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Abstract

Correlations were computed between first-lactation milk records expressed as deviations from herd-mate averages of pairs of Holstein paternal half-sibs in the same and in different herds. These were compared to the comparable daughter-dam regressions. After correcting the daughter-dam regression for environmental correlation and change in variance from the dam to the daughter generation, both the daughter-dam and paternal half-sib estimates of heritability were about .34, which suggests that maternal genetic variance is unimportant. This estimate is, however, higher than the .25 found from the paternal half-sib estimate from an analysis for variance components.

The comparison of the half-sib correlations where the pair was in the same herd (.168) and in different herds (.086) suggests that the environmental correlation among paternal half-sibs in the same herds is about .08 of the total variance. There was no evidence that this environmental correlation is less for pairs of artificially sired than for naturally sired paternal half-sisters in the same herd.

Several reports (7-10) have attempted to find reasons for the difference between heritability estimates from daughter-dam regression (.44) and paternal half-sib correlation (.25) reported by Bradford and Van Vleck (2) for first-lactation milk records of Holstein cows expressed as deviations from herd-mate averages. Most heritability estimates from daughter-dam regression in these data are about .40. The correlation between daughter and dam records in the same herd apparently accounts for about .02 of the difference (9). The increase in variance associated with time through an increase in mean production also can account for 10-12% of the total variance (7). Removal of these two sources of upward bias in the daughter-dam estimates gives a corrected estimate of about .34, which is still higher than the paternal half-sib estimate.

The purpose of this study was to see if the variance component procedure used in estimating the paternal half-sib correlation may be giving a lower estimate than the method which uses the product moment correlation between pairs of animals by the same sire. An estimate of the environmental correlation between paternal half-sibs was also obtained by comparing product moment correlations between pairs in the same and different herds.

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Materials and Methods

The basic set of data was also used by Van Vleck and Hart (9). Briefly, there were first-lactation milk records (2 ×, 305-day, M.E.) of 130,000 Holstein cows coded as registered and in the files of the New York Dairy Records Laboratory. Records of daughter and dam pairs were found by matching the tape against a duplicate. Therefore, pairs were found, whether in the same or different herds.

The data were grouped for records of daughters of natural service sires, sires used in artificial insemination, and all sires, regardless of type of service. Each of these groups was further divided into sets of data consisting of: (1) a set of records of three daughters of each sire, two in one herd, and the third in a different herd, or if these conditions were not met, then either (2) a set of records of two daughters of each sire, both in the same herd, or (3) a set of records of two daughters of each sire in different herds. If a sire was represented in Set One, he was not represented in Sets Two or Three. A sire could be represented in only one of the three sets. A dam could not have more than one daughter in a set of data. Correlations were computed for deviations from herd-mate averages (3) among the daughters, and regressions were computed for the daughter and dam relationship.

Some sires had some daughters with records coded as naturally sired and some daughters coded as artificially sired. This was possible, as some sires sired daughters prior to their entry into A.I. service and these were coded as natural service daughters. Thus, the number of sires in the N.S. and A.I. groups exceeded the number in the combined group.

The mature equivalent and deviation means are given in Table 1 for each set of data. Variances of deviations are also given. Com-

TABLE 1
Means and variances of records included in the various analyses

Record		Naturally sired			Artificially sired			Either N.S. or A.I.		
		Mean		Variance of deviation	Mean		Variance of deviation	Mean		Variance of deviation
		M. E.	Dev.		M. E.	Dev.		M. E.	Dev.	
		(kg)	(kg)	$(kg/10)^2$	(kg)	(kg)	$(kg/10)^2$	(kg)	(kg)	$(kg/10)^2$
Two daughters in same herd (1 and 2), one in a different herd (3)										
Daughter	1	5,845	−158	11,522	5,979	−186	13,310	5,857	−156	11,576
Dam	1	5,951	53	8,999	5,885	68	9,457	5,937	59	9,110
Daughter	2	5,826	−203	12,458	6,162	−42	12,362	5,841	−201	12,388
Dam	2	5,926	34	9,647	5,971	166	8,374	5,934	61	9,455
Daughter	3	5,712	−195	11,928	5,967	−132	11,896	5,736	−187	11,905
Dam	3	5,894	−29	10,186	6,119	260	10,857	5,929	26	10,522
Two daughters in same herd (1 and 2)										
Daughter	1	5,612	−226	10,859	....	....	.....	5,606	−230	10,888
Dam	1	5,728	61	8,600	....	....	....	5,727	61	8,610
Daughter	2	5,649	−215	10,043	....	....	....	5,642	−220	10,052
Dam	2	5,734	60	8,969	....	....	....	5,732	61	8,950
One daughter in one herd (1), one in a different herd (2)										
Daughter	1	5,730	−153	12,465	5,951	−128	10,376	5,794	−128	12,163
Dam	1	5,842	27	10,007	6,164	269	9,127	5,913	72	9,981
Daughter	2	5,705	−234	12,175	5,987	−89	10,673	5,742	−228	12,307
Dam	2	5,868	40	9,008	6,026	109	9,934	5,906	53	9,354

parison of means and variances of daughter and dam deviations indicates that dams which have daughters are a selected group.

Results and Discussion

Results of the various analyses are shown in Table 2. The estimates fluctuate considerably for each type of relationship. Weighted averages of the estimates were obtained by weighting each estimate by the number of pairs of records included in the estimate. This procedure is approximately the same as weighting by the inverse of the variance. Note that some estimates were correlated, i.e., in the first set, the correlations of Daughters 1 and 3 and of Daughters 2 and 3 both include Daughter 3. This correlation between estimates was ignored in obtaining the weighted averages shown at the bottom of Table 2.

The daughter-dam regression (.199) is almost exactly that reported earlier for much of the same data (9). The paternal half-sib correlation (.086) when the pairs were in different herds is slightly less than half the daughter-dam regression. On face value this would suggest that additive maternal genetic variance, A_m^2, is, at most, .054 of the total variance. This assumes additive-by-additive genetic variance is zero (8), no environmental correlation between daughters and dams, and a zero covariance between additive direct and additive maternal genetic effects (A_oA_m). If the last assumption is not applicable, then $2.5\ A_oA_m + A_m^2 = .054$, where A_oA_m can be either positive or negative.

Van Vleck and Hart (9), however, reported an environmental correlation of .01 between daughter and dam records in the same herd, as was the case for most of the pairs in this analysis. Reducing the daughter-dam regression by this amount, reduces $2.5\ A_oA_m + A_m^2$ to .034. Van Vleck (7) suggested that the change in variance between the daughter and dam generations could increase the daughter-dam covariance by about 10-12%. Applying this correction and the correction for environmental correlation, the daughter-dam regression becomes about .17, which is almost the same as twice the paternal half sib correlation. This line of reasoning suggests that only additive genetic variance is important and is about 34% of the total variance of deviation records. There is still the possibility that if A_oA_m is negative, A_oA_m and A_m^2 may balance each other, although other evidence (10) suggests that neither are of much importance in determining likeness between relatives.

Thus, the contradiction between daughter-dam and paternal half-sib estimates of heritability for deviation records seems resolved. The two estimates can be manipulated to give the same answer. The difference, however, between the .34 estimate from the product-moment correlation of pairs of paternal half-sibs and the

TABLE 2

Regressions or correlations between daughter-dam pairs or paternal half-sibs

Pair of records	Naturally sired b	s_b	Artificially sired b	s_b	Either N.S. or A.I. b	s_b
Two daughters in same herd (1 and 2), one in a different herd (3)						
N	1294		233		1476	
Daughter 1–Dam 1	.215	(.031)	.192	(.077)	.221	(.029)
Daughter 2–Dam 2	.242	(.031)	.338	(.077)	.263	(.029)
Daughter 3–Dam 3	.167	(.030)	.123	(.068)	.158	(.027)
Daughter 1–Daughter 2	.165	(.028)	.242	(.064)	.171	(.026)
Daughter 1–Daughter 3	.085	(.028)	.090	(.066)	.093	(.026)
Daughter 2–Daughter 3	.044	(.028)	.150	(.065)	.059	(.026)
Two daughters in same herd (1 and 2)						
N	1902		10		1895	
Daughter 1–Dam 1	.190	(.025)	...	......	.192	(.025)
Daughter 2–Dam 2	.168	(.024)	......	......	.162	(.024)
Daughter 1–Daughter 2	.163	(.023)	......	......	.165	(.023)
One daughter in one herd (1), one in a different herd (2)						
N	425		124		478	
Daughter 1–Dam 1	.183	(.054)	.137	(.096)	.156	(.050)
Daughter 2–Dam 2	.248	(.055)	.224	(.092)	.272	(.051)
Daughter 1–Daughter 2	.147	(.048)	.083	(.090)	.146	(.046)
Weighted averages						
Daughter–dam	.196	(.013)	.208	(.040)	.199	(.013)
Paternal half sibs, same herd	.164	(.018)	.242	(.065)	.168	(.017)
Paternal half sibs, different herds	.076	(.018)	.112	(.041)	.086	(.017)

.25 from the paternal half-sib intraclass correlation arising from an analysis for variance components is not resolved. The size of the sampling error of the estimate in this analysis does not rule out the possibility of no difference between the estimates from product-moment correlation and intraclass correlation. Yet, the chance of this no-difference hypothesis being true is not very great. There may be something inherent in the analysis for variance components of deviation records which causes this difference.

Comparison of the paternal half-sib correlations in the same or different herds gives an estimate of the magnitude of the environmental correlation, C^2, between paternal half-sibs. Although the environmental correlation might be expected to be higher for naturally sired daughters than for artificially sired daughters, the reverse appears in these results, .088 vs. .130. The best estimate, however, probably is from the combined data, where C^2 in terms of Bereskin and Lush (1) appears to be .082 of total variance for pairs in the same herd. This value is in agreement with the value of .06 to .12 reported by Van Vleck and Hart (9) for full sibs in the same herd. However, they found no important environmental correlation among maternal half-sisters in the same herds. There certainly is no evidence that the correlation between paternal half-sisters is lower for artificially sired pairs than for naturally sired pairs in the same herd.

Conclusions

Estimates of heritability from daughter-dam regression and paternal half-sib correlation on the basis of pairs of records are the same for deviation records after correcting for environmental correlation between daughter and dam records and for change in variance from the daughter to the dam generation. The estimate of heritability in the strictly additive sense is .34. Other sources of genetic variance are apparently not important.

The discrepancy between the estimates from paternal half-sib product moment and intraclass correlations is not explained. McDaniel and Legates (5), however, have demonstrated that not considering the number of herd-mates in analyzing deviation records may bias the intraclass correlation downward. Extrapolation of their analyses suggests that this source of error might account for about a third of the difference found in the present analysis. Their estimates of heritability from intraclass correlation from records of 1,560 cows were, however, .33 to .36 for three methods of analysis. Those estimates

are in close agreement with the product-moment correlation shown in Table 2, but are much higher than the .25 found in New York data from intraclass correlation.

The environmental correlation between pairs of paternal half-sibs in the same herd is relatively large (.08) and certainly should be considered in natural service sire evaluation. There is no evidence that the correlation is lower for pairs of artificially sired paternal half-sibs in the same herd than for naturally sired paternal half-sibs. Nevertheless, other evidence (3, 4, 6) suggests that environmental correlation is not very important in A.I. sire evaluation, probably because the fraction of daughters of a sire in the same herd is small, relative to the fraction in different herds.

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