GENETIC ANALYSES OF FERTILITY TRAITS IN BROWN SWISS AND SIMMENTAL BREEDS

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INTRODUCTION

Profitability of dairy farms is strongly related with cattle fertility. However, in recent decades, there is a well-founded evidence of loss of fertility in most of dairy cattle populations (Walsh et al., 2011; Lopez-Gatius, 2012), that has been accompanied by an increase of milk production (Lucy, 2001). Several alternatives have been proposed as the causes of this fertility loss. Among them, a negative correlation with milk production traits has been pointed out by several authors (Pryce et al., 2004; Tiezzi et al., 2011, 2012).

One potential solution for this problem can be achieved by the inclusion of fertility traits in the selection index of dairy populations (VanRaden et al., 2004; Huang et al., 2007). Nevertheless, their inclusion in current breeding programs is scarce because of the difficulty to obtain phenotypic records with enough quality. The most easily available fertility trait (caving interval) is available only for cows that became pregnant, whereas the other traits suffer of censoring. The consequence is that their heritability is often low and estimated with methods not taking into account censoring, for the large majority of cases on Holstein Friesian cattle.

The objective of the present study was to estimate genetic parameters of fertility interval traits in Brown Swiss and Simmental breeds.

MATERIAL AND METHODS

Data

Fertility records on Brown Swiss and Simmental breeds were obtained from the Breeders Federation of Alto Adige/Südtirol (Associacione Provinciale delle Organizzazioni Zootecniche Altoatesine) of Bolzano province (Italy). The data used were from cows which calved from years 2009 to 2017. Two different datasets, one for the Brown Swiss and one for the Simmental breed were created, with the variables of interest, fertility traits and the pedigree.

Fertility traits studied were calving interval (CI), and the intervals between calving and first service (ICF) and between first service and conception (IFC) and their sum, days open (DO). Traits ICF, IFC and DO contained censored records. DO was restricted to be between 20 and 395. Cows with DO lower than 20 were discarded and cows with a value higher than 395 were censored with an assigned value of 395. Herds with less than five observations/year were discarded.

Statistical Analyses

Estimation of variance components were obtained using a Bayesian approach assuming a single-trait animal model for each fertility trait. The assumed model was

$$\boldsymbol{y} = \boldsymbol{Xb} + \boldsymbol{Wp} + \boldsymbol{Za} + \boldsymbol{e}$$

where $\boldsymbol{y}$ is the vector of observations for the fertility traits, $\boldsymbol{b}$ is the vector of systematic effects, $\boldsymbol{p}$ is the vector of random permanent environment effect, $\boldsymbol{a}$ is the vector of animal genetic effect and $\boldsymbol{e}$ is the vector of residuals; and $\boldsymbol{X}, \boldsymbol{W}$ and $\boldsymbol{Z}$ are the incidence matrices for systematic and random environmental and additive genetic effects, respectively. Systematic effects included in the model were parity -4 levels-, year of calving –7 levels- and herd – 2151 levels for the Italian Brown Swiss and 1693 (for CI) and 1695 (for DO, ICF and IFC) levels for the Simmental breed-. The pedigree file (39517 animals for fertility trait CI, 35521 for ICF and 50588 for IFC and DO for the Brown Swiss and 31217 animals for fertility trait CI, 29617 for ICF and 36560 for IFC and DO for the Simmental) comprised animals with a phenotypic record and all their known ancestors. The analyses were implemented using the software TM (Legarra et al., 2008). For all analyses, the total number of iterations was 800000 with a burn in of 50000

RESULTS AND DISCUSSION

Phenotypic Records

Descriptive Statistics for fertility traits for both breeds are shown in Table 1. For the Brown Swiss breed, the number of valid records, number of animals and number of sires were highest for fertility traits IFC and DO, followed by CI and lowest for ICF. The number of herds was the same for all fertility traits studied. For fertility traits ICF, IFC and DO, the model included censored data. The percentage of censored data was highest for fertility trait IFC, followed by DO and ICF (29.94%, 29.14% and 24.11%, respectively).

For the Simmental breed, the number of valid records, number of animals and number of sires were highest for fertility traits DO and IFC, followed by CI and lowest for ICF. The number of herds was the same for fertility traits DO, ICF and IFC (1695) compared to CI (1693). For fertility traits ICF, IFC and DO, the model included censored data. The percentage of censored data was highest for fertility trait IFC, followed by DO and ICF (22.95%, 22.59% and 19.08%, respectively). Mean values for fertility traits ICF and CI are similar to those estimated in other studies (Berry et al.,2017; Liu et al., 2017; Morton et al., 2018) as well as for trait DO (Liu et al., 2017).

For all fertility traits studied (CI, ICF, IFC and DO), the number of valid records, animals, sires and herds as well as the percentage of censored data were higher for the Brown Swiss compared to the Simmental breed. The mean value estimated for fertility traits for the Brown Swiss and Simmental breeds were 420.59 and 391.21 days for CI, 91.82 and 79.88 days for ICF, 35.30 and 24.31 days for IFC and 128.78 and 104.59 days for DO, respectively. As seen in the study by Toledo-Alvarado et.al, (2017), mean values for the dairy breeds (Holstein Friesian and Brown Swiss) were higher for all fertility traits compared to the dual purpose breeds (Simmental and grey Alpine).

Variance components and heritability

Posterior (and standard deviation) estimates of variance components are shown in Table 2. All estimated variance components obtained where higher for the Brown Swiss compared to the Italian Simmental. In addition, for all fertility interval traits, as expected, the residual variance (σ_e^2) was the highest compared to the additive, herd and animal permanent environment variance ($\sigma_A^2, \sigma_{herd}^2$and σ_{pe}^2).

For the Brown Swiss breed, the additive variance was highest for the fertility trait DO (733.31) and similar between fertility traits CI, ICF and IFC (253.26, 247.76 and 288.92, respectively). For the Simmental breed, the additive variance was highest for the fertility trait DO (303.79), similar between CI and ICF (147.39 and 143.61, respectively) and lowest for IFC (89.20).

Estimates of heritabilities and herd, animal permanent environment and residual effects are shown in Table 3. For both Brown Swiss and Simmental breeds, posterior distribution of across-herd heritability of fertility interval traits was low and the highest effect was due, as expected, to the residual component. Across-herd heritability estimates of fertility traits in Brown Swiss breed ranged from 0.043 to 0.076 and in Simmental breed ranged from 0.024 to 0.074 for fertility traits IFC and ICF, respectively. Results obtained for heritability estimates for both Brown Swiss and Simmental breeds fell in the upper part of the range of heritability of fertility traits estimated in other studies (Liu et al., 2017) and confirms the difficulties of implementing an efficient breeding strategy for these traits. Nevertheless, some of them (i.e., 0.068 and 0.076 for fertility traits DO and ICF, respectively, for the Brown Swiss) have enough additive genetic variation to achieve a relevant genetic progress. Still, the assumed approach assumed independency with respect to the production level. In future research, we will explore the Genotype x Environment interaction with the production level trough several non-exclusive approaches such as a multiple trait or a reaction norm model.

ACKNOWLEDGMENTS

The authors thank the Associazione Provinciale delle Organizzazioni Zootecniche Altoatesine/Vereinigung der Sudtiroler Tierzuchtverbande (Bolzano/Bozen, Italy) for providing the data. The Italian Brown Swiss Cattle Breeders Association (ANARB, Verona, Italy) and Italian Simmental Cattle Breeders Association (ANAPRI) are also acknowledged for supplying pedigree information.

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Table 1. Descriptive statistics of fertility traits, number of records, animals, herds and sires and percentage of censored records for Brown Swiss and Simmental breeds.

	N	Animals	Herds	Sires	Mean	SD	Min	Max	Censored records, %
Brown Swiss									
CI[1],d	50911	25795	2151	1173	420.59	76.42	277	761	-
ICF[2],d	34930	22260	2151	1163	91.82	40.92	20	260	24.11
IFC[3],d	71751	34930	2151	1381	35.30	52.18	0	240	29.94
DO[4],d	71751	34930	2151	1381	128.78	70.97	20	395	29.14
Simmental									
CI[1],d	47136	21650	1693	730	391.21	60.21	276	761	-
ICF[2],d	35743	20038	1695	730	79.88	33.28	20	260	19.08
IFC[3],d	61013	26301	1695	810	24.31	42.11	0	240	22.95
DO[4],d	61013	26301	1695	810	104.59	57.37	20	395	22.59

CI[1] = calving interval; ICF[2] = interval from calving to first service, IFC[3] = interval from first service to conception, DO[4] = days open.

Table 2. Posterior estimates of variance components (additive, σ_A^2, herd, σ_{herd}^2, animal, σ_{pe}^2 and residual, σ_e^2) of fertility traits for Brown Swiss and Simmental breeds.

	σ_A^2	σ_{herd}^2	σ_{pe}^2	σ_e^2
Brown Swiss				
CI[1],d	253.26	534.15	572.197	4542.53
ICF[2],d	247.76	590.25	371.21	2064.92
IFC[3],d	288.92	377.31	639.14	5460.79
DO[4],d	733.31	986.96	1478.50	7593.26
Simmental				
CI[1],d	147.39	359.49	271.87	2879.44
ICF[2],d	143.61	373.45	162.06	1267.41
IFC[3],d	89.20	173.09	216.63	3189.58
DO[4],d	303.79	640.00	549.63	4649.53

CI[1] = calving interval; ICF[2] = interval from calving to first service, IFC[3] = interval from first service to conception, DO[4] = days open.

Table 3. Estimates of heritability (h^2) with its highest posterior density intervals between brackets, herd effect (h_{herd}^2), animal effect (h_{pe}^2) and residual effect (h_{re}^2) for fertility traits in Brown Swiss and Simmental breeds.

	h^2	h_{herd}^2	h_{pe}^2	h_{re}^2
Brown Swiss				
CI[1],d	0.043 [0.032; 0.055]	0.090	0.097	0.770
ICF[2],d	0.076 [0.054; 0.099]	0.180	0.113	0.631
IFC[3],d	0.043 [0.032; 0.055]	0.056	0.094	0.807
DO[4],d	0.068 [0.054; 0.082]	0.091	0.137	0.703
Simmental				
CI[1],d	0.040 [0.027; 0.053]	0.098	0.074	0.787
ICF[2],d	0.074 [0.054; 0.093]	0.192	0.083	0.651
IFC[3],d	0.024 [0.015; 0.034]	0.047	0.059	0.869
DO[4],d	0.049 [0.037; 0.063]	0.104	0.089	0.757

CI[1] = calving interval; ICF[2] = interval from calving to first service, IFC[3] = interval from first service to conception, DO[4] = days open.