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Abstract

Variance components were estimated from type appraisal data to determine the importance of year, herd, sire, and herd x sire effects upon 49 body, udder, and management traits. Estimates were based on over 16,000 appraisals on daughters of Holstein artificial insemination sires. The variation explained by these effects never exceeded 34% of the total variance. Year effects were almost nonexistent (−2 to 3%). Herd effects were small for all traits except feeding speed, body weight, intensity and persistency of edema, and ketosis, and never exceeded 25%.

Most appraisal traits had low heritabilities. The estimate for milking speed was .23 while estimates for other management traits were less than .08. The estimates for body weight and upstandingness were .40 and .39. Other body traits having estimates from .16 to .21 were sharpness, height of thurls, depth of body, levelness of rump, tightness of shoulders, and height of tail setting. The heritability estimates for udder traits were low. Estimates for only three of 21 udder traits exceeded .14. These were strength of rear attachment, rear teat spacing, and depth of udder.

Introduction

Genetic improvement in milk production was slow in the past because emphasis was directed to a multitude of type traits. Studies (1, 3, 6, 10, 13, 18, 22, 23, 25) on type classification data have shown that heritabilities for final type rating and some categories are comparable to those for milk production. Traits which measure body size may be more genetically influenced than are production variables (2, 13, 23, 26). There is insufficient information to ascertain which other conformation and management traits would be receptive to selection.

Descriptive type programs have been developed to supply this information. A few studies have been completed on limited quantities of type appraisal data. O'Bleness, Van Vleck, and Henderson (21) estimated heritabilities for 27 traits from 842 daughter-dam pairs of Holsteins in 178 herds. Estimates were from .24 to .40 for temperament, depth of barrel, strength of rear attachment, udder texture, and milking quality. Van Vleck (27) obtained paternal half-sib heritabilities from data of 1,400 Holsteins under 35 months of age and 4,080 older cows. Heritabilities for resistance to mastitis and ketosis, milking speed, dairy character, shoulder tightness, depth of body, upstandingness, levelness of udder floor, depth of udder, strength of rear and fore udder attachment were all near .25. White, Legates, and Koonce (29) obtained paternal half-sib heritabilities from 1,403 daughters of 120 sires in nine herds. Heritabilities ranged from .11 to .33 for body traits, .13 to .30 for udder traits, and .08 to .51 for teat characteristics.

Herd or year effects on type ratings have generally been smaller than on milk production (3, 13, 16, 23, 27, 30). Van Vleck (27) and Carter, Rennie, and Burnside (3) suggested herdmates need not be considered when reporting type ratings for sires' daughters. As herd size increases, however, this possibility would be more advantageous.

Type classification ratings are only moderately repeatable. McGilliard and Lush (16) noted that disagreement in ideals between experienced judges was small, so real changes in appearance were important causes of imperfect repeatability. Johnson and Lush (11) found that consecutive ratings, when cows were classified at yearly intervals, appeared to be no more repeatable than nonconsecutive ratings.

The purpose of this study was to examine the importance of herd, year, and sire effects as sources of variation in type appraisal traits and to estimate heritabilities and repeatabilities for these traits.

Methods of Analysis

Sources of variation. Records were from 188 Holstein herds appraised every 2 years from

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1961 to 1968 through the New York type appraisal program. The source of data was the same as reported by Norman and Van Vleck (20). The 49 type appraisal traits were defined in that paper.

Records of daughters of artificial insemination (AI) sires were used in estimating variance components. Estimates were based on 16,928 appraisals for 45 traits and 16,662 appraisals for the four traits added in 1961 (persistency of edema, height of thurls, heel depth, and upstandingness). Because of the complete confounding of sets of herds and years, the data were treated as two separate experiments. This resulted in two estimates of the variances and, thus, gave some indication of the sampling variance of the estimates. Variance components were estimated by Henderson's Method I (8). The following model was used:

$$X_{ijkl} = \mu + y_i + h_j + s_k + (hs)_{jk} + e_{ijkl}$$

where: X_{ijkl} is the observation on the *lth* daughter of the *kth* sire in the *jth* herd in the *ith* year;

μ is a fixed effect common to all observations;

y_i is an effect common to observations in the *ith* year;

h_j is an effect common to observations in the *jth* herd;

s_k is an effect common to daughters of the *kth* sire;

$(hs)_{jk}$ is an effect common to daughters of the *kth* sire in the *jth* herd;

e_{ijkl} is a random error effect associated with the *lth* daughter of the *kth* sire in the *jth* herd in the *ith* year.

Each effect in the model with the exception of μ was an uncorrelated random variable distributed with mean zero and a specific variance. This model was used to estimate components of variance for the observations corrected by the age x stage-of-lactation constants reported earlier (20). Variance components were estimated separately for lactation numbers 1, 2, 3-4, 5-6, 7-8, and 9-10. This same model was used to describe the production variables. There was no confounding of herds and years for production, so a single analysis was made for each lactation number.

Heritabilities. Heritability was estimated by dividing four times the sire variance component by the total variance composed of sire, herd $\times$ sire, and error components of variance. Heritabilities combined over all lactations were calculated from pooled variance components. Variance components were pooled by weighting the individual variance estimates by the number of observations in the estimates.

Repeatabilities. Repeatabilities were estimated using records of all cows (AI and non-AI). Over 22,840 type ratings were available for all traits on approximately 14,000 cows. Estimates were the regression within herd of an individual type appraisal score on a previous appraisal. Regression estimates were for all pairs of lactation numbers. Pooled estimates of repeatabilities over all lactation numbers were weighted averages of the individual estimates, weighted inversely according to the variances of the estimates.

Results and Discussion

Sources of variation. The percentages of the total variance explained by year, herd, sire, herd x sire, and error components of variance are in Table 1 for the 49 type traits and some production variables. These variance components were pooled over all lactations and both data sets. Components of variance for year effects were small for all the type traits (−2 to 3%), thus suggesting only minor changes in appraising scores with time. Carter et al. (3) found that time of classification accounted for zero to 1% of the variation.

Herd components of variance for most type appraisal traits are proportionally less than those for mature equivalent (ME) milk production. Herd components of variance in scores of the management traits are greater than those for the body and udder traits. Management traits were coded by each dairyman for his own herd, and, thus, herd differences in scores would be expected. Greater herd variation (20 to 25%) for ketosis–5[2], intensity of edema–11, and persistency of edema–12 than for the remaining management traits suggest, nevertheless, that real herd differences exist for these traits. Schultz (24) has outlined the effects of nutritional intake on the incidence of ketosis. Emery et al. (4) have shown prepartum grain feeding influences edema in first calving heifers.

The herd component for body weight–13 was 19%. Although animals were to be taped during the appraisal, in some cases values recorded on the Dairy Herd Improvement (DHI) production report were used. This deviation in procedure might have inflated the herd component for body weight. Herd components of variance for the remaining body and udder traits were all less than 10%, in

[2] Hyphenated number following each trait is the trait number in Tables 1, 2, and 4.

TABLE 1. Variance components for type and production traits pooled for all lactations.

No.	Trait	Percentages					Total variance
		Year	Sire	Herd	H×S	Error	
	Management traits						
1	Excitability	−.2	1.8	5.7	6.3	86.5	.20
2	Feeding speed	.8	1.3	14.5	5.9	77.5	.32
3	Mastitis	−.2	.6	9.1	4.4	86.1	.18
4	Mastitis from injury	.1	.2	6.4	2.0	91.3	.08
5	Ketosis	.4	−.7	20.2	3.1	77.0	.10
6	Milk fever	.2	.3	9.6	1.4	88.5	.05
7	Breeding problems	.4	.2	6.4	.3	92.7	.12
8	Cystic ovaries	.2	.8	7.5	−2.4	93.9	.07
9	Milking speed	.4	5.2	8.3	8.3	77.8	.42
10	Milk leak	−.1	−1.0	6.3	4.2	90.5	.07
11	Intensity of edema	1.1	.7	24.8	7.9	65.6	.34
12	Persistency of edema	.8	.9	23.7	6.1	68.4	.36
	Body traits						
13	Body weight (kg/10)	−1.1	8.3	18.8	4.7	69.3	34.45
14	Sharpness	.1	4.9	4.8	7.5	82.7	.27
15	Typical head	.0	1.4	3.2	5.4	90.0	.13
16	Strength of head	−1.5	2.8	1.8	−1.8	98.7	.03
17	Tightness of shoulder	.5	3.7	7.3	−4.1	92.6	.31
18	Arching of back	−.2	2.1	3.7	5.8	88.5	.34
19	Straightness of hock	.6	3.3	4.5	1.5	90.1	.42
20	Straight legs (rear view)	.4	1.4	6.5	2.2	89.4	.33
21	Strength of pastern	1.7	2.9	7.4	1.5	86.4	.40
22	Depth of body	.6	4.2	5.1	4.4	85.7	.27
23	Levelness of rump	.1	4.0	3.8	3.4	88.6	.25
24	Smoothness of pelvic arch	.7	2.8	2.4	−2.4	96.6	.18
25	Height of tail setting	−.0	4.0	2.1	10.1	83.9	.17
26	Height of thurls	.5	4.4	6.1	2.7	86.2	.38
27	Heel depth	2.2	1.8	6.0	2.3	87.7	.35
28	Upstandingness	−.1	9.3	5.9	4.0	80.8	.41
	Udder traits						
29	Rear udder length	1.0	1.7	4.6	2.3	90.4	.38
30	Rear udder bulginess	.0	.1	1.1	−.4	99.2	.06
31	Rear udder funnelness	.2	.1	1.3	.0	98.4	.06
32	Fore udder length	.5	2.3	3.6	.8	92.9	.34
33	Fore udder bulginess	1.0	2.1	3.8	.5	92.6	.11
34	Fore udder funnelness	.5	−.4	3.1	−7.1	104.0	.03
35	Udder quality	1.5	1.3	9.6	2.0	85.6	.34
36	Depth of udder	2.2	3.4	8.3	3.2	83.0	.32
37	Forward slope to udder	−.0	3.0	2.8	2.3	92.0	.58
38	Height of rear udder	2.0	3.2	4.9	3.2	86.8	.33
39	Strength of R. udder attach.	.1	3.7	6.8	5.2	84.2	.47
40	Strength of F. udder attach.	.6	2.3	8.2	3.5	85.3	.45
41	Udder halving	2.8	2.0	8.9	2.5	83.8	.41
42	Udder quartering	.9	2.7	3.8	4.3	88.2	.27
43	Rear teats forward	−.2	.3	2.3	7.7	89.9	.04
44	Rear teats sideways	−.4	2.5	.7	13.9	83.3	.05
45	Fore teats forward	−.4	2.2	1.3	3.5	93.4	.05
46	Fore teats sideways	.2	.7	3.7	5.9	89.5	.09
47	Rear teat spacing	2.3	3.6	8.2	1.6	84.3	.16
48	Fore teat spacing	.5	2.3	4.8	−.7	93.0	.11
49	Rear to fore teat spacing	.8	1.7	3.7	6.9	87.0	.04
	Production traits						
50	Mature equiv. milk (kg/10)	3.9	6.0	19.9	2.1	68.0	19,304
51	Mature equiv. fat (kg)	4.3	4.9	22.1	2.1	66.7	2,624
52	Deviation milk (kg/10)	.1	4.7	1.3	2.2	91.7	14,513
53	Deviation fat (kg)	.1	3.3	1.6	1.6	93.5	1,905
54	Fat percentage	−1.6	9.1	7.3	4.5	80.7	.12

TABLE 2. Heritabilities from previous and present type appraisal data for first and later lactations.

		From previous studies[a]			From present study				
					Data set 1		Data set 2		
					Lactation no.		Lactation no.		Pooled
No.	Trait	(21)	(27)	(29)	1	2-10	1	2-10	estimate
	Management traits								
1	Excitability	.40	−.23 to .16	..	.09	.10	.01	.08	.08
2	Feed. speed	.02	−.17 to .14	..	.05	.04	.02	.09	.07
3	Mastitis	.05	.17 to .24	..	−.05	.01	.07	.04	.03[b]
4	Mast-injury	..	.11 to .73	..	.06	.02	.01	−.01	.00[b]
5	Ketosis	−.03	−.06 to .28	..	−.01	−.05	−.12	−.02	−.03[b]
6	Milk fever	..	.28 to .32	..	[c]	−.00	[c]	.02	.01[b]
7	Breeding prob.	.03	.15 to .33	..	.07	−.02	−.05	.04	.01
8	Cystic ovaries	..	.09 to .81	..	.12	.01	.06	.04	.04[b]
9	Milking speed	.24	.08 to .59	..	.22	.21	.36	.20	.23
10	Milk leak	.11	.04 to .11	..	−.12	−.05	.12	−.05	−.04[b]
11	Int. of edema	..	.03 to .14	..	.10	.01	.01	.05	.04
12	Persistency-edema	..	−.16 to .04	..	−.06	.06	−.02	.07	.05
	Body traits								
13	Body weight	..	..	..	.30	.41	.30	.46	.40
14	Sharpness	.10	.01 to .52	..	.14	.22	.24	.20	.21
15	Typical head	..	.00 to .09	..	.03	.03	.04	.11	.06[b]
16	Strength of head	.15	−.10 to .38	..	.12	.07	.10	.16	.12
17	Tightness-should.	.10	−.31 to .21	.11	.13	.21	.10	.13	.16
18	Arching of back	..	.00 to .24	.19	.11	.13	.05	.06	.09
19	Straightness-hock	.08	.01 to .26	.26	.10	.12	.16	.15	.14
20	Straight legs-RV	.04	−.06 to .12	.24	.02	.09	.06	.06	.06
21	Strength-pasterns	.12	.02 to .18	.15	.06	.11	.08	.17	.13
22	Depth of body	.33	−.01 to .20	.25	.20	.23	.13	.13	.17
23	Levelness-rump	..	..	..	.12	.24	.22	.10	.17
24	Smooth. pelvic arch	..	..	..	.07	.12	.10	.12	.12[b]
25	Height tail setting	..	..	..	.09	.21	.19	.14	.16
26	Height of thurls	..	.02 to .19	..	.21	.20	.18	.18	.19
27	Heel depth	..	−.04 to .20	..	.17	.03	.07	.09	.08
28	Upstandingness	..	.13 to .54	..	.47	.40	.40	.37	.39
	Udder traits								
29	R. udder length	.04	.04 to .16	..	−.00	.05	.14	.09	.07
30	R. udder bulginess	..	−.01 to .23	..	.02	−.05	−.03	.05	.00[b]
31	R. udder funnelness	..	.06 to .51	..	−.03	−.01	.05	.01	.01[b]
32	F. udder length	−.05	−.05 to .19	..	.06	.07	.10	.12	.10
33	F. udder bulginess	..	−.01 to .26	..	.04	.08	.02	.14	.09[b]
34	F. udder funnelness	..	−.08	..	.03	−.09	−.14	.05	−.02[b]
35	Udder quality	.28	.03 to .19	..	.01	.11	.08	.02	.06
36	Depth of udder	.22	.01 to .46	.30	.17	.15	.08	.18	.15
37	F. slope to udder	.09	−.25 to .33	.20	.13	.17	.01	.10	.12
38	Height R. udder	..	−.03 to .15	..	.16	.15	.10	.13	.13
39	Str. R. udder attach.	.30	.02 to .33	.20	.09	.19	.19	.14	.16
40	Str. F. udder attach.	.16	.00 to .31	.22	.02	.15	.08	.08	.10
41	Udder halving	..	.04 to .43	.13	.09	.11	.08	.07	.09
42	Udder quartering	.18	.09 to .81	.24	.08	.14	.07	.11	.11
43	R. teats forward	..	.08 to .13	..	−.09	.03	.01	.02	.01[b]
44	R. teats sideways	..	.03 to .21	..	.06	.13	.34	.03	.09[b]
45	F. teats forward	..	.02 to .04	..	−.12	.08	.19	.11	.09[b]
46	F. teats sideways	..	−.03 to .06	..	−.08	.03	.14	.01	.03[b]
47	R. teat spacing	..	..	..	.17	.22	.25	.07	.16
48	F. teat spacing	..	..	..	−.01	.11	.14	.10	.10
49	R-F teat spacing	..	..	..	.22	.04	.01	.07	.07[b]

[a] Previous estimates: (21) O'Bleness et al., (27) Van Vleck, and (29) White et al.
[b] Threshold traits which are binomials, thus most likely to be underestimated.
[c] Was not calculated due to the low frequency of the trait.

agreement with other studies (3, 27) that there would be little advantage to considering herdmates when reporting type ratings for sires' daughters unless all daughters were in one herd. Consideration of the herdmate values for a few of the management traits may be advantageous, or having dairymen standardize their rating for these few traits might be an alternative.

The herd x sire interaction components of variance ranged from −7 to 14%, being negative for 7 of the 49 traits. Included in a herd x sire component would be part of any classifier x sire effect since effects of classifiers were partially confounded with the herd variation. The herd x sire component of variance may be biased upward by the presence of heterogeneous variance, that is, the sire variance may differ from herd to herd. This may be the case since the variance and mean of the traits are not independent.

Heritabilities. The heritabilities from the two data sets are in Table 2 along with three previous sets of estimates (21, 27, 29) from type appraisal data. The heritabilities from the two data sets were fairly consistent, giving some indication that variances of the estimates were small. The average absolute difference in heritability of these paired estimates for first lactations was .09 and for later lactations was .05.

The majority of heritabilities are low. In general the estimates compared more closely to those reported by O'Bleness et al. (21) using daughter-dam regression on earlier New York data than to those by Van Vleck (27) using paternal half-sib estimates on early observations from these same data. Van Vleck (27) treated each category of a type trait as a binomial variable, and O'Bleness et al. (21) coded each trait ordinally as in this study. The values by White et al. (29) were consistently higher than the present estimates. The higher estimates in the North Carolina study may have resulted from using the arbitrated opinion of four different appraisers in scoring each animal.

Although management traits are economically important to dairymen, genetic variability of these traits is apparently small. The heritability for excitability−1, .08 was substantially lower than reported by O'Bleness et al. (21) but agreed closely with that by Van Vleck (27). The heritabilities for mastitis–3, 4 were low, .00 to .03. There has been substantial variation in prior estimates of this important economic trait. These results resemble the low estimates reported by Wilton and Van Vleck (31), and O'Bleness et al. (21) of from −.11 to .12. Others (14, 15, 32) have given estimates as high as .40 but generally on limited observations.

The present data suggest the genetic resistance to both milk fever–6 and ketosis–5 is nearly zero, lower than earlier estimates from some of the data (27). The heritability of milk fever in first lactation was not calculated due to its low frequency. The estimates for breeding problems–7 and cystic ovaries–8 were also near zero in agreement with most studies (5, 12, 17, 19) regardless of the means of measuring fertility. The estimate for milk leak–10 was negative, and estimates for edema traits –11 and 12 were low, .04 and .05. Two of the higher estimates were for milking speed–9 at .29 and .20 for the first and later lactations. Johansson and Rendel (9) have reported heritability for rate of milk flow in the range of .5 to .6. To what extent the dairyman gave consideration in appraising milking speed to total milk secreted, rate of flow, or total milking time is difficult to determine. Enough evidence is available showing genetic differences in rate of milking to recommend ratings for sires, particularly those in AI.

The highest heritabilities were for measures of body size. Such traits appear to be the primary basis for the belief that sires have a major influence upon type conformation of their daughters. The heritabilities of .43 and .38 for upstandingness–28 of first and later lactations agree with the corresponding estimates of Brum and Ludwick (2) of .42 and .22 but were lower than .73 and .57 found by Touchberry (24) and Legates (13). The estimates for body weight–13 of .30 and .43 for first and later lactations were similar to .38 and .37 in other studies (2, 24).

The heritability for dairy character–14 was .21, near the average of a number of estimates from .03 to .34 from other studies (1, 6, 10, 11, 13, 18, 21, 23, 27). The estimates for the remaining body traits were less than .20 and do not appear to differ from previous findings. Traits–23, 25, and 26 measuring rump characteristics (levelness of rump, height of tail setting, and height of thurls) had estimates from .16 to .19. Depth of body–22, tightness of shoulders–17, straightness of hocks–19, and strength of pasterns–21 had estimates from .13 to .17. The remaining body traits had heritabilities so low that progress in these traits through direct selection would be slow.

Fifteen of the 21 heritabilities for the udder traits were equal to or less than .10. Those traits (36, 37, 38, 39, 42, 47) with higher estimates were strength of rear udder attachment, rear teat spacing, depth of udder, height of rear udder, slope of udder, and udder quartering with values from .11 to .16. The estimate by O'Bleness et al. (21) for udder quality–35 was .28, considerably higher than the .06 in this study. The majority of herds in the O'Bleness et al. study were scored only once. The quantity of milk in the udder appeared to influence udder texture score, and so ratings taken at the same time during the day would have given a higher and more realistic heritability.

Most of the type appraisal variables were threshold traits, and 18 of the 49 were binomials. Van Vleck (28) showed that variables with normal distribution coded as binomials gave estimates lower than the true heritability. He found that if the frequencies of coding in the binomial classes were .10 and .90, the estimates were only one-third of the true heritabilities. If the frequencies were both .50, the estimates were about two-thirds of the true heritabilities. Although the underlying distributions of the threshold variables are unknown, it is likely that heritabilities of some of these traits are underestimated. The traits which are binomials and are likely to be underestimated are marked in Table 2.

Means and heritabilities for production by individual lactation numbers are in Table 3. First lactation heritabilities were .40 and .25 for ME milk and herdmate deviation milk, and .36 and .21 for ME fat and herdmate deviation fat. The estimate for fat percentage in first lactation was .45. The estimates were all lower for later lactation variables. These values are in line with those from previous DHI data (7, 17).

Repeatabilities. Repeatabilities were higher than the corresponding heritabilities for all of the 49 type traits. Nevertheless, many of these estimates were lower than expected. Pooled estimates are in Table 4 for all lactations and for lactation numbers differing by one, two, three, and four. Twenty-nine pooled estimates were less than .20, and 14 were between .20 to .29. Estimates for four traits (milking speed–9, temperament–1, height of tail setting–25, and levelness of udder floor–37) were from .33 to .39. Repeatabilities for body weight–13 and upstandingness–28 were highest at .46 and .45.

Repeatabilities for dairy character–14 from type classification studies (1, 6, 18) were from .20 to .25, similar to the .19 for the present estimate. The average repeatabilities for other traits from type classification were higher, ranging from .28 for feet and legs to .55 for rump. The reason for higher values from type classification data is uncertain. Type classification ratings have more categories for each trait which may account for some of the difference. Phenotypic and genetic relationships between type appraisal traits may be such that composite traits as exist in type classification give higher values for heritabilities and repeateabilities. The repeatabilities for the head traits –15 and 16 were low, even in consecutive lactations. These are traits which would be expected to change little after the cow is 3 years of age. This example may point out one of the problems for some type appraisal traits, namely getting agreement on the part of the appraisers.

Repeatabilities for production were similar to those from past studies (1, 19). Estimates pooled over all lactation numbers gave values ranging from .36 to .38 for milk and fat yield to a value of .61 for fat percentage. A decline in repeatability for nonconsecutive records is clearly shown.

TABLE 3. Means and heritabilities for production variables by lactation number[a].

	Means				Heritabilities			
	Lactation no.				Lactation no.			
	1	2	3-10	Pooled	1	2	3-10	Pooled
Mature equiv. milk (kg/10)	668.6	681.8	666.8	670.4	.40	.29	.29	.32
Mature equiv. fat (kg)	243.4	247.7	241.2	243.1	.36	.24	.22	.26
Deviation milk (kg/10)	−3.6	13.2	3.6	4.1	.25	.18	.17	.19
Deviation fat (kg)	−.2	−5.3	4.9	1.5	.21	.13	.09	.13
Fat percentage	3.66	3.65	3.63	3.64	.45	.41	.35	.39
Number of observations	16,870	15,664	41,087	73,621	12,180	11,153	25,247	48,580
Number of sires					382	362	[b]	

[a] Means are based on all cows, heritabilities on daughters of artificial insemination sires.
[b] Number of sires for single lactations ranged from 101 to 334.

TABLE 4. Repeatabilities for type and production traits–pooled regressions for lactation numbers differing by one, two, etc.

No.	Trait	1	2	3	4	Overall
	Management traits					
1	Excitability	.29	.37	.31	.29	.35
2	Feeding speed	.22	.20	.17	.11	.19
3	Mastitis	.23	.26	.24	.13	.24
4	Mastitis from injury	.19	.16	.21	.06	.15
5	Ketosis	.15	.16	.06	.02	.14
6	Milk fever	.21	.23	−.02	.00	.19
7	Breeding problems	.14	.12	.01	.10	.11
8	Cystic ovaries	.17	.11	.08	.11	.11
9	Milking speed	.39	.42	.19	.32	.39
10	Milk leak	.22	.30	.08	.30	.27
11	Intensity of edema	.16	.13	.05	.17	.14
12	Persistency of edema	.19	.15	.04	.13	.14
	Body traits					
13	Body weight	.49	.48	.30	.37	.46
14	Sharpness	.15	.21	.13	.15	.19
15	Typical head	.07	.08	.08	.13	.08
16	Strength of head	.04	.10	.09	.06	.09
17	Tightness of shoulder	.22	.21	.22	.23	.22
18	Arching of back	.18	.17	.07	.16	.16
19	Straightness of hock	.29	.27	.28	.21	.26
20	Straight legs (rear view)	.12	.15	.12	.20	.15
21	Strength of pasterns	.14	.19	.27	.14	.18
22	Depth of body	.16	.22	.08	.14	.19
23	Levelness of rump	.23	.30	.41	.24	.29
24	Smoothness of pelvic arch	.14	.14	.15	.11	.14
25	Height of tail setting	.32	.36	.39	.34	.35
26	Height of thurls	.19	.21	.13	.19	.20
27	Heel depth	.11	.11	.07	.03	.10
28	Upstandingness	.51	.45	.48	.41	.45
	Udder traits					
29	Rear udder length	.10	.18	.12	.07	.15
30	Rear udder bulginess	.03	.15	.11	.06	.13
31	Rear udder funnelness	.02	.14	.17	.09	.12
32	Fore udder length	.16	.23	.15	.20	.21
33	Fore udder bulginess	.08	.18	.08	.05	.14
34	Fore udder funnelness	−.03	.26	.05	.19	.20
35	Udder quality	.06	.10	.03	.08	.09
36	Depth of udder	.18	.24	.17	.24	.23
37	Forward slope to udder	.31	.33	.31	.33	.33
38	Height of rear udder	.14	.22	.05	.19	.20
39	Strength of R. udder attach.	.20	.31	.33	.22	.29
40	Strength of F. udder attach.	.22	.24	.25	.17	.23
41	Udder halving	.18	.18	.11	.24	.19
42	Udder quartering	.19	.22	.20	.17	.21
43	Rear teats forward	.10	.15	.09	.13	.14
44	Rear teats sideways	.21	.21	.03	.20	.19
45	Fore teats forward	.18	.21	.21	.10	.19
46	Fore teats sideways	.25	.20	.08	.21	.19
47	Rear teat spacing	.17	.25	.10	.31	.24
48	Fore teat spacing	.18	.19	.05	.14	.17
49	Rear to fore teat spacing	.27	.11	.15	.07	.13
	Production traits					
50	Mature equiv. milk	.47	.36	.25	.18	.37
51	Mature equiv. fat	.46	.34	.23	.17	.36
52	Deviation milk	.45	.37	.29	.23	.38
53	Deviation fat	.43	.35	.27	.22	.36
54	Fat percentage	.64	.61	.58	.56	.61

Conclusions

The greatest portion of the variation in type traits was unexplained. Year effects were almost nonexistent. Herd effects were small for most of the body and udder traits, accounting for less than 10% of the variation. This was not the case for body weight, intensity of edema, persistency of edema and ketosis where herd components were 19 to 25%. There appears only limited advantage in considering herdmates for daughters of sires except for these few traits or unless all daughters were in a single herd.

Heritabilities and repeatabilities for most of the type appraisal traits were low. Genetic progress for these traits would be slow, especially if selection is directed toward more than one trait. Substantial progress could be made by selecting for the management trait, milking speed. Present and previous estimates suggest the heritability is about .25 for the dairyman's rating. Estimates for other management traits were all less than .08.

A number of the body traits have heritabilities large enough to provide moderate genetic progress if economic considerations call for selection for those particular traits. The estimates for body weight and upstandingness were .40 and .39. Traits with estimates from .16 to .21 were sharpness, height of thurls, depth of body, levelness of rump, tightness of shoulders, and height of tail setting.

Heritabilities for udder traits were low. Estimates for only six of 21 traits exceeded .11. These were strength of rear attachment, rear teat spacing, depth of udder, height of rear udder, udder slope, and udder quartering.

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