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ABSTRACT

Type classification records of 15,697 Brown Swiss cows by 1955 sires in 852 herds were analyzed with a cross-classified (herd-year and sire of cow) model. Fractions of variance due to herd-year effects ranged from 8% for mammary system to 17% for body capacity. Within herd-year heritabilities ranged from 24% for feet and legs to 43% for final score. Descriptive traits were analyzed by the same model except that each category was treated as a binomial variable. Proportions of variance due to herd-year effects for the descriptive traits were generally below 10%. Heritabilities were generally below 15%.

INTRODUCTION

Estimates of heritability of type traits (1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 16, 18, 19, 20, 21, 22, 23, 24, 28, 30) mostly are for Holstein-Friesian cattle. Much of this research was reviewed by White (27). Descriptive trait evaluations have been analyzed only for Holstein-Friesian cows. The purpose of this study was to estimate heritabilities for standard type traits of Brown Swiss cattle from a larger set of data than has been available and to estimate heritabilities for descriptive terms which were added to the Brown Swiss evaluation system in 1971. In addition, estimates of variation associated with herd and year of classification were obtained. These estimates can be used to implement sire evaluation procedures for type traits of Brown Swiss cattle.

MATERIALS AND METHODS

Records of official classification for 15,697 Brown Swiss cows classified by 47 mo of age between 1971 and 1976 were used. These cows represented 1955 sires in 852 herds. Before analysis, the records of traits in Table 1 were adjusted to the basis of a lactating cow 47 mo of age, classified in the fall (15). Descriptive traits (Table 2) were not adjusted due to the discrete nature and nonlinear coding of the traits. For a more complete description of the standard type traits scored between 1 for best and 6 for poorest see the Purebred Dairy Cattle Association scorecard as adopted by the Brown Swiss Association of America (BSAA). Descriptive traits were scored as present or absent as outlined by the BSAA.

Variance components were estimated by computing sums of squares as in the standard analysis of variance of orthogonal data and equating these sums of squares to their expectations according to Henderson's Method I (10).

The following model was used to describe the record of the kth daughter of the jth sire in the ith herd-year:

$$y_{ijk} = M + H_i + S_j + e_{ijk}$$

where M is a constant, H_i is an effect common to observations in the ith herd-year, S_j is an effect common to daughters of the jth sire, and e_{ijk} is a random effect associated with the kth daughter of the jth sire in the ith herd-year. Each effect in the model with the exception of M was an uncorrelated random variable distributed with mean zero and a specific variance. Herd-year by sire interaction was not included in the model because of the small number of filled subclasses.

Heritability within herd and year was estimated by multiplying by four the ratio of the sire variance to the sum of the sire and error variance.

RESULTS AND DISCUSSION

The fractions of total variance explained by

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TABLE 1. Fractions of total variance in type traits[a] associated with sire, herd-year, and residual effects and heritabilities within herd-year.

Trait	Component of variance			Total variance	Mean	Within herd-year herita-bility
	Sire	Herd-year	Resi-dual			
	(fraction)					
1 Final score	.09	.14	.77	12.09	84.31	.43
2 Final classification	.08	.12	.80	.497	2.60	.36
3 General appearance	.09	.12	.79	.562	2.63	.39
4 Feet and legs	.05	.11	.84	.684	2.61	.24
5 Rump	.09	.11	.80	.750	2.75	.41
6 Dairy character	.06	.15	.79	.381	2.06	.26
7 Body capacity	.07	.17	.76	.400	2.11	.36
8 Mammary system	.07	.08	.85	.726	2.69	.29
9 Fore udder	.07	.09	.84	.834	2.71	.30
10 Rear udder	.06	.10	.83	.731	2.52	.29

[a]Final score recorded on a 60 to 92 scale with 92 being most desirable; all other traits recorded on a 1 to 6 scale with 1 as most desirable.

sire, herd-year, and residual components of variance are in Tables 1 and 2 for traits of the standard type classification system and descriptive traits, respectively. In the following discussion, components of variance will be expressed as fractions of total variance.

The fraction of total variance attributed to herd-years ranged from .08 to .17 for the traits in the standard type classification system. These fractions were small but similar for all traits. For descriptive traits, variance components due to herd-years were generally even smaller than for the standard type traits. These results agree with (2, 13, 17, 25).

The fraction of variance due to sires was .09 or less for all traits under both classification procedures. Final score, general appearance, and rump had estimates of .09. The largest fraction of total variance was in the residual for both standard classification and descriptive classification traits. Variation due to these two sources, sires and residual, provide estimates of heritability within herds and years.

Heritabilities for standard type classification measures are in Table 1 and for descriptive traits are in Table 2. Results for the standard system have a similar relative order but are larger than those reported by Johnson and Fourt (11), who used Brown Swiss data collected much earlier. Legates (13), using Holstein records, reported larger heritabilities for all type traits except dairy character which had a heritability of .25, similar to our estimate. Scores for mammary system and fore and rear udder all had similar heritabilities, .29, .30, and .29. Even though several investigators (1, 3, 6, 13, 16, 20, 28) reported different heritabilities for mammary traits, they found nearly equal heritabilities for the three traits, as in this study. The heritability for body capacity was .36, which agrees with the average of many other estimates for Holstein records (6, 8, 13, 14, 30). The .41 for rump was higher than for other breeds but was similar to the .36 reported by Johnson and Fourt (11). Feet and legs had the lowest heritability, .24. The highest estimate was for final score, .43.

Heritabilities indicate that genetic progress could be made for most type traits measured under the standard type classification system in use by the BSAA. Since final score has the highest heritability and is phenotypically and genetically correlated with other type traits

TABLE 2. Fractions of total variance in descriptive traits associated with sire, herd-year, and residual effects and heritabilities within herd-year.

Trait	Component of variance			Total variance	Mean	Within herd-year heritability
	Sire	Herd-year	Residual			
	(fraction)					
Stature						
1 Upstanding	.06	.10	.84	.2383	.39	.25
2 Intermediate	.04	.07	.89	.2470	.55	.16
3 Low set	.07	.04	.89	.0502	.05	.29
Head						
1 Superior	.02	.14	.84	.1850	.24	.08
2 Acceptable	.01	.07	.91	.2266	.65	.05
3 Plain and/or coarse	.04	.06	.90	.0866	.10	.15
4 Weak	.04	.00	.96	.0060	.01	.17
Front end						
1 Shoulder smoothly blended, chest strong and wide	.02	.13	.85	.2160	.31	.11
2 Desirable strength and width	.01	.09	.90	.2460	.57	.06
3 Coarse shoulder and neck	.04	.06	.90	.0866	.06	.15
4 Narrow and weak	.03	.05	.92	.0362	.04	.14
5 Low front end	.04	.01	.95	.0256	.03	.17
Back and loin						
1 Straight, full crops, strong wide loin	.04	.16	.80	.2390	.39	.18
2 Medium strength and width	.03	.12	.85	.2500	.48	.13
3 Low chine	.03	.07	.90	.0171	.02	.11
4 Weak loin and/or back	.04	.08	.87	.0916	.10	.18
Rump						
1 Long, wide, near levelness	.02	.05	.92	.0844	.09	.09
2 Medium width, length, or levelness	.02	.06	.91	.2430	.41	.10
3 High and/or coarse tailhead	.05	.09	.86	.2268	.35	.21
4 Narrow especially at pins	.04	.08	.87	.0500	.05	.19
5 Sloping	.02	.03	.94	.0820	.09	.10

Hind legs						
1 Strong, clean flat bone, squarely placed clean flat thigh	.01	.09	.89	.1392	.17	.03
2 Acceptable	.02	.05	.93	.2491	.53	.07
3 Sickled and/or close at hocks	.04	.11	.85	.1983	.27	.20
4 Bone too light or refined	.02	.04	.94	.0218	.02	.10
5 Coarse or blemished hocks	-.01	.02	.99	.0083	.01	-.03
Feet						
1 Strong, well formed	.01	.18	.81	.1730	.22	.05
2 Acceptable with no serious faults	.01	.11	.88	.2458	.56	.04
3 Front feet toe out	.02	.06	.91	.0256	.03	.10
4 Shallow heel	.01	.11	.87	.1053	.12	.07
5 Weak pastern	.03	.07	.89	.0613	.06	.15
Mammary terms – Fore udder						
1 Moderate length and firmly attached	.02	.08	.90	.1166	.13	.09
2 Moderate length, acceptable attachment	.01	.04	.94	.2500	.50	.05
3 Short	.05	.07	.88	.1750	.23	.21
4 Bulgy or loose	.02	.04	.94	.1100	.12	.07
5 Broken and/or very faulty	.01	.00	.98	.0136	.01	.07
Rear udder						
1 Firmly attached, high and wide	.01	.10	.89	.1350	.16	.03
2 Intermediate in height and width	.01	.04	.94	.2500	.51	.05
3 Low attachment but firm	.02	.12	.85	.1603	.20	.12
4 Narrow and pinched	.05	.07	.88	.0868	.10	.20
5 Loosely attached and/or broken	.05	.02	.93	.0300	.03	.20
Udder support and floor						
1 Strong suspensory ligament, clearly defined halving	.04	.16	.80	.2373	.39	.18
2 Acceptable	.02	.13	.84	.2492	.47	.08
3 Floor too low	.08	-.00	.93	.0164	.02	.30
4 Tilted and/or uneven floor	.04	.07	.89	.0950	.10	.18
5 Broken suspensory ligament, and/or weak floor	.06	.10	.85	.0193	.02	.25
Udder quality						
1 Soft and pliable	.03	.23	.74	.2468	.56	.16
2 Intermediate	.03	.22	.75	.2404	.40	.16
3 Could not determine	.00	.01	.99	.0247	.03	.00
4 Meaty	.01	.03	.96	.0141	.01	.04
5 Persistent edema	-.01	-.02	1.03	.0015	.00	-.03

TABLE 2. Continued.

Trait	Component of variance			Total variance	Mean	Within herd-year herita-bility
	Sire	Herd-year	Resi-dual			
	(fraction)					
Teat size and placement						
1 Plumb, desirable length and size, squarely placed	.04	.21	.74	.2393	.40	.22
2 Acceptable with no serious faults	.02	.18	.79	.2360	.38	.12
3 Wide front teats	.05	.04	.91	.1150	.13	.22
4 Other undesirable placements	.04	.07	.89	.0480	.05	.18
5 Objectionable teats	.05	.03	.93	.0381	.04	.19

(20, 29), selection on final score alone would improve other type traits if those correlations were also true for Brown Swiss cattle. In fact, selection on final score alone has been recommended (26) as an efficient means of achieving a wide range of goals in improving type traits. Work is underway to estimate genetic correlations between final score and the component and descriptive terms for Brown Swiss data.

Most heritabilities for descriptive terms were below .20. Several traits, however, had higher estimates. Estimates for upstanding and low set statures were .29. Estimates for high and/or coarse tailhead, and short fore udder categories were .21. Most traits of udder support had heritabilities ranging from .18 to .30. The estimate for acceptable udder support was lower, .08. The least desirable rear udder categories (4 and 5) and the category of sickled legs and/or close at hocks under hind legs had estimates of .20. Estimates for teat size and placement categories ranged from .18 to .22 although category 2, which is acceptable, had a lower estimate of .12. These estimates are generally lower than those adjusted for discontinuity reported by LaSalle et al. (12) for Holstein records. Some terms under the Holstein descriptive type classification system, however, differ from BSAA descriptive terms.

Heritabilities were not adjusted for discontinuity since the appropriate variance ratios to use for genetic evaluation are those associated with the discontinuous variables. Predictions of genetic progress would require adjustment as well as the assumption of an underlying normal distribution which seems unlikely for some of the descriptive traits.

Genetic progress could be moderate for many of the descriptive type traits. Most traits do not have heritabilities large enough to expect rapid improvement through selection. Since most of the descriptive terms are given some consideration under the standard system of classification, it probably would be advantageous to make selection decisions based on the more general standard system of classification. Phenotypic correlations from the same type data were higher between final score and each of the other type traits than for any other trait, which supports the use of final score as the best single indicator of desirable type. These results are supported by findings of

White and Vinson (29), who strongly suggested that selection for type traits showed maximum improvement from selecting on final score. Descriptive classification terms, however, may be useful and helpful in correcting specific faults in a particular animal or group of animals. But if a large number of descriptive traits were considered in correcting faults, emphasis on important economic traits would be reduced and decrease economic progress. Thus, it is important to resist overuse of such supplementary traits in sire selection.

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