive associations between common environments for DO and SPC. Negative relationships could be observed for SPC and FS80d, SPC and PD100d, SPC and PD200d which meant that animals with a low success of pregnancy would also have a longer interval for DO and that cows with a high number of inseminations would have a reduced chance of becoming pregnant. Level of management of herds may be partially the reason for these relationships.

CONCLUSION

The primary objective of this study was to identify traits other than CI to be used to predict the ability of cows to become pregnant. This required estimating correlations between several fertility traits. Based on the results of this study, traits such as CFS, DO and SPC can be used to predict the ability of cows to become pregnant. The results show that there is wide genetic variation in fertility traits, and therefore sufficient scope for selection.

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