INTERACTIONS BETWEEN AI SIRES AND MANAGERIAL PRACTICES IN DAIRY HERDS

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An Abstract

**Submitted to the College of Agriculture
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Five environmental factors were studied to determine the existence and amount of interaction between these factors and milk, fat, and test of sires' daughters. The factors were based on herd information and included level of production, location, days dry, calving interval, and type of housing. Data were first records reported in Michigan Dairy Herd Improvement Association for AI daughters in tested herds with at least one yearly herd average reported.

The analysis of the five herd classifications involved the following data: (1) 8638 Holstein AI daughters of 192 AI sires in 1211 herds and 1872 Guernsey AI daughters of 138 AI Guernsey bulls in 355 herds were divided into three levels of production on the average annual production of their respective herds. (2) The 1211 Holstein herds were divided into six geographical locations of the state. (3) and (4) 394 Holstein herds were divided into three levels based on the average number of days cows were dry and the average number of months per cow between calvings. These data included 4081 AI daughters from 172 sires. (5) 627 Holstein herds were divided into 3 groups on the type of housing for dairy cows. This classification included 5240 AI daughters of 186 AI bulls.

The general component of interaction between herds and sires accounted for between zero and nine per cent of the variation in milk and fat production and test. When herds and herd-by-sire components were split into one of the five constitutive environments, there was no apparent interaction with sires. Therefore, the ranking of AI sires in herds on the basis of their daughters' performance will be independent of any of the five environmental segments studied. Holstein AI sires are not equally represented in all herds.

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INTRODUCTION

Interaction between sires and herds may be principally a differential response of a sires' daughters to different environments. In dairy cattle the interaction between sires and herds constitutes only a small part, if any, of the total variation in milk and fat yield and test. The literature generally ascribes from none to seven per cent of the total variation to the interaction of sires with herds. Absence of interaction indicates that differences between groups of daughters by different sires remain the same regardless of the environment in which they are compared. To the individual breeder of dairy cattle and to the committees for selection of sires for use in AI (artificial insemination) the negligible interaction has meant that different bulls need not be selected for specific environments.

A small general interaction between sires and herds does not mean, per se, that interactions between specific environments and the genotypes of individuals living under those environments may not be of some importance. Environments of herds are a composite of many environments with the managerial practices of the dairyman being an integral part of these environments. The constitutive environments may be the primary environments with which sires' daughters interact. In the general sire by herd interaction, individually important interactions between sires' daughters and the constitutive environments of the herds may be swamped and cancelled out. This cancelling effect may reduce the sire by herd interaction to near zero even when interactions involving specific environments are important.

The purpose of this study is to ascertain the existence and size of interactions between sires and a few measurable constitutive environments.

REVIEW OF LITERATURE

Recent estimates by Pirchner and Lush (1959), Specht (1957), and Mason and Robertson (1956) ascribe to differences between herds 30 to 40 per cent of the total variation in milk and fat production. Of this amount only a small fraction is heritable. Pirchner and Lush (1959) indicate that 6.5 per cent of the differences in milk and fat production between herds within years are heritable. Other estimates from the literature place genetic differences between herds between zero and 12 per cent.

Little work has been reported concerning the fraction of the total variation for milk and fat production directly due to some segment of the total herd environment. Plum (1935) attributed 11.4 per cent of the total variation in fat production in Iowa DHIA records to differences between herds in feeding methods.

More recent studies of feeding methods do not indicate how much of the total variation in production may be accounted for by specific feeding and managerial practices but do estimate the relative importance of specific feeding and managerial practices. Bayley and Heizer (1952) conducted for 20 months a study of 967 grade and registered Holsteins in 47 Wisconsin herds to determine the relationships between five measures of environment or management and production of milk and fat. They used the last completed lactation record for all cows bred, born, raised, and still living in the herd. Records were standardized to 305 days, included only 2X milking and were uncorrected for age. Specific factors reported were condition before freshening, selection rating, TDN fed per 1,000 lb. of body weight, nutritive ratio, and size of herd. Ratings and systems of scoring were devised for influences not readily evaluated numerically. The selection rating had a range of from 1 to 45 points for the methods of selection of breeding stock in the herds. The four grades for condition at the time of calving ranged from excellent to poor with 85 per cent of the cows in the excellent and good grades and less than 1 per cent in the poor grade. TDN fed per 1,000 lb. body weight and nutritive ratios were based on rations fed during the winter months in the barn and ranged from 12.4 to 27.0 and 5.2 to 9.2, respectively. The number of cows of milking age in the herds determined the size of herd which had a range of 12 to 165 cows.

Multiple regression was used to estimate the importance of the specific factors. The regression of milk yield on the selection rating indicated that with each increase of five points in the selection rating, there was an average increase of 305 lb. in milk yield. No indication of curvilinearity was reported for regression of milk production on selection ratings. The effects of condition at time of freshening were reported as average differences between the observed milk and fat production records and the predicted milk and fat production as determined by the multiple regression of the quantitatively measured factors. This method showed an increase of 46 lb. of milk from "fair" to "good" grades and an increase of 850 lb. from "good" to "excellent". For a daily increase of 1 lb. of TDN fed per 1,000 lb. body weight, there was an increase of 551 lb. of milk produced. A change in the nutritive ratio from 9.2 to 5.2 resulted in an increase in milk yield of 2,952 lb. Herd size had a negative effect on milk production with a decrease of 775 lb. milk for an increase in herd size from 20 cows to 49. The decline was 521 lb. for an increase in herd size from 50 to 79 cows with only slight decreases in milk production for herds containing more than 80 cows.

In a continuation of the previous study, Starkey, Corley, and Heizer (1958) collected 1,168 records of production and environmental information from 43 DHIA Holstein herds in Wisconsin during a three year period. Results, which were comparable with the previous study, are in fair agreement. Of particular interest, however, to the present study was the highly significant partial regression coefficient for milk yield on calving interval and previous dry period. A lack of linearity in the data was noted which would make the regression coefficients given reliable for only certain parts of the ranges listed for the environmental factors considered.

While the studies cited give indications of the relative importance of some of the constitutive environments that go into the overall herd environment, they by no means cover all possibilities. The studies of Bayley and Heizer and of Starkey _et al_. are plagued with problems common to this type of study such as the paucity of exact measurements, lack of linearity within the ranges of the variables being considered, and all variables considered not being completely independent of each other. The motivation for these studies has been to develop correction factors to standardize environment and, thereby, to reduce environmental differences between herds. Where sufficient numbers of animals are involved, correction factors are an economical and reasonably accurate method of standardizing environment for sire analysis work.

In order to escape the vagaries of correction factors as much as possible and at the same time to standardize environment, special testing stations have been established in Denmark for evaluating daughters of potential AI sires. Robertson and Mason (1956) found that the variation between sires' daughters in milk yield was much larger at the stations than in farmer herds of the same production level. The authors point out that there is extra variation between progeny groups at the testing stations that is not repeated in the field. A possible environmental source of this extra variation is suggested to be the manner in which progeny groups are segregated in the testing stations. The authors suggest desegregating these groups in order to reduce variation between sires. They state: "It is doubted whether the test stations can give as much useful information on the numerical aspects of performance as the field records usually available. The principle value of the test stations is one of demonstration of managerial methods".

Touchberry and Rottensten (1958) studied the Danish testing station and field records covering an eight year period. The station records included 5454 daughters of 305 Red Danish Milkrace sires. Farmer herd records were from 110 of these sires with 3270 daughters. The testing station data showed components of variance between sires to be 223 and intra sire to be 1140 after adjustment for age at calving and days in milk. Data of sires' daughters from farmer herds were expressed as deviations from the mean annual production of the herd. The components between and within sires were 47 and 887, respectively. The authors observed by comparing the between and within components of variance for sires, that the test stations were injecting environmental variation that was not found in the farmer herds. The authors found that the correlation between station and farmer-herd tests was .16. A negative component of interaction between sires and herds within AI centers was reported.

The studies reviewed indicate many constitutive environments make up the herd environment. If interactions are taking place they are between sires and these constitutive environments and not between sires and herds, _per se_. Wadell (1957) noted no interaction between sires and herds for 1,496 Holsteins sired by 199 sires in 282 Michigan herds. This study analyzed each AI record as a deviation from the average of all the natural records in the herd, and for cows with more than one record all but one record were eliminated in a random manner.

Specht (1957) observed a positive herd-sire interaction that accounted for 7 per cent of the total variation in milk yield for 5,098 Holstein AI daughters sired by 30 bulls in 211 Michigan herds. The interaction components from the records of 2,631 AI progeny in the three years 1953, 1954, and 1955 accounted for three, two, and zero per cent respectively, of the total variation in milk production. When the data for these three years were recombined and reanalyzed, an interaction component accounting for 9 per cent of the total variation in milk production was noted.

Pirchner and Lush (1959) analyzed 2,903 Holstein AI heifers in 1,177 Iowa herds on an intra-year study involving 481 sires. Sire-herd interactions accounted for 4 and 3 per cent of the total variation in milk and fat production of AI heifers. Genetic differences between herds accounted for 6.5 per cent of the differences between herds. On an intra-year-season basis, interaction components amounted to 7 per cent of the total variation for both milk and fat. This basis, however, led to estimates of 28 and 24 per cent for genetic differences between herds for fat and milk production, respectively. The authors suggest sampling errors as a possible cause for the larger proportion of genetic differences.

Korkman (1953) studied 35 AI sires with 10 daughters in any of the 252 herds analyzed. His results suggest that herd differences are due to specific environmental influences. By dividing herds into three planes of nutrition, he found that within a given plane of nutrition there was a significant difference between the breeding values of sires, but there is no difference between the adaptability of the daughter groups of different sires to different planes of nutrition.

Mason and Robertson (1956) divided herds into three groups on the annual average production for the herds. Analyzing first annual records from 13,000 AI daughters of 152 sires in Denmark, they found no evidence of sire-herd interaction either between or within the three herd levels. They concluded that the ranking of sires within levels will remain the same from herd to herd. They also noted a decrease in the coefficient of variation as production of herds increased.

Legates, Verlinden, and Kendrick (1956) worked with 24,754 AI daughters of Guernsey, Holstein, and Jersey sires throughout the United States for the years 1946 through 1950 to estimate herd-sire interaction. They found that interaction for test was not important except in Jerseys where it approached the variation of sires in magnitude. Sire by herd interaction for milk yield was indicated to be at or near zero. They concluded that specific sire by herd differences are not of a major importance. In other words, the ranking of sires should remain relatively the same from herd to herd regardless of environmental differences between herds.

Hancock (1953) estimated interaction between environment and genotypes by a method different from those previously discussed. Fifteen sets of monzygous twins were divided into three groups of ten each and each group was divided over three different levels of environment. In design, this experiment was a balanced incomplete block. The study covered a three year period with milk, fat, and casein content recorded daily. All records were terminated (1) after fat production fell below 8 lb. for 28 days; (2) six weeks prior to freshening; or (3) 309 days after calving. Milk yield was corrected for age (ME). The analysis of variance was by years with the range of components of interaction between environment and genotypes for the three years accounting for between 5 and 9 per cent of the total variation in milk production and between 6 and 11 per cent of the total variation in fat yield. The components of interaction, as noted by the author, are actually residual components only partially made up of interaction and contain errors of measurement and errors due to uncontrollable factors specific to individuals.

MATERIALS AND METHODS

First records reported in the Michigan Dairy Herd Improvement Association for AI daughters in tested herds with at least one yearly herd average reported were used. These records were from standard DHIA and DHIA-IBM and included records completed through September 1958. All records were 305-2X-ME and were completed lactations of 180 to 305 days in length. Lactations longer than 305 days were terminated at 305 days. The pounds of milk and fat produced and per cent fat were recorded for each cow together with her sire and herd. Herds were classified by level of production, location, average days dry, calving interval, and type of housing.

Levels of Production. In a first attempt to identify a potential source of sire-environmental interaction, it was decided that yearly herd averages might provide a guide to reduce non-genetic differences between herds. Three levels of production were established by dividing the array of herds (as based on an average of all available yearly herd averages) into essentially equal numbers of herds within each level.

Table 1 presents for each level the number of herds in that level, the average number of cows per herd, and the per cent of cows that were produced by AI. The average milk production per level is also indicated and is calculated from the average of the annual herd averages. Some automatic relationships exist between the level of production of a herd and the AI daughters in the herd since it was possible for AI daughters to be included in the calculation of the annual herd average. Complete independence between annual herd average and AI daughters would be desirable since there should be no predetermined connection between levels based on herd averages and the AI daughters in them. The amount and effect of the automaticity is considered small.

TABLE 1

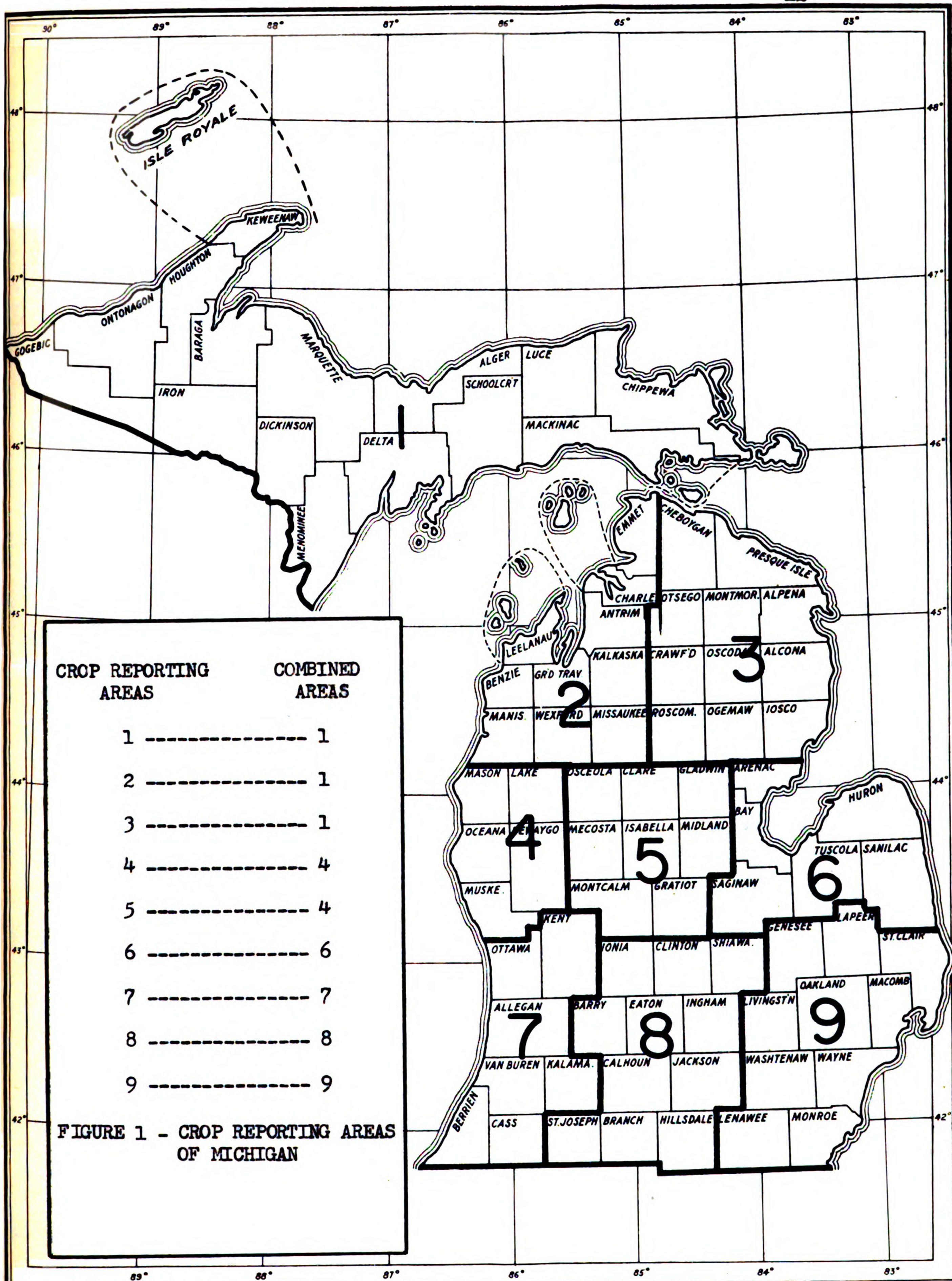
SIZE, NUMBER AI, AND AVERAGE PRODUCTION FOR HERDS AT THREE LEVELS OF PRODUCTION

Level	Holstein				Guernsey			
	No. Herds	No. AI	Herd Size	Ave. Milk	No. Herds	No. AI	Herd Size	Ave. Milk
1	404	2325	24	9,140	117	601	24	6,762
2	403	3058	25	10,983	116	832	22	8,307
3	404	3255	23	12,775	122	439	26	10,244
All	1211		24	10,966	355		24	8,464

<u>Location</u>. Since the nine crop reporting areas of Michigan contain within each area a somewhat uniform type of farming with a different type of farming between areas, it was decided that some uniformity of environment might exist on dairy farms within each reporting area.

Areas 1 through 5 (Figure 1) were combined into two composite areas because of insufficient numbers of cows on test. Crop reporting areas 1, 2, and 3 were combined into Group 1. Crop reporting areas 4 and 5 were combined into Group 4. This study included all of the Holstein herds included in the previous division into groups by level of production of the herd. Numbers of Guernseys were too small to use here or in any of the subsequent groupings.

<u>Days Dry and Calving Intervals</u>. Calving interval is considered



CROP REPORTING AREAS	COMBINED AREAS
1	1
2	1
3	1
4	4
5	4
6	6
7	7
8	8
9	9

FIGURE 1 - CROP REPORTING AREAS OF MICHIGAN

one of the best single criteria for rating good overall management on a dairy farm (Benne, 1958). It implies in one readily available value the level of such managerial factors as the reproductive efficiency of the herd which is in turn directly affected by the health and condition of the herd and by the ability of the dairyman to cope with reproductive disorders. Days dry seemed also to present a good indication of management in general. Four hundred and ten herds with information of days dry and calving interval previously studied by Benne (1958) were used to code matching herds in the present study. Table 2 indicates the division of the herds by the range of days dry and calving intervals.

TABLE 2

NUMBER OF HERDS AND RANGE OF THREE MANAGERIAL LEVELS FOR DAYS DRY AND FOR CALVING INTERVAL

Days Dry		Calving Interval	
No. Herds	Range (days)	No. Herds	Range (months)
36	0-45	62	10-11
335	46-75	222	12
49	76-111	126	13-16

Type of Housing. Types of housing as analyzed by Knisely (1959) involved 627 herds with qualifications for inclusion in the present study. The types of housing included 471 herds with stanchion type, 199 with loose type, and 37 with switch type. Switch was the case where the herd was too large for the milking facilities of the stanchion barn, and as a result, cows were held as in loose housing for certain periods of the day but were milked in the stanchion barn.

Method of Analysis. All sires were not represented equally in all herds. The majority of the sires were represented by daughters in few herds with the number of daughters being from 0 to 6 in a herd. Henderson's (1953) method 1 for components of variance of non-orthogonal data was used for the following two arrangements.

First, an over-all analysis was done to estimate the components of variance for herds (H), sires (S), interaction between herds and sires (HS), and residual (E). The second method involved sub-dividing the components of variance H and HS on each of the classifications, levels of production (LP), locations (A), days dry (DD), calving intervals (CI), types of housing (TH). For example, H was divided into variance between levels of production LP and H within LP; HS was divided into interaction between sires and levels of production S by LP and into HS within levels. This procedure estimated the interaction between sires and various characteristics of herds related to their environment and management.

In the model for the over-all analysis y_{ijk} denotes the record made by the kth daughter of the jth sire in the ith herd:

$$y_{ijk} = u + \underbrace{h_i}_{l_l + h_{il}} + s_j + \underbrace{hs_{ij}}_{ls_{jl} + hs_{ijl}} + e_{ijk}.$$

u is common to all observations, h_i is the deviation from the mean caused by the ith herd and s_j is the deviation of the daughters of the jth sire from the mean. hs_{ij} is peculiar to records of the daughters of the jth sire in the ith herd. e_{ijk} is a random element in each daughter's record. The notations below h_i and hs_{ij} of the model represent graphically the division of the first model for the second method of analysis

as given in the previous paragraph.

Henderson (1953) points out in the description of his method 1 that it is assumed that u is a constant and other elements of the first model are uncorrelated variables with means zero and variances H, S, HS, E. It is not known to what extent, if at all, this condition is met in this study. Conceivably a nominated mating system could impart some degree of correlation between h_j and s_j. As Pirchner and Lush (1959) point out, "The information on a bull's breeding value at the time he is selected is generally meager and would seem to warrant assuming that the correlation between the genetic merit and the environmental level of DHIA or HIR herds is negligible."

The process of computation consisted of calculating sums of squares and equating them to their expectations. Estimates of the components of variance for the elements of the linear model were obtained by solving the equations of the component matrix.

RESULTS AND DISCUSSION

The results and discussion of each constituent environment will be deferred to its separate heading together with its respective tables.

Levels of Production (Holstein). When AI daughters were grouped into three environmental levels based on the average annual production of the herds in which they were, the component of interaction between sires and levels of production accounted for none of the total variation in milk, fat, or test (Table 3). The ranking of sires would be the same in any of the three environmental levels measured by annual herd averages. Interactions within levels between sires and herds were still taking place, however, and accounted for 3 per cent of the total variation in milk and fat yield. This is only slightly less than the 4 per cent calculated for all herds by sire interactions for milk and fat yield. Mason and Robertson (1956), and Legates *et al.* (1956) indicated that interaction between sires and herds was near zero, but recent estimates of interaction place the value at 6 per cent of the total variation within year in milk and fat production (Pirchner and Lush, 1959). Specht (1957) estimated that interaction between sires and herd accounted for 9 per cent of the total variation in milk and fat production. Interaction between herds and sires of 4 per cent of the total variation falls within the range cited by others.

Grouping herds according to levels of production effectively placed most of the variation between herds in the component of variance for levels. About half of the differences between herds for milk and fat yield were removed by grouping AI daughters in this manner. If

TABLE 3

COMPONENTS OF VARIANCE FOR LEVELS OF PRODUCTION, HERDS AND SIRES FOR HOLSTEINS

Source of Variation	df	Mean Squares	Component of Variance	Percent of Total[1]
Milk[2]				
Sire	192	16,866	231	3
Herd	1,210	19,041	2,066	33
SireXHerd	5,385	3,923	241	4
Residual	1,850	3,760	3,760	60
Total	8,637		6,298	
Sire	192	16,866	222	3
Level	2	4,856,626	1,695	25
Herd/Level	1,208	11,032	941	14
Sire/Level	310	4,951	31	0
Sire-Herd/Level	5,075	3,860	227	3
Residual	1,850	3,760	3,760	55
Total	8,637		6,876	
Fat				
Sire	192	16,718	178	2
Herd	1,210	26,212	2,925	36
SireXHerd	5,385	5,016	288	4
Residual	1,850	4,813	4,813	58
Total	8,637		8,204	
Sire	192	16,718	186	2
Level	2	5,878,794	2,051	23
Herd/Level	1,208	16,522	1,563	18
Sire/Level	310	5,826	- 19	0
Sire-Herd/Level	5,075	4,966	312	3
Residual	1,850	4,813	4,813	54
Total	8,637		8,906	
Test				
Sire	192	0.62	0.01	6
Herd	1,210	0.23	0.02	11
SireXHerd	5,385	0.09	-0.04	0
Residual	1,850	0.15	0.15	83
Total	8,637		0.14	
Sire	192	0.62	0.02	11
Level	2	0.80	0.00	0
Herd/Level	1,208	0.23	0.02	11
Sire/Level	310	0.10	0.00	0
Sire-Herd/Level	5,075	0.09	-0.04	0
Residual	1,850	0.15	0.15	78
Total	8,637		0.15	

[1]Negative variance components were considered as essentially zero in the calculations of per cent of total.

[2]Mean squares and components of variance for milk multiplied by 10^{-3}.

herd differences are between 6 and 10 per cent heritable as estimated by Lush and Straus (1942), Pirchner and Lush (1959), Robertson and Rendel (1954), and others, then at least 90 per cent of the differences between levels is non-genetic if genetic herd differences are the same for all levels of environment.

It has generally been thought that since dairymen have had equal opportunity to select between bulls in AI, genetic differences betweeen AI herds are small, and are being reduced by the same bulls being used in many herds. To determine if dairymen with herds in one of the three levels of environment were selecting bulls more or less than dairymen with herds in some other level, a chi-square test of the proportionate use of sires in the three levels was made. Seventy-five bulls having five or more AI daughters per sire-level cell were used. The results of the test ($\chi^2 = 178.8$, d.f. = 148, $P < .05$) indicated that selection has been taking place. Various AI bulls were not uniformly represented in all environmental levels. This might indicate that the genetic difference between levels could be something more than the 10 per cent between herds indicated by the literature. The fallacy of this assumption lies in the observations of Pirchner and Lush (1959) that no dairyman is going to select bulls for low production and that the generally meager information available at the time the dairyman selects an AI sire for use in his herd does not allow intelligent selection to be made based on the true genetic merit of the bull.

Table 4 presents the average production of the AI daughters by the level of production of the herd in which they were. In comparing these results with those in Table 1, while each level consisted of an

TABLE 4

PRODUCTION BY HOLSTEIN AI DAUGHTERS AT VARIOUS LEVELS OF PRODUCTION OF HERDS

Level	No. of Records		Milk	Fat	Test
1	2325		11,018	402	3.67
2	3058		12,103	439	3.65
3	3255		13,640	493	3.63
Total	8638	Average	12,390	450	3.65

equal number of herds essentially of the same size, there is a definite increase in the proportion of AI daughters in herds of the higher level. If there is no correlation between environment level and genetic merit of herd then these herds in the high level have high annual production more because of their environments (which includes management), than because the genetic quality of their AI daughters is superior to the genetic quality of AI daughters in the lower herds.

Levels of Production (Guernsey). The results obtained from the analysis of levels of production for Guernseys were essentially the same as for Holsteins. Table 5 summarizes these results. The component of variance between Guernsey sires was relatively large as compared with Holsteins. If differences between progeny groups are mainly due to genetic differences, then it would appear that Guernsey sires have larger genetic differences than Holstein sires and that close attention to sires selected would be a profitable consideration for Guernsey dairymen.

TABLE 5

COMPONENTS OF VARIANCE FOR LEVELS OF PRODUCTION, HERDS AND SIRES FOR GUERNSEYS

Source of Variation	df	Mean Squares	Component of Variance	Percent of Total[1]
Milk[2]				
Sire	138	6,886	259	8
Herd	355	8,425	1,181	35
SireXHerd	865	1,549	80	2
Residual	513	1,819	1,819	55
Total	1,871		3,339	
Sire	138	6,886	274	8
Level	2	436,531	665	18
Herd/Level	353	6,000	721	20
Sire/Level	159	1,388	- 115	0
Sire-Herd/Level	706	1,586	180	5
Residual	513	1,819	1,819	49
Total	1,871		3,544	
Fat				
Sire	138	16,635	663	8
Herd	355	21,543	3,265	38
SireXHerd	865	2,644	- 682	0
Residual	513	4,602	4,602	54
Total	1,871		7,848	
Sire	138	16,635	657	7
Level	2	973,507	1,467	16
Herd/Level	353	16,150	2,250	25
Sire/Level	159	3,939	- 140	0
Sire-Herd/Level	706	2,352	- 539	0
Residual	513	4,602	4,602	52
Total	1,871		8,297	
Test				
Sire	138	0.51	0.02	11
Herd	355	0.32	0.02	10
SireXHerd	865	0.16	0.02	9
Residual	513	0.15	0.15	70
Total	1,871		0.21	
Sire	138	0.51	0.03	13
Level	2	0.21	0.00	0
Herd/Level	353	0.32	0.02	9
Sire/Level	159	0.14	-0.01	0
Sire-Herd/Level	706	0.17	0.03	13
Residual	513	0.15	0.15	65
Total	1,871		0.22	

[1]Negative variance components were considered as essentially zero in the calculations of per cent of total.

[2]Mean squares and components of variance for milk multiplied by 10^{-3}.

The total variance in fat and milk production for Guernseys was smaller than for Holsteins, with the two main sources of variation being herds and residual. Differences between Guernsey herds were less than those of Holsteins and residual components of variance for Guernseys were about one-half those of Holsteins. Wadell (1957) also noted this difference between the two breeds. While these observations hold for milk and fat yield, they do not hold for test where Guernseys exhibit more total variability than Holsteins. This criterion is also the location of the largest component of interaction between sires and herds found in this study, contributing 9 per cent of the total variation.

The summaries of AI daughters as grouped by herd levels for Guernseys in Table 6 indicate a marked decrease in the number of AI

TABLE 6

PRODUCTION BY GUERNSEY AI DAUGHTERS AT VARIOUS LEVELS OF PRODUCTION OF HERDS

Level	No. of Records		Milk	Fat	Test
1	601		7,465	363	4.89
2	832		8,662	418	4.86
3	439		9,213	447	4.87
Total	1872	Average	8,407	407	4.87

daughters in herds with higher environmental levels. In both Holsteins and Guernseys, averages of the herd levels in Table 1 have been below those of the AI daughter averages for the same levels with one exception. This was in the high environmental level of Guernsey where the herd averages exceed the AI daughter averages. As pointed out by Wadell (1957),

TABLE 7

COMPONENTS OF VARIANCE FOR AREAS, HERDS, AND SIRES

Source of Variation	df	Mean Squares	Component of Variance	Percent of Total[1]
Milk[2]				
Sire	192	16,866	231	3
Herd	1,210	19,041	2,066	33
SireXHerd	5,385	3,923	241	4
Residual	1,850	3,760	3,760	60
Total	8,637		6,298	
Sire	192	16,866	318	5
Location	5	198,515	119	2
Herd/Location	1,205	18,296	1,963	29
SireXLocation	544	2,314	- 375	0
Sire-Herd/Location	4,841	4,104	537	8
Residual	1,850	3,760	3,760	56
Total	8,367		6,322	
Fat				
Sire	192	16,718	178	2
Herd	1,210	26,212	2,925	36
SireXHerd	5,385	5,016	288	4
Residual	1,850	4,813	4,813	58
Total	8,637		8,204	
Sire	192	16,718	305	3
Location	5	356,193	236	3
Herd/Location	1,205	24,843	2,731	31
SireXLocation	544	2,196	- 570	0
Sire-Herd/Location	4,841	5,333	739	8
Residual	1,850	4,813	4,813	55
Total	8,637		8,257	
Test				
Sire	192	0.62	0.01	6
Herd	1,210	0.23	0.02	11
SireXHerd	5,385	0.09	-0.04	0
Residual	1,850	0.15	0.15	83
Total	8,637			
Sire	192	0.62	0.00	0
Location	5	4.81	0.01	5
Herd/Location	1,205	.21	0.02	10
SireXLocation	544	- .30	-0.04	0
Sire-Herd/Location	4,841	.13	0.02	10
Residual	1,850	.15	0.15	75
Total	8,637			

[1]Negative variance components were considered as essentially zero in the calculations of per cent of total.

[2]Mean squares and components of variance for milk multiplied by 10^{-3}.

bull studs should provide bulls of sufficient genetic merit as to be at least as good as the sires being used naturally now by the better herds. It would seem from the results of Tables 1 and 6 that this is not being done in the case of Guernseys.

While Guernseys exhibit a large component of interaction between sires and herds for test, when considered on the basis of environmental groups, they failed to give any indication of interaction.

Areas. This section contains the same herd and sire information as does the first section for Holstein levels. However, as Table 7 shows, very little was removed from the component of variance between herds as a result of grouping herds by areas. While the areas were relatively close together geographically as compared to the areas covered by Legates *et al.* (1956), the conclusions are the same; there is no need to designate certain sires for use in certain areas, at least not in Michigan.

Table 8 gives a tabulation by area of the AI daughter averages.

TABLE 8

AVERAGE BY AREAS OF RECORDS FIRST REPORTED FOR AI DAUGHTERS

Area	No.		Milk	Fat	Test
1	722		11,467	417	3.66
4	648		12,493	456	3.67
6	2196		12,353	443	3.60
7	734		12,587	462	3.70
8	2593		12,695	464	3.68
9	1745		12,250	441	3.62
Total	8638	Average	12,390	450	3.65

TABLE 9

COMPONENTS OF VARIANCE FOR DAYS DRY, HERDS, AND SIRES

Source of Variation	df	Mean Squares	Component of Variance	Percent of Total[1]
Milk[2]				
Sire	172	11,769	222	3
Herd	394	24,480	1,955	30
SireXHerd	2,496	3,871	- 169	0
Residual	1,018	4,313	4,313	67
Total	4,080		6,321	
Sire	172	11,769	294	4
Days Dry	2	134,959	229	3
Herd/Days Dry	392	24,916	1,906	28
SireXDays Dry	157	5,679	- 91	0
Sire-Herd/Days Dry	2,339	3,750	- 152	0
Residual	1,018	4,313	4,313	64
Total	4,080		6,499	
Fat				
Sire	172	11,439	110	1
Herd	394	33,816	2,755	33
SireXHerd	2,496	5,049	- 188	0
Residual	1,018	5,566	5,566	66
Total	4,080		8,243	
Sire	172	11,439	144	2
Days Dry	2	194,709	334	4
Herd/Days Dry	392	32,995	2,683	31
SireXDays Dry	157	7,987	- 42	0
Sire-Herd/Days Dry	2,339	4,852	- 181	0
Residual	1,018	5,566	5,566	64
Total	4,080		8,504	
Test				
Sire	172	0.38	0.01	5
Herd	394	0.23	0.01	5
SireXHerd	2,496	0.07	-0.06	0
Residual	1,018	0.19	0.19	90
Total	4,080		0.15	
Sire	172	0.38	0.01	5
Days Dry	2	0.01	0.00	0
Herd/Days Dry	392	0.23	0.01	5
SireXDays Dry	157	0.11	0.00	0
Sire-Herd/Days Dry	2,339	0.07	-0.09	0
Residual	1,018	0.19	0.19	90
Total	4,080		0.12	

[1]Negative variance components were considered as essentially zero in the calculations of per cent of total.

[2]Mean squares and components of variance for milk multiplied by 10^{-3}.

<u>Days Dry and Calving Intervals</u>. Days dry and calving intervals are considered to be good indicators of the overall managerial ability of the dairyman (Benne, 1958). However, very little of the component of variance between herds was accounted for by these criteria, 2 or 3 per cent as indicated in Tables 9 and 11. This is much smaller than expected.

As previously mentioned, it is possible to have sire by herd interactions overwhelmed by herd differences and by cancelling effects within herds. In the sire by herd analysis for milk and fat production in Table 11 the component of interaction between sires and herds is negative or essentially zero. Yet, when this component of interaction between sires and herds is divided into herd groups based on calving intervals in the herd, the component of interaction between sires and calving interval groups becomes a positive value. While this is less than one per cent of the variance, it could indicate that some interaction was being identified - albeit very little. Sampling error might be a more plausible reason.

The criterion of days dry as shown in Table 10 would seem to favor shorter dry periods, however, no conclusions should be drawn.

TABLE 10

AVERAGE BY DAYS DRY OF RECORDS FIRST REPORTED FOR AI DAUGHTERS

Days Dry	No.		Milk	Fat	Test
1	114		13,540	493	3.65
2	3592		12,620	458	3.65
3	375		11,929	432	3.64
Total	4081	Average	12,582	457	3.65

TABLE 11

COMPONENTS OF VARIANCE FOR CALVING INTERVALS, HERDS, AND SIRES

Source of Variation	df	Mean Squares	Component of Variance	Percent of Total[1]
Milk[2]				
Sire	172	11,769	222	3
Herd	394	24,480	1,955	30
SireXHerd	2,496	3,871	- 169	0
Residual	1,018	4,313	4,313	67
Total	4,080		6,321	
Sire	172	11,769	210	3
Calving Interval	2	191,928	124	2
Herd/Calving Interval	392	23,626	1,883	29
Sire/Calving Interval	237	6,543	32	0
Sire-Herd/Calving Interval	2,259	3,591	- 196	0
Residual	1,018	4,313	4,313	66
Total			6,366	
Fat				
Sire	172	11,439	110	1
Herd	394	33,816	2,755	33
SireXHerd	2,496	5,049	- 188	0
Residual	1,018	5,566	5,566	66
Total	4,080		8,243	
Sire	172	11,439	104	1
Calving Interval	2	237,798	149	2
Herd/Calving Interval	392	32,775	2,669	31
Sire-Calving Interval	237	8,586	19	0
Sire-Herd/Calving Interval	2,259	4,678	- 210	0
Residual	1,018	5,566	5,566	65
Total			8,297	
Test				
Sire	172	0.38	0.01	5
Herd	394	0.23	0.01	5
SireXHerd	2,496	0.07	-0.06	0
Residual	1,018	0.19	0.19	90
Total	4,080			
Sire	172	0.38	0.01	5
Calving Interval	2	2.61	0.00	0
Herd/Calving Interval	392	.22	0.01	5
Sire/Calving Interval	237	.11	0.00	0
Sire-Herd/Calving Interval	2,259	.07	-0.09	0
Residual	1,018	.19	0.19	90
Total			0.12	

[1] Negative variance components were considered as essentially zero in the calculations of per cent of total.

[2] Mean squares and components of variance for milk multiplied by 10^{-3}.

Table 12 indicates small differences between the averages of AI daughters in herds where, as Table 2 suggests, the recommended managerial practices are not being carried on under calving intervals 1 and 3.

TABLE 12

AVERAGE BY CALVING INTERVAL OF RECORDS FIRST REPORTED FOR AI DAUGHTERS

Calving Interval	No.		Milk	Fat	Test
1	550		12,893	477	3.72
2	2244		12,305	448	3.65
3	1287		12,936	465	3.61
Total	4081	Average	12,582	457	3.65

<u>Types of Housing</u>. Here again, an attempt has been made to separate differences between herds by grouping AI daughters by the type of housing under which they are confined. As Table 13 indicates, type of housing has very little effect on dividing differences between herds.

Table 14 presents averages of AI daughters for the three types of housing. Milk and fat yield are not affected by the type of housing, but test seems to vary more than would be expected. If the sire by herd interaction for test is valid, it might explain this difference in test between the different types of housing.

TABLE 13

COMPONENTS OF VARIANCE FOR TYPES OF HOUSING, HERDS, AND SIRES

Source of Variation	df	Mean Squares	Component of Variance	Percent of Total[1]
Milk[2]				
Sire	185	12,565	209	3
Herd	626	20,967	1,979	31
SireXHerd	3,214	4,027	208	3
Residual	1,214	3,943	3,943	63
Total	5,239		6,339	
Sire	185	12,565	22	0
Housing	2	74,502	23	0
Herd/Housing	624	20,796	2,000	32
Sire/Housing	229	6,252	- 23	0
Sire-Herd/Housing	2,985	3,856	194	3
Residual	1,214	3,943	3,943	64
Total	5,239		6,159	
Fat				
Sire	185	14,198	193	2
Herd	626	29,047	2,826	34
SireXHerd	3,214	5,010	47	1
Residual	1,214	5,191	5,191	63
Total	5,239		8,257	
Sire	185	14,198	19	0
Housing	2	50,501	- 12	0
Herd/Housing	624	28,979	2,859	35
Sire/Housing	229	8,519	- 1	0
Sire-Herd/Housing	2,985	4,741	29	0
Residual	1,214	5,191	5,191	65
Total	5,239		8,085	
Test				
Sire	185	0.41	0.01	5
Herd	626	0.25	0.02	10
SireXHerd	3,214	0.08	-0.07	0
Residual	1,214	0.18	0.18	85
Total	5,239		0.14	
Sire	185	0.41	0.00	0
Housing	2	0.83	0.00	0
Herd/Housing	624	0.24	0.02	10
Sire/Housing	229	0.13	0.00	0
Sire-Herd/Housing	2,985	0.08	-0.07	0
Residual	1,214	0.18	0.18	90
Total	5,239		0.13	

[1]Negative variance components were considered as essentially zero in the calculations of per cent of total.

[2]Mean squares and components of variance for milk multiplied by 10^{-3}.

TABLE 14

AVERAGE BY TYPE OF HOUSING OF RECORDS FIRST REPORTED FOR AI DAUGHTERS

Type of Housing	No.		Milk	Fat	Test
1	3570		12,622	458	3.64
2	1309		12,235	448	3.67
3	361		12,638	457	3.61
Total	5240	Average	12,526	455	3.65

CONCLUSIONS

The general component of interaction between herds and sires accounted for between zero and nine per cent of the variation in milk and fat production and test. When components for herds and herd by sire interaction were split into one of the five constitutive environments, there was no apparent interaction with sires. Therefore, the ranking of AI sires in herds on the basis of their daughter's performance will be independent of any one of the five environmental segments studied. From a practical standpoint this means that the committees for selection of AI sires need not be concerned with having to provide different bulls for the different types of environment.

That no interaction was found between sires and any of the five environmental factors studied does not mean that interaction is not present. This is evident from the general sire by herd interaction observed and from the sire by herd interactions within three of the environmental segments, production levels, types of housing, and locations. How much effect cancelling within herds of opposing interactions may have on the magnitude of the component of interaction is not known. It seems reasonable to assume that the cancelling effect does exist. The literature suggests that year and season effects may be important in an analysis of this type. As more records become available through the expanded DHIA-IBM program these two parameters should be included in any future study.

The chi-square test indicated that Holstein AI sires were not equally represented in all herds. While probably not affecting the genetic difference between herds, it does indicate that dairymen are aware of some kind of difference between the bulls offered by the AI studs. On what basis dairymen select bulls for use in their own herds might be of interest.

SUMMARY

Five environmental factors were studied to determine the existence and magnitude of interaction between sires' daughters and these factors. The factors were based on herd information and included level of production, location, days dry, calving interval, and type of housing. In no instance was a component of interaction between sires' daughters and an environmental factor detected. The ranking of sires by the performance of their daughters would be generally the same in any of the environments examined.

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