COMPARISONS OF MATES OF SIRES USED ARTIFICIALLY AND NATURALLY AND THE HERITABILITY OF MICHIGAN DHIA HOLSTEIN PRODUCTION RECORDS

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

Victor Clement Beal, Jr.

1957

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By

Victor Clement Beal, Jr.

AN ABSTRACT

Submitted to the College of Agriculture
Michigan State University of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Dairy

1957

Approved Dale E. Madden

ABSTRACT

Victor Clement Beal, Jr.

Genetic improvement of dairy cattle is an important factor in successful dairying and is a function (a) of the genetic level of the individuals (sires and their mates) chosen to reproduce and (b) of the accuracy of selection.

A knowledge of the level of mates of sires used artificially (AB) and naturally (non-AB) is pertinent to the evaluation of daughters of these sires. When daughter averages are compared, is it valid to assume that when these daughters are equal the sires have equal transmitting abilities or are there differences in levels of their mates.

Heritability is a measure of the accuracy of selection and indicates the methods of most effective selection in choosing individuals to reproduce. Heritability values for Michigan DHIA Holstein cattle have not been reported previously.

Approximately 45,000 Dairy Herd Improvement Association records made by 20,000 Michigan Holstein cows for the period 1944 to 1956 were analyzed (a) to compare production levels of mates of AB and non-AB sires and (b) to estimate heritability of milk and fat production.

Mates were compared in herds with both AB and non-AB daughters. Purebred and grade mates were analyzed separately since the former had higher levels of production and higher average number of records than the latter. Purebred mates of AB sires did not produce significantly more milk or fat but did have significantly more records than non-AB purebred mates (12,794 pounds milk, 452 pounds fat, and 2.79 records for AB mates and 12,711 pounds milk, 449 pounds fat, and 2.60 records for non-AB mates). Grade mates of AB sires did not produce significantly less milk or fat or have significantly more records than non-AB grade mates (11,537 pounds milk, 421 pounds fat, and 2.43 records for AB mates and 11,659 pounds milk, 422 pounds fat, and 2.34 records for non-AB mates). Although some dairymen intend to mate certain levels of their cows in a given manner, evidence from this study indicates that when producing ability is represented by the average of a cow's records, these dairymen actually have not recognized their better cows.

Heritability was computed by doubling the intra-sire (for non-AB situations) or intra-herd intra-sire (for AB situations) regression of daughter on dam for the various groups (purebred and grade, AB and non-AB). Heritabilities of single records ranged from .17 to .44 for milk and from .05 to .51 for fat. Regressions for these groups did not differ significantly and were combined to provide a pooled heritability value of .26 for milk and fat.

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INTRODUCTION

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A knowledge of the level of mates of AB and non-AB sires is pertinent to the evaluation of daughters of these sires. When daughter averages of AB and non-AB sires are compared, is it valid to assume that when these daughters are equal the sires have equal transmitting abilities or are there differences in the levels of their mates.

Heritability represents the accuracy of selection and indicates the methods of most effective selection in choosing individuals to reproduce. Heritability values computed by the regression of daughter on dam have not been reported for Michigan DHIA Holstein cattle.

The purpose of this study is (a) to compare production levels of mates of AB and non-AB sires and (b) to estimate the heritability or accuracy of selection of milk and fat production for Michigan DHIA Holstein cattle.

General dairy statistics for Michigan indicate that of the 817,000 Michigan dairy cows, the approximately 60,000 cows enrolled in DHIA programs averaged 382 pounds fat and 9,725 pounds milk (Murray, 1957). Over 30 percent of Michigan dairy cows are serviced artificially and approximately 70 percent of the cattle are Holstein.

REVIEW OF LITERATURE

Comparison of Mates of AB and non-AB Sires

The evaluation of a sire's transmitting ability has been considered by several authors (Gaunt and Legates, 1955; Lush and McGilliard, 1955). Various methods of sire evaluation are the daughter average, the daughter-dam comparison, the equal parent index, the daughter-contemporary comparison in the same herd, and the daughter-contemporary herd index. No one measure was found to be superior although the daughter-contemporary comparison and index were useful for correcting for large environmental differences between herds (Gaunt and Legates, 1955). A sire's transmitting ability can be defined as the amount by which he makes his daughters deviate from breed average. Biases in evaluation can be introduced in several ways, namely, through selecting the best daughters, selecting the mates, and/or selecting the records used for each daughter (Lush and McGilliard, 1955).

James and Southcombe (1948) compared AB heifers with mature non-AB cows in the same herd and concluded that New Zealand dairy production was being increased more by AB than non-AB. Robertson and Rendel (1954) and Wadell (1957) found no difference between contemporary AB and non-AB daughters. These latter workers did not report on differences between the dams of daughters used in their studies. No reports have been observed of comparisons of AB and non-AB mates to determine these differences.

Heritability of Milk and Fat Production

Heritability is defined as the fraction of the observed or phenotypic variance which is caused by differences between the genotypes of the individuals (Lush, 1949). Heritability in the narrow sense refers to that portion of the phenotypic variance which is due to the average effects of the genes, referred to as the additively genetic variance. Heritability in the broad sense also includes deviations resulting from interactions between alleles and between non-alleles.

Choices of methods of selection depend partially on the magnitude of heritability (Lush, 1940). If heritability is high, individual selection will be effective. If heritability is low, but with little epistatic variance, considerable use of pedigrees, progeny tests, and family selection without inbreeding would be a better plan. If there is little additively genetic variance and much epistatic variance, inbreeding is useful.

Heritability is computed from associations between relatives. For dairy production traits, the intra-sire regression of daughter on dam is preferred to the daughter-dam correlation, which is biased by selection of the dams (Lush, 1940). Environmental differences and peculiarities of the mating system are largely discounted by analyzing groups of females bred to one sire. When the daughters and mates of a sire are in various herds, as in AB data, an intra-herd intra-sire regression will accomplish essentially the same results.

Reported estimates of heritability are listed below:

Breed	Heritability Milk	Fat	Source
Holsteins		.22	Legates (1957)
Holsteins		.23	Gifford (1930)
Holsteins		.25 - .30	Lush, et al. (1941)
Holsteins	.19 - .24	.17 - .21	Mitchell, et al. (1957)
Several Breeds		.27	Beardsley, et al. (1950)
Several Breeds		.25	Lush and Schultz (1936)
Several Breeds		.14 - .17	Lush and Straus (1942)
Ayrshire	.25 - .30		Mahadevan (1951)
Ayrshire	.31	.28	Tyler and Hyatt (1947)

Heritability, as a biological parameter, is not a constant value to be applied to all groups of dairy cattle indiscriminantly but may be expected to vary from situation to situation. The interesting point is that agreement is as general as reported above, since heritability values from .2 to .3 encompass most of the reported values. Removal of recognized sources of variation usually result in values comparable to those generally reported.

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Completed lactations of 180 to 305 days duration or the first 305 days of longer lactations were included. Only lactations with twice-a-day milking were used. These records were adjusted for age differences using the factors presented by Kendrick (1953) thereby providing 2x-305 day-M.E. milk and fat records. After eliminating the records not fulfilling the above conditions, there were about 45,000 purebred and 4,000 grade lactations from the first source and 8,000 purebred and 10,000 grade lactations from the second source. Approximately one-third of the grade lactations from the second source were discarded because of missing sire and/or dam identification. A summary by Specht (1957) is presented in Table 1 to indicate the general levels of production for various breeding methods, and the overall level for Michigan DHIA Holsteins. These data are grouped as purebred and grade daughters of AB and non-AB sires.

Table 1--Production levels of Michigan daughters of Holstein sires.[a]

Source of data		Number of			Average pounds of	
Sires	Daughters	Sires	Daughters	Records	Milk	Fat
AB	Purebred AB	139	2,678	4,938	12,537	451
AB	Purebred non-AB	141	1,983	4,513	13,296	484
AB	Grade AB	117	2,420	3,753	12,049	437
AB	Grade non-AB	75	292	523	12,326	444
Non-AB	Purebred non-AB	6,716	22,274	44,165	12,215	431
Non-AB	Grade non-AB	1,287	4,426	7,500	11,783	421
Total		8,475	34,073	65,392	12,237	435

[a]Specht (1957).

From the data presented in Table 1, dams were selected which had records in the same herds as their daughters. Only mates of registered sires were used. Daughters were

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[a]Specht (1957).

From the data presented in Table 1, dams were selected which had records in the same herds as their daughters. Only mates of registered sires were used. Daughters were classified as purebred or grade depending on the presence or absence of a registration number and their dams were classified accordingly. Therefore, if an unregistered daughter had a registered dam, both were classified as grades. Daughters were classified as daughters of AB and non-AB sires and their dams accordingly were classified as mates of AB and non-AB sires. The dam was included with each daughter and therefore might appear both as an AB and a non-AB dam.

Average records were used as the measure of producing ability. In comparing mates of AB sires and non-AB sires, data were included only for herds which had both AB and non-AB mates. In estimating heritability, data were included for all herds with daughter-dam comparisons. Natural daughters of AB sires are listed in Table 1 as non-AB daughters of AB sires. These were not used in the comparison of mates but were used in the heritability analyses.

METHODS OF ANALYSIS AND RESULTS

Comparison of Mates of AB and non-AB sires

In the comparison of mates of AB and non-AB sires, mates were grouped also as purebred or grade as noted above. Statistics for these four groups of dams are presented in Table 2, where average production levels were obtained from the sum of all average records divided by the number of cows.

Table 2--Average milk and fat production for purebred and grade mates of AB and non-AB sires.

Source of data		No. of	Records		Milk (lbs.)		Fat (lbs.)	
Sires	Mates	mates	Avg. No.	Std. dev.	Avg.	Std. dev.	Avg.	Std. dev.
AB	Purebred	1,055	2.89	1.70	12,623	2,322	448	84
Non-AB	Purebred	2,286	2.77	1.53	12,723	2,415	451	90
AB	Grade	126	2.52	1.59	11,736	2,143	422	71
Non-AB	Grade	187	2.39	1.55	11,966	2,096	432	76
Total		3,654	2.79	1.67	12,621	2,375	448	88

Purebred mates of AB and non-AB sires differ little in average number of records and production levels. Grade mates of AB and non-AB sires differ little in average number of records and production levels but are distinctly lower than purebred mates.

Because of wide variation in numbers of comparisons within herds, an analysis of variance for two classifications and disproportionate subclass numbers using unweighted means (Snedecor, 1946) was chosen to test for differences between AB and non-AB mates. Herds with only one mate in a Herd x Method of Breeding subclass were not included when comparing mates since these provided no information for estimating the error or within subclass variance. Average numbers of records and production levels were obtained for AB and non-AB mates in the same herd. These intra-herd AB and non-AB averages were then averaged over all herds and are presented in Table 3 as adjusted averages.

Table 3--Adjusted average milk and fat production for purebred and grade mates of AB and non-AB sires.

Source of data		No. of herds	Records		Milk (lbs.)		Fat (lbs.)	
Sires	Mates		Avg. No.	Std. dev.	Avg.	Std. dev.	Avg.	Std. dev.
AB	Purebred	183	2.79	1.02	12,794	1,876	452	69
Non-AB	Purebred	183	2.60	.82	12,711	1,713	449	63
AB	Grade	31	2.43	.95	11,537	1,678	421	59
Non-AB	Grade	31	2.34	1.08	11,659	1,628	422	60
Total		214	2.65	.94	12,585	1,819	446	66

The same relative situation is evident as in Table 2 since purebred mates did not appear different, grade mates did not appear different, but purebred mates had greater numbers of records and higher production than grade mates.

The sources of variation considered in analyzing these data to compare mates were Herds, Methods of Breeding, Herds by Methods Interaction, and Error. The first three of these were found directly by obtaining sums of squares on the adjusted averages, i.e., using subclass means as the individual observation. A within subclass error term was computed as the difference between total and subclass sums of squares with the individual cow average production as the variable. This error term was then adjusted for use with the other three sources of variation by multiplying by the product of the reciprocal of the number of subclasses and the sum of the reciprocals of the number (n_i) of mates in each subclass, so that:

$$\sigma e^2 = \frac{1}{\text{Number of subclasses}} \left(\frac{1}{n_1} + \frac{1}{n_2} + \dots \frac{1}{n_n} \right) \left(\begin{matrix} \text{Within subclass} \\ \text{mean square} \end{matrix} \right)$$

Since average records were used in this study, it was impossible to remove the effects of years and of the number of records per mate. In order to ascertain whether differences existed in the number of records per mate, an analysis (as described above) was made with number of records per mate as the variable. These analyses are presented in Table 4.

Table 4--Analysis of differences in number of records per mate for mates of AB and non-AB sires.

Source of variation	Purebred mates		Grade mates	
	d.f.	Mean Square	d.f.	Mean Square
Herds	182	1.383**	30	1.586**
Methods of Breeding	1	3.342**	1	.101
Herds X Methods	182	.335	30	.482
Error	2,975	.429	251	.476

**Significant at the 1% level.

Highly significant differences between herds in numbers of records were found for both purebred and grade mates. The purebred AB mates had significantly more records per mate than did their non-AB counterparts. No difference in numbers of records per mate between grade AB and non-AB mates was found.

Differences in levels of milk and fat production for AB and non-AB mates were determined using the analysis noted above and are presented in Table 5.

Table 5--Analysis of differences in milk and fat production for purebred and grade mates of AB and non-AB sires.

Source of variation	Purebred mates			Grade mates		
	d.f.	Mean Square		d.f.	Mean Square	
		Milk[a]	Fat		Milk[a]	Fat
Herds	182	5,631**	7,612**	30	4,855**	6,579**
Methods of Breeding	1	628	959	1	232	7
Herds X Methods	182	840	1,109	30	611	596
Error	2,975	779	1,026	251	765	950

[a]Milk multiplied by 10^{-3}.
**Significant at the 1% level.

Significant differences between herds for levels of milk and fat production for AB and non-AB mates were found for both purebreds and grades. Mates did not differ in production levels between the Methods of Breeding for either purebred or grade mates nor were significant Herd x Methods interactions present.

Heritability of Milk and Fat Production

Heritability is measured by associations between relatives. Daughter-dam association is the usual method of comparison for dairy production purposes. Comparisons used in this study have been grouped as purebred or grade daughters of AB sires and include daughters conceived prior to and during AB use, and as purebred or grade daughters of non-AB sires.

The relative levels of production of daughters and dams included in this portion of the study are presented in Table 6. Daughters exceed dams in fat production, are about equal in milk production, and have fewer records per individual than their dams.

In order to avoid the bias which selection of dams would contribute to a daughter-dam correlation, the regression of daughter's production on dam's production is preferred (Lush, 1940). An intra-sire regression provides information on differences which exist only between females mated to the same sire. This eliminates differences between sires and analyzes only differences or variations within sires.

The number of herds, the number of sires, the number of sires in more than one herd, and the number of sires within herds involved in each comparison are presented in Table 6. In the two non-AB sire groups and the group of grade non-AB daughters of AB sires, relatively few sires were used in more than one herd. Assuming natural sires were used in only one herd, an intra-sire analysis would be appropriate. For the group of purebred non-AB daughters of AB sires, a higher percentage of sires were used in several herds than in the other non-AB situations but a lower percentage than in AB situations. A high percentage of AB sires were used in more than one herd. An intra-herd intra-sire

Table 6--Production levels of daughters and dams used in the heritability analyses.

Source of data		Number of					Daughters			Dams			
Sires	Daughters and dams	Daughter-Dam Comparisons	Herds	Sires	Sires within herds	Sires in more than one herd	Avg. No. of records	Milk (lbs.)	Fat (lbs.)	Avg. No. of records ($\bar{m}$)	σ_m^2	Milk (lbs.)	Fat (lbs.)
AB	AB purebred	1,584	409	123	1,343	97	1.79	12,596	455	2.70	2.23	12,649	448
AB	Non-AB purebred	991	169	108	228	53	2.14	13,666	502	2.79	2.62	13,132	472
AB	AB grade	627	242	90	577	73	1.39	12,278	446	2.05	1.58	12,160	436
AB	Non-AB grade	113	49	36	51	8	1.83	12,834	464	2.40	1.88	12,703	454
Non-AB	Non-AB purebred	8,127	897	2,306	2,750	303	1.88	12,475	448	2.64	2.30	12,578	443
Non-AB	Non-AB grade	928	291	420	439	16	1.60	11,878	427	2.38	2.01	11,993	423
Total		12,370	2,057	3,083	5,388	550	1.84	12,534	452	2.61	2.28	12,567	444

analysis would be appropriate for such situations. Some were not used in more than one herd because of a short stay in the AB organization, not maintained in a Michigan AB organization, or erroneous calving dates.

The usefulness of the intra-sire and intra-herd intra-sire covariance analyses for estimating the regression of daughter on dam depends on the validity of the assumptions listed above. The intra-sire analysis is probably less valid for the non-AB situation where half the sires have been used in more than one herd than for the non-AB situations where few sires have been used in more than one herd. The intra-sire analyses were computed for purebred and grade daughters of non-AB sires and for grade non-AB daughters of AB sires. Intra-herd intra-sire analyses were obtained for purebred and grade AB daughters and for purebred non-AB daughters of AB sires, the latter group being included in this type of analysis because about half of these sires were used in more than one herd. Appropriate variances and covariances for the different groups are listed in Table 7. The first part contains the total variances and covariances while the second and third parts contain the intra-sire or intra-herd intra-sire variances and covariances. The appropriate regression values (b) presented in Table 8 are obtained by dividing the covariance by the variance of dams in the lower part of Table 7.

Table 7--Variances and covariances for estimating heritability of milk and fat.

Source of variation		d.f.	Milk[a]			Fat		
Sires	Dams and daughters		Var. Dams	Cov.	Var. Daus.	Var. Dams	Cov.	Var. Daus.
			Total					
AB	AB purebred	1,583	5,632	2,301	5,859	7,532	3,421	7,632
AB	Non-AB purebred	990	6,323	2,247	6,868	9,011	3,437	9,043
AB	AB grade	626	5,686	2,468	5,962	7,380	3,280	7,572
AB	Non-AB grade	112	5,324	2,722	6,379	6,683	4,075	8,022
Non-AB	Non-AB purebred	8,126	6,460	2,648	6,451	8,654	3,774	8,508
Non-AB	Non-AB grade	927	5,093	2,303	4,774	6,916	3,343	8,217
			Intra-sire					
AB	Non-AB grade	77	3,532	1,023	5,138	4,105	1,424	3,660
Non-AB	Non-AB purebred	5,821	4,094	781	3,863	5,159	1,007	4,908
Non-AB	Non-AB grade	508	2,730	357	3,009	3,611	612	4,174
			Intra-herd intra-sire					
AB	AB purebred	241	3,674	427	3,086	3,986	487	3,922
AB	Non-AB purebred	763	3,820	438	4,090	4,897	601	5,457
AB	AB grade	50	2,081	319	2,045	2,033	61	2,730

[a]Milk multiplied by 10^{-3}.

To correct the regressions for the reduced variation resulting from the use of average records of the dams, the factor of Lush and Straus (1942),

$$\left[\frac{1 + (\bar{m} - 1)\, r}{\bar{m}} + \frac{\sigma^2 m\, (1 - r)}{\bar{m}^3}\right]$$

where $\bar{m}$ is the mean of the number of dams' records, r is the repeatability of milk or fat records, and σm^2 is the variance of the dams' records, was multiplied by the computed regressions (b) to obtain regressions corrected to a single record basis. Appropriate $\bar{m}$ and $\sigma^2 m$ values for dams are listed in Table 6. Repeatability values (r) of .46 for milk and .40 for fat were obtained by Specht (1957). Heritability values, obtained by doubling the corrected regressions, and their standard errors are listed in Table 8. The original regressions were compared (Goulden, 1952) to determine if they were significantly different. Since these regressions did not differ significantly, the original sums of squares, crossproducts, and degrees of freedom for intra-sire or intra-herd intra-sire groups were pooled. The regression obtained was corrected to a single record basis and doubled to provide an overall heritability of .26 ± .02 for both milk and fat as noted in Table 8.

Table 8--Regressions of daughter on dam and heritabilities of milk and fat production.[a]

Source of variation		Milk		Fat	
Sires	Dams and Daughters	b	Heritability	b	Heritability
AB	AB purebred	.116	.168 ± .084	.122	.168 ± .088
AB	Non-AB purebred	.115	.166 ± .054	.123	.170 ± .052
AB	AB grade	.153	.232 ± .230	.030	.048 ± .264
AB	Non-AB grade	.290	.438 ± .204	.347	.506 ± .148
Non-AB	Non-AB purebred	.191	.278 ± .018	.195	.274 ± .018
Non-AB	Non-AB grade	.131	.202 ± .072	.169	.250 ± .070
Pooled		.179	.264 ± .016	.186	.262 ± .018

[a]Regressions computed for average records; heritabilities corrected to a single-record basis.

DISCUSSION

Comparison of Mates of AB and non-AB sires

The main purpose of this study was to determine if mates of AB sires had milk and fat production levels different from mates of non-AB sires. Averages and adjusted averages in Tables 2 and 3 indicate that AB and non-AB mates do not differ in levels of production. Grade mates are lower than purebred mates and were analyzed separately. Further bases for concluding that significant differences in production do not exist between AB and non-AB mates are found in Table 5 where differences between Methods of Breeding are not significant for milk and fat production of purebred and grade mates. The conclusion that significant differences do not exist between AB and non-AB mates has practical significance in two respects, namely, reports that AB and non-AB daughters do not differ and reports that certain dairymen intend to breed their best cows in a given manner.

When daughters of AB and non-AB sires were compared, Robertson and Rendel (1954), working with data from several British dairy cattle breeds, and Wadell (1957), working with several breeds of Michigan dairy cattle, found no significant differences. These authors apparently considered mates of AB and non-AB sires about equal. Since daughters did not differ, they concluded that AB sires transmitted the same level of production as did non-AB sires. Since no significant differences between mates were found, the present study, using some of the same data, substantiates Wadell's (1957) conclusion of no differences between Holstein sires. That is to say, if neither daughters nor mates differ, sires do not differ.

Various opinions have existed concerning which cows are mated artificially in herds which use both AB and non-AB sires. In response to a questionnaire (Wadell, 1957), Michigan dairymen indicated that the grade herds are breeding their better cows artificially more frequently than the registered herds, that some dairymen with both registered and grade cows may breed the former artificially and the latter naturally, and that the grade herds are breeding their heifers naturally more frequently than the registered herds. The present study is able to offer only general information on these subjects. If Michigan dairymen are attempting to mate certain levels of their cows in a given manner, they have not been successful. Although their intentions may be to mate their best cows artificially, or vice versa, insofar as the average record is a good indication of the cow's ability, the dairymen have not actually recognized their better cows. This is substantiated by the work of Dunbar and Henderson (1954) who found that when comparing several approximate indexes with a "best" index for ranking cows, the owner's ranking of his cows was the least correlated with the "best" index of any of the indexes considered. The present study also indicates that the grade breeder is not mating his better cows artificially any oftener than is the purebred breeder.

As mentioned previously, a dam may appear both as an AB and non-AB mate. The occurrence of such dams would reduce differences between AB and non-AB levels and supports the conclusion that dairymen actually are not picking out their better cows to mate in a given manner even if they desire to do so.

Since various views have been expressed concerning length of stay of mates in herds, the number of records per cow was tested to determine if AB mates remained in the herds longer than did non-AB mates. As illustrated in Table 4, herds differ significantly in the number of records per mate, but only purebred mates differ significantly between Methods of Breeding as to the number of records per cow. These small differences (2.79 for AB and 2.60 for non-AB mates) probably have little practical significance but statistically are significantly different, indicating that purebred AB mates remain in the herd slightly longer than purebred non-AB mates. Differences in numbers of records per cow for grade AB and grade non-AB mates were not significant.

Pertinent questions not considered here were: year to year effects and possible differences in variation of individual production records by the same cow. Specht (1957) found no significant differences between levels of production for different years. The use of average records would have permitted random year to year variations partially to cancel out, but permitted no measurement of variability of individual production records.

Heritability of Milk and Fat Production

The choice of breeding plans is dependent on the accuracy of selection as measured by heritability. The purpose of this section of the study was to measure heritability of milk and fat production in various daughter-dam groups. The heritability values presented in Table 8 are in general agreement with those found in the literature and presented above in the Review of Literature. Several of the heritabilities found here seem extreme and have large sampling errors. These values may be the result of limited sample sizes and/or errors in field recording, such as recording identification and production information. The values from .4 to .5 for milk and fat in non-AB grade daughters of AB sires probably result from limited numbers, since only 113 comparisons on 36 sires were available. However, 8 of these 36 sires, or 22 percent, were used in more than one herd.

An intra-sire regression method was utilized and failure to remove herd differences may have increased the likeness between daughter and dam in the same herd, producing the large heritability values. The other extreme heritability value is .05 for fat for grade AB daughters. The corresponding value for milk of .23 may indicate an error in one or the other (milk or fat) since milk and fat are known to be highly correlated (Tabler and Touchberry, 1955). The data were recomputed to determine errors in calculations but none were found. Examination of the individual daughter-dam comparisons indicated that there may be errors in identifying the daughter with her proper sire or dam. Some large extremes were found in milk and fat between certain daughters and dams with very little difference in fat percent. With limited numbers, a few cases of a high level dam with a low level daughter, or vice versa, could have lowered the regression drastically. When certain extreme records were eliminated, the regression for milk was increased slightly but the regression for fat was increased sufficiently to make it one half instead of one fifth the magnitude of the regression for milk. This leads one to believe that there were errors in recording the data but since there is no logical basis for removing these extreme records, the original records were used.

The heritability values computed on an intra-sire basis are higher than those computed on an intra-herd intra-sire basis, and may have overestimated heritability. If sires which were used in more than one herd had not been included, a lower heritability value would have been obtained. Table 6 indicates the number of sires used in more than one herd.

As noted previously, the regressions found in Table 8 did not differ significantly and were combined to give an overall heritability of 0.26 for milk and fat.

SUMMARY

Michigan DHIA Holstein records from 1944 to 1956 were analyzed (a) to compare production levels of mates of sires used artificially (AB) and naturally (non-AB) and (b) to obtain heritability of milk and fat production.

Purebred and grade mates were analyzed separately since the former had higher levels of production and higher average number of records than the latter. Purebred mates of AB sires did not produce significantly more milk or fat but did have significantly more records than non-AB purebred mates. Grade mates of AB sires did not produce significantly less milk or fat or have significantly fewer numbers of records than non-AB grade mates.

Heritabilities, computed by doubling the intra-sire or intra-herd intra-sire regression of daughter on dam, for the various groups (purebred and grade, AB and non-AB) ranged from .17 to .44 for milk and from .05 to .51 for fat. Regressions for these groups did not differ significantly and were combined to provide a pooled heritability value of .26 for milk and fat for Michigan DHIA Holsteins.

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ACKNOWLEDGEMENTS

I am greatly indebted to Dr. D. E. Madden for his assistance and guidance in the gathering, preparing, interpreting, and writing of this material. I am also indebted to Dr. W. D. Baten for his assistance and guidance in a portion of the analyses. I would like to extend many thanks to: Dr. L. D. McGilliard for his advice and helpful suggestions; Dr. N. P. Ralston, Head of the Department of Dairy, for his encouraging me to proceed with graduate studies; Mr. L. W. Specht for his assistance and permission to use some results of his efforts; and Mr. R. P. Witte for his assistance and technical advice in the use of I.B.M. machines for analyzing these data. Finally, my sincere thanks go to my parents who have made it possible for me to pursue these graduate studies.

Date Due

~~APR 19 1972~~

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