J. Dairy Sci. 101:1–7
https://doi.org/10.3168/jds.2017-13041

Genetic parameters for yield, fitness, and type traits in US Brown Swiss dairy cattle

K. D. Gibson[1] and C. D. Dechow
Department of Animal Science, ThePennsylvania State University, University Park 16802

ABSTRACT

The objective of this research was to evaluate heritabilities and genetic correlations among yield, fitness, and type traits for US Brown Swiss cattle born in 2000 and later. The data set used consisted of 108,633 first through fifth lactation records from 45,464 cows for yield, somatic cell score (SCS), days open, and productive life. Approximately half of the records had observations for 17 type traits and 41,074 had observations for milking speed. These data were analyzed using a series of 3 trait models. Heritability estimates of each trait were similar to previously reported values for both Holsteins, and Brown Swiss in other countries. Milk, fat, and protein yield had strong positive genetic correlations with productive life (0.67 to 0.71), whereas days open and SCS had strong negative correlations with productive life (−0.60 and −0.69, respectively). Days open was more unfavorably correlated with dairy form (angularity) than with yield. The genetic correlation of udder depth and milk yield was unfavorable (−0.40), whereas rear udder height (0.20) and width (0.48) were favorably correlated with milk yield. Udder depth had a favorable genetic correlation with SCS (−0.26). Type traits with the strongest genetic correlations with productive life were fore udder attachment, mobility, and final score (0.44, 0.50, and 0.57, respectively). These updated genetic parameters will allow for improved genetic selection within the Brown Swiss breed.
Key words: yield, type, milking speed, mobility

INTRODUCTION

Worldwide, dairy cattle breeding programs have shifted their emphasis from primarily yield and type traits to a more balanced breeding objective that includes fitness traits (Miglior et al., 2005). Relationships among yield, type, and fitness traits have been well documented for Holstein cattle in the United States; however, such is not the case for Brown Swiss cattle. Holsteins make up approximately 85% of the US dairy herd, whereas Brown Swiss represent less than 1%. However, Brown Swiss cattle offer benefits from a cheese-making standpoint and were reported to yield 5% more cheese despite producing 9% less milk on a per-day basis (De Marchi et al., 2008). This is an attractive characteristic in a changing dairy market, where in the United States cheese production has doubled over the past 25 yr (Johnson and Lucey, 2006). The objective of this study was to estimate heritabilities and correlations among yield, fitness, and type traits using a population of Brown Swiss cows in the United States to update genetic parameters and facilitate progress for the breed.

MATERIALS AND METHODS

Data were from first- through fifth-lactation Brown Swiss cows in the United States born in 2000 or later from herds involved in DHI testing. There were 108,633 lactation records with data for at least 1 trait from 45,464 cows in 386 herds and 8,420 herd calving clusters. Herd calving clusters comprised cows that calved in the same herd in the same time period and were generated with the FASTCLUS procedure of SAS (version 9.4; SAS Institute, Cary, NC), with starting cluster seeds set to a 60-d window and a minimum of 10 cows per cluster required. Records for second and later lactations for all traits were kept only from cows that also had a first-lactation record in the data set to avoid selection bias. In total, 105,991 of the records had values for milk, fat, and protein yield, which were adjusted to 305-d mature equivalents, and 104,909 records had a lactation-average SCS value. The 2,642 records missing yield data were from cows that calved but then died or were culled early in lactation and before they had a 305-d yield. These records were still considered for productive life evaluations. Productive life was available for 31,489 cows and was expressed as months in milk with the diminishing credits procedure as described by VanRaden et al. (2006). Days open records were confirmed by subsequent calvings, veterinary confirma-

Received April 18, 2017.
Accepted October 2, 2017.
[1]Corresponding author: kgibson@selectsires.com

Table 1. Descriptive statistics of yield, fitness, and type traits[1]

Item	No. of records	No. of cows	Mean	SD	Minimum	Maximum
MY (kg)	105,991	45,423	9,882	213	1,964	24,081
FY (kg)	105,991	45,423	399	93	64	1,283
PY (kg)	105,991	45,423	328	70	70	748
SCS	104,909	45,088	2.76	1.3	0.15	9.58
MS	41,074	26,346	5.8	1.5	1	8
DO	83,343	37,982	149.9	68.5	25	250
PL	31,489	31,489	25.7	17.8	0.04	119
STAT	52,263	31,123	29.2	7.8	1	50
STR	52,262	31,123	26.0	7.6	3	45
BD	52,262	31,123	27.4	7.7	2	45
RA	52,259	31,122	24.3	7.2	5	50
RW	52,248	31,116	26.6	7.2	4	45
DF	52,257	31,123	27.9	8.1	1	45
FA	52,249	31,120	28.5	7.9	1	50
RLS	52,259	31,122	24.0	6.4	1	47
RLR	44,198	27,636	30.2	7.3	5	45
MO	35,442	22,414	84.1	4.3	50	95
UD	52,258	31,123	29.3	7.4	5	50
FU	52,251	31,121	27.5	8.1	2	50
RUH	52,246	31,115	28.2	7.3	2	50
RUW	52,240	31,112	28.8	7.7	1	50
UC	52,238	31,115	26.0	8.2	3	49
TP	52,254	31,122	25.8	7.5	4	50
TL	52,255	31,122	24.3	8.3	2	45
FS	52,262	31,125	84.2	3.3	53	93

[1]MY = milk yield; FY = fat yield; PY = protein yield; MS = milking speed; DO = days open; PL = productive life; STAT = stature; STR = strength; BD = body depth; RA = rump angle; RW = rump width; DF = dairy form; FA = foot angle; RLS = rear leg side view; RLR = rear leg rear view; MO = mobility score; UD = udder depth; FU = fore udder attachment; RUH = rear udder height; RUW = rear udder width; UC = udder cleft; TP = teat placement; TL = teat length; FS = final score.

tion of pregnancy, or culling for infertility. Days open values of less than 25 were recoded as missing, and days open greater than 250 were set to 250, consistent with edits for national genetic evaluations of daughter pregnancy rate (VanRaden et al., 2004). Following this edit, there were 83,343 records that had a value for days open. Data for yield, SCS, productive life, and days open were provided by the Council on Dairy Cattle Breeding (Reynoldsburg, OH). In addition, producer-assigned milking speed scores and classification scores were provided by the Brown Swiss Cattle Breeders' Association of the USA (Beloit, WI). There were 41,074 milking speed records on a scale of 1 (slow milking) to 8 (fast milking), approximately 52,250 records for 16 linear type traits scored on a scale of 1 to 50, and a final classification score on a scale of 60 to 94. There were also 35,442 mobility scores; these were assigned during type classification and range from 50 to 99. A higher value is more desirable and indicates that the cow is able to move, stand up, and lie down and has structurally correct feet and legs. Number of records and cows, means, standard deviations, minimums, and maximums for each trait are summarized in Table 1. The final data set consisted of 45,464 first-lactation, 29,998 second-lactation, 18,327 third-lactation, 10,111 fourth-lactation, and 4,733 fifth-lactation records. The pedigree file included 127,401 animals, including 5,728 bulls with daughters that had records. Sire pedigrees were traced in the Council on Dairy Cattle Breeding database to 1960, whereas dam pedigrees were traced as far as the data would allow—generally back to 2000.

These data were analyzed using a series of 3 trait models in ASREML (Gilmour et al., 2009). Three trait models were selected to reduce the total number of evaluations required when compared with 2-trait models and, at the same time, retain computational efficiency by not requiring estimation of an excessive number of parameters during a single analysis. In total, 142 evaluations were conducted so that each pair of traits was included together in at least 1 analysis. The model for the analyses was

$$y_{ijklm} = \mu + L_i + Age_j + HCC_k + A_l + PE_m + \varepsilon_{ijklm},$$

where fixed effects were lactation (L; i = 1 to 5), age at calving class (Age; j = 1 to 94 classes, where there was a class for every month of age for animals 19 to 100 mo old, a class for every 2 mo of age for animals greater than 100 mo old, and a single class for animals greater than 125 mo old), and herd calving cluster (HCC; k = 1 to 8,420). Random effects were animal (A; l = 127,401), permanent environment (PE; m = cow 1 to 45,464),