BREEDING EFFICIENCY IN A SOUTHERN CALIFORNIA DAIRY HERD

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

Dennis Vern Armstrong

1964

ABSTRACT

BREEDING EFFICIENCY IN A SOUTHERN CALIFORNIA DAIRY HERD

by Dennis Vern Armstrong

The breeding records of 4,008 Guernsey and Holstein cows, with 5,940 Guernsey and 5,686 Holstein calving records over a 10 year, 10 month period, under the same herd management were used in this study.

Breeding efficiency was measured as the number of days from parturition to first breeding, and the number of days from first breeding to conception. The effect on breeding efficiency of seven factors; breed, month, year, parity, service sire, sire of dam, and multiple births was estimated. Estimates of heritability and repeatability were determined.

There was no significant difference between the Holstein and Guernsey breeds for breeding efficiency as determined by the "t" test. The data indicate that mean monthly temperature has little or no effect on any of the factors used in this study to measure breeding efficiency, but the year to year management changes do influence breeding efficiency.

Parity number did affect the number of days from first breeding to conception and it could influence days from parturition to first breeding.

Service sire did affect days from first breeding to conception, but had no influence on the days from parturition to first breeding. The sire of the dam had no effect on breeding efficiency when measured by number of days from parturition to first breeding. A significant difference was found for days from first breeding to conception.

Dennis Vern Armstrong

Heritability of breeding efficiency was estimated by doubling the daughter-dam regression. Heritability was estimated to be between .00 and .06 for days from first breeding to conception and .03 to .10 for days from parturition to first breeding. Thus the results indicate that it is not practical to select for breeding efficiency in dairy cows.

Estimates of repeatability of breeding efficiency were calculated by the regression of the second record on succeeding record as .09 and regression of second record on subsequent records as .09 for the same cow.

BREEDING EFFICIENCY IN A SOUTHERN CALIFORNIA DAIRY HERD

By

Dennis Vern Armstrong

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Dairy

1964

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Mr. T. A. Knight and J. E. Elliot and the owners of Adohr Milk Farms, for making these records available, to Dr. G. W. Ward and E. K. MacKellar of Colorado State University for the financial help, to Dr. C. A. Lassiter, Chairman of the Department of Dairy, for the computing facilities, also the author is indebted to Dr. L. D. McGillard and A. J. Thelan for the analysis.

The author is indebted to W. W. Snyder for his assistance throughout this study and Dr. C. E. Meadows and Dr. R. S. Emery for the help with the manuscript.

The author is deeply grateful also to his wife, Sonja, for her continous understanding and encouragement in the preparation of the manuscript.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Efficient reproductive performance and long life are essential qualities in the dairy cow and contribute to the sound economics of dairy. The loss from infertility in the United States dairy industry was estimated at 250 million dollars in 1949 by Gibbons (23). A .U.S.D.A. report (13), indicated that 16% of the cows sold from herds on D.H.I.A. were sold because of breeding problems. This compares with the 1963 Michigan D.H.I.A. Herd Summary Report (37) which showed that 19.3% of the cows sold from Michigan dairy herds were removed for sterility reasons. The need for regular calving to maintain efficient milk production is apparent, but clarification of the influence of genetic and environmental effects on reproductive performance is needed.

The object of this investigation was to estimate the repeatability and heritability of breeding efficiency, with breeding records compiled over a 10 year period. The effect of several factors which may influence breeding efficiency was estimated.

THE REVIEW OF LITERATURE

The literature pertaining to breeding efficiency of dairy cattle may be divided into four main categories: measures of breeding efficiency, factors affecting breeding efficiency, heritability, and repeatability of breeding efficiency.

Measures of Breeding Efficiency

Breeding efficiency can be measured by several different methods. The discussion of breeding efficiency will be divided into the following topics: services per conception, days from first breeding to conception, days from parturition to first service, calving interval, and non-return rates.

Services per conception

The most popular method of determining breeding efficiency is the number of services per conception. Successful conception is one which results in a pregnant cow. Conception is an all or none proposition; it is either successful or a failure. Services per conception is based on the number of services required for conception and is sometimes referred to as conception rate. Morrison and Erb (40) reported that services per conception varied from 1.5 to over 3.0 for different herds. Services per conception has found a wide use because of the ease of calculation and understanding by both scientist and dairyman. The disadvantage of service per conception as a measure of breeding efficiency is that it fails to distinguish a difference between fertilization or breeding failure, early embryonic death, and loss of time due to silent or missed heats.

Cushman (12) reported that 56% of the cows bred were pregnant at first service and 81% were pregnant after three services.

Days from first breeding to conception

The number of days from first breeding to conception has been used to calculate breeding efficiency. The total number of days from first breeding to conception is used to calculate days from first breeding to conception. For example, a cow that conceived on first breeding would have as her measure of breeding efficiency, zero days. On over 2600 cows, Erb (18) reported an interval of 47 days for the days from first breeding to conception. Carman (8) found the days from first breeding to conception to be 28 $\pm$ 1.7 in the University herd and 42 $\pm$ 2.7 in another state owned herd.

The disadvantage of using the days from first breeding to conception to measure breeding efficiency is that the time of the first breeding may vary, due to management practices such as the desirable time of the year to have cows calving in order to maximize profits. The influence of post-partum interval may greatly bias any measurement using first breeding as part of the measure of breeding efficiency.

Days from parturition to first breeding

Management practices could influence the days from parturition to first service. Reproductive disease, post-partum care, and veterinary management would greatly influence any estimate of breeding efficiency as measured by the number of days from partuirition to first breeding. Erb and Shaw (19), as well as Hofstad (31) and Scott (50) suggested a minimum of 50 days between parturition and first breeding for a desirable conception rate. Olds et al. (41) found only 29% of the cows conceived when bred at less than 25 days after calving. In the same report they also found the average time of the first heat period to be 30 days post-partum.

Calving interval

The calving interval measured as the number of days from parturition to parturition has been used to estimate breeding efficiency. Legates (32) reported a mean calving interval of 406 days on 2,419 records. Hutchinson et al. (29) found a mean calving interval of 392 days. The longest calving interval for a group of cows found in the literature was 453 days on 629 cows, reported by Davis (14). Calving interval has found great acceptance because of the ease of calculation.

Non-return rates

Artificial insemination units have used non-return rates on first services as a measure of the breeding efficiency of bulls. Non-return rates for first services are expressed in percentages and are based on the number of cows not returning for a repeat service in a given number of days. Sixty to ninety days is the most common interval used to express non-return rates. Non-return rates are not considered an accurate measure of breeding efficiency because some cows may die, be sold, or be bred naturally, or bred artificially to a bull from another A.I. unit. These cows would be recorded as non-returns. Barrett (2) and Adler (1) found a -5.5% discrepancy between 60-90 day non-return rates and actual pregnancies, as determined by manual palpation in first service animals.

Factors Affecting Breeding Efficiency

There are many different factors affecting breeding efficiency of dairy cattle. The following will be considered breed, age of cow, age of service sire, year, season, parity, multiple births, mating system, production level, and post-partum interval.

Breed of Cow

The difference in breeding efficiency between breeds is a factor which has received considerable publicity. The Michigan Artificial Breeders (36) report higher non-return rates for Holsteins than for other dairy breeds. The 60-90 non-return rates on first service were Holsteins averaging 73.5% for 1962 and 72.9% for 1961; Guernseys averaging 67.1% for 1962 and 65.7% for 1961. Boyd (5) found no significant difference between Holsteins, Guernseys, and Jerseys, although Jerseys had the lowest services per conception. Hutchinson (29) using both calving intervals and service per conception as a measure of breeding efficiency found no difference between Aryshire, Holsteins, and Jerseys. Guernseys were found to have a lower service per conception rate than Holsteins in a study by Tanabe and Casida (53). They also found 2.0% genital abnormalities in Guernseys as compared to 18.2% in Holsteins, with an average of 10.6% of cows at slaughter with genital abnormalities which would impare pregnancy.

Age of cow

Olds and Seath (43), Miller and Graves (38), Olds et al. (42), and Davis and Brost (15) reported a higher breeding efficiency for heifers when compared with older cows. The breeding efficiency of older cows would be lower because they have been subjected to more natural problems, such as calving difficulties, retained placenta, metritis, insemination or natural breeding. In all populations of cows studied to date for reproduction efficiency there is a natural culling effect on the cows that have a low breeding efficiency. Bowling (4), Olds and Seath (43), Salisbury (49), Morgan and Davis (39), and Seath et al. (51) have shown that heifers have a higher service per conception rate than cows. Davis (14), using both service per conception and calving interval, found no difference in older age groups for either measure of breeding efficiency.

Tanabe and Casida (53) reported a higher fertilization rate and a lower embryonic death rate in younger cows, but the results were not significantly different.

<u>Age of service sire</u>

Becker and Arnold (3) reported that artificial breeding associations removed 46% of the bulls from service because of either permanent or temporary low fertility, so that only 35% of the sires remained over three years. Morgan and Davis (39), Erb <u>et al</u>. (20) and Gildow (24) found a lower breeding efficiency with advance age of service sire. Miller (38) and Bowling <u>et al</u>. (4) found lower breeding efficiency in bulls over six years of age.

<u>Year to year</u>

Conception rate among normal cows did not vary significantly from year to year, according to Morrison and Erb (40). Records in sufficient numbers have not been available, so that year to year variation could be investigated in other studies. Management changes from year to year such as A.I. or natural breeding, changing from fresh to frozen semen, or different veterinary practices could result in a difference in breeding efficiency from one year to the next.

<u>Season of year</u>

The effect of the season or the month of service on breeding efficiency could vary, due to the difference in geographic location. Mercier <u>et al</u>. (35) found fertility levels of three herds in Canada at different latitudes not to be significant, but reported significance between seasons of year. Temperature changes did have an effect on fertility; the highest percentages of successful services were obtained during the summer and fall. They concluded that the length of daylight could influence the fertility of dairy cattle. Erb et al. (20), Gowen and Davis (25), Heider et al. (30), Morgan and Davis (39), and Trimberger (55) reported that where high environmental temperatures were found, decreasing hours of daylight were associated with a lower breeding efficiency. The effect of high temperature on bull's sperm production, and settling capability were demonstrated by Casady et al. (9). Spermatogenesis was impared significantly with temperatures of 85° F. or higher, for periods exceeding five weeks.

Parity number

Parity number is the number of successful pregnancies. When cows are grouped by parity number, all cows in the group would have the same number of pregnancies.

Parity is used to measure the effect of calving on breeding efficiency. Seath et al. (51), using services per conception as a measure of breeding efficiency, found no significant difference in parity number. Olds et al. (41) found that the first pregnancy required 1.9 more services per conception than the average of all later pregnancies.

Multiple birth

A 50% reduction in reproductive efficiency caused by twin births was reported by Pfau et al. (45). The conception rate of cows following twin births was 3.23 services per conception with a herd average of 2.21. The effect of multiple births on breeding efficiency of any population of dairy cattle would be insignificant due to the low frequency of twinning.

Mating systems

White et al. (57), Miller and Graves (38) and Fincher and Williams (21) reported that when an inbreeding system using sires mated to their own daughters was followed, over one-half the resulting offspring developed reproductive tracts which were abnormal. A higher rate of abortions among inbred cattle was reported by Regan et al. (47). Woodward and Graves (60) noted no decline in fertility of inbred cattle when compared to outbreds until the sixth generation. After the sixth generation, a rapid decline of fertility in the inbred group was reported (59).

Christian et al. (10) reported that using bulls from one breed had no effect on increasing the conception rate of repeat-breeder cows of a different breed.

Production levels

A correlation of .04 $\pm$ 0.01 between milk production and the number of days from parturition to conception was reported by Gaines (22) using 4,671 records. Lewis and Horwood (33) showed that low producing cows had shorter calving intervals than high producing cows. Boyd (5) found no significant correlation between number of services required for pregnancy and level of milk production during the first 120 days of lactation. Clapp (11), Herman and Edmondson (28) and Olds and Seath (44) reported no correlation between milk production and breeding efficiency.

Post-partum interval

An average of 47 days from calving to involution of uterus, with an increase of five days for cows which calved abnormally was reported by Olds et al. (41). After 90 days, 95% of the cows had normal involution of the uterus. Hofstad (31) stated that abortion, metritis, dystocia and retained placenta occured in 40% of the cows that were bred less

[illegible]

than 40 days post-partum. Erb and Shaw (19) found a shorter calving interval and fewer services per conception in cows allowed 50 to 60 days to recover from the previous pregnancy. Scott (50), Swenson (52), Trimberger (55), and VanDermark and Salisbury (56) reported that at least 50 days should elapse between parturition and first service for a high conception rate.

Estimates of Heritability

The estimates of heritability of breeding efficiency range from .00 to .32 as shown in table 1. The value for heritability using services per conception reported by Legates (32) using 398 daughter-dam comparison was zero. This agrees with Olds (41) who used 91 daughter-dam comparison and reported a correlation of -.01. A heritability estimate of .07 was found from data by Pov et al. (46). Dunbar et al. (17) estimated heritability of all breeds in the University of West Virginia herd to be zero. Carman (8) indicated that the heritability of breeding efficiency when measured by days to first estrus, days to conception, and services to conception are zero, or nearly so. An estimate of heritability of .10 was reported by Branton et al. (6). Wilcox et al. (58) reported the largest estimate of heritability in the literature reviewed. They found the heritability to be .32 when analyzing the records of 575 cows, over a 30 year period.

Table 1. Heritability of breeding efficiency - A review of the literature

Measure of breeding efficiency	Heritability estimates	Reference
Calving interval for cows with 3 records	.0	Brown *et al.* (7)
Calving interval for cows with 5 records	.01	Brown *et al.* (7)
Calving interval	.00	Legates, J. E. (32)
Services per conception	.10	Brandton *et al.* (6)
Services per conception	.07	Pov *et al.* (46)
Services per conception	.03	Legates, J. E. (32)
Services per conception herd 1	.08	Carman, G. M. (8)
Services per conception herd 2	-.15	Carman, G. M. (8)
Days to conception herd 1	.08	Carman, G. M. (8)
Days to conception herd 2	-.09	Carman, G. M. (8)
Days to first estrus herd 1	-.06	Carman, G. M. (8)
Days to first estrus herd 2	-.03	Carman, G. M. (8)
Occurance of first estrus on first record	.27	Olds *et al.* (44)
Occurrance of first estrus on all records	.32	Olds *et al.* (44)
Non-returns to first service	.00	Dunbar *et al.* (17)
Cystic ovaries during life	.43	Rice *et al.* (48)

Estimate of Repeatability of Breeding Efficiency

Legates (32) reported repeatability of calving interval to be .13 and service per conception to be zero. Erb (18) found a repeatability of services for conception to be .20. Pov (46) found the repeatability of services per conception to be .12, the repeatability of days from first service to conception to be .11 and repeatability of regularity of heats .18. Using non-return data as a measure of fertility, Dunbar and Henderson (16) calculated a repeatability of a single reproductive record of a cow to be .03. Branton et al. (6) found the repeatability of services per conception to be .10, and recommended that little weight should be given to breeding records in any selection and culling program. Carman (14) estimated repeatability from the components of variance, and found the value near zero for days to first estrus, days to conception, and service to conception. Repeatability of breeding efficiency of sires in an artificial breeding unit varied by breeds, with Holstein .50, Guernsey .45 and Jersey .31. Harvey (26), using service per conception, estimated repeatability to be .21 and stated that in determining success of any service, the cow was four to six times as important as the bull. Olds and Seath (44), using single records of the same cow, reported that repeatability of service per conception was .29.

EXPERIMENTAL PROCEDURE

Source of Data

The data used to study and evaluate heritability and repeatability of breeding efficiency, met the following conditions:

1. Complete and accurate records
2. A high level of uniform management over the period studied
3. More than one breed of dairy cattle under the same management
4. A high level of uniform herd management over a period of years
5. A herd large enough that the number of records available for a short period of years would be adequate for the genetic estimates indicated.

The data for this study were obtained from the records of Adohr Milk Farms, Camarillo, California, located 60 miles Northwest of Los Angeles. The herd consists of approximately 1500 Holstein and 1500 Guernsey cows of milking age. All cows which dropped their second calf from January 1, 1948, through December 1, 1959, were included. Data for the first calvings were not available since most of the heifers were pasture bred. The number of records available for the 10 year 10 month period was 5,940 Guernseys and 5,686 Holsteins.

The following information was tabulated for each cow included in this study during each gestation period of 250 days or more.

1. Breed, herd number, birth data, sire and dam herd numbers.
2. Parturition number, date of service, service sire for each breeding and calving date resulting from last service.

The above information was copied from the original herd records and then punched on I.B.M. cards, in preparation for analysis.

Preparation of Data

A second set of cards referred to as a summary for each pregnancy was punched. The following information was included on the summary cards:

1. Breed, herd number, birth date, sire and dam herd numbers.
2. Number of days from parturition to first breeding indicated as (X).
3. Number of days from first breeding to conception indicated as (Y).
4. Crossproducts of X and Y (XY).

The summary cards were sorted by breed, year, month, parity, sire of dam, and service sire. The sums of X, Y, and XY were totaled for the two measures of breeding efficiency. The heritability of breeding efficiency was estimated by doubling the correlation of daughter and dam. Repeatability of breeding efficiency was estimated by correlating second records to all records for each cow within each breed.

RESULTS AND DISCUSSION

The effect on breeding efficiency of seven factors; breed, month, year, parity, service sire, sire of dam and multiple births was estimated. Breeding efficiency was measured as the number of days from parturition to first breeding, and the number of days from first breeding to conception.

Breed

The arithmetic mean, variance, and standard deviation for days from first breeding to conception and from parturition to first breeding are reported in table 2. The "t" test was used to determine if there was any significant differences between the Holstein and Guernsey breeds. There was no significant difference between the two breeds at the .01 level.

Table 2. Arithemetic means and variation for measures of breeding efficiency.

A. Days from first breeding to conception

Breed	Records	Mean	Variance	Standard deviation
Guernsey	5,940	31.8	3,489	59.1
Holstein	5,686	30.6	3,390	58.2

B. Days from parturition to first breeding

Breed	Records	Mean	Variance	Standard deviation
Guernsey	5,940	72.4	1,052	32.5
Holstein	5,686	74.7	1,048	32.4

Month of Breeding

The month of breeding may effect breeding efficiency and was used as a variable because of the climatic conditions which exist in Southern California. If season of year had been used, it could best have been divided into two seasons; the dry season, May through October; and the rainy season, November through April. Using only two seasons the effect of total daily sunlight on breeding efficiency could not have been measured with any degree of accuracy.

The month of breeding for first breeding to conception was determined by the date of the first breeding, and for parturition to first breeding by the date of parturition. For example, a cow that calved in June and had her first breeding in August, was classified as a June cow for parturition to first breeding record, and August cow for the first breeding to conception record.

The monthly average of the combined breeds for first service to conception and parturition to first breeding are shown in table 3. The high month, was 78 days for June, the low month, was 69 days for March for parturition to first breeding. The three low months, January, February, and March, were followed immediately by the three high months, April, May, and June. The three months with the lowest mean daily temperature, January, February and March, had a shorter period of days from parturition to first breeding than the months with the highest mean daily temperature, July, August, and September. The difference between 71 days for the cool months and 74 days for the warm months was not significant at the .01 level, when tested by the "t" test.

The high month for days from first breeding to conception were 39 days for February, the low months were 27 days for September and November. The coolest three months, January, February and March had the longest interval, 35 days for first breeding to conception; the warmest three months had an interval of 28 days. The difference was not significant at the .01 level of significance, when tested by the "t" test.

The months with the lowest number of days from parturition to conception were August, September, and November. January, February, and October were the highest in days from parturition to conception. The difference between 108 for the high months and 100 for the low months was not significant at .01 level. The data indicate that temperature as measured by the mean monthly temperature has little or no effect on either measure of breeding efficiency.

Table 3. Effect of month of breeding on breeding efficiency.

Month	Number of conceptions	Quarterly mean tempt. 1949-1959 (°F)	Parturition to first breeding (days)	First breeding to conception (days)	Parturition to conception (days)
January	1,006	52.9	73	34	107
February	836	52.9	71	39	110
March	906	52.9	69	35	104
April	985	65.8	73	30	103
May	1,000	65.8	75	31	106
June	1,047	65.8	78	32	110
July	1,009	72.4	76	29	105
August	968	72.4	73	28	101
September	980	72.4	73	27	100
October	946	69.7	73	34	107
November	891	69.7	73	27	100
December	1,052	69.7	73	31	104

The data in table 4 indicates that month effect on breeding efficiency was not significant for parturition to first breeding for either breed. The difference between months was significant for Holstein but was

Table 4. Analysis of variance of the month of parturition and first breeding on breeding efficiency.

A. Parturition to first breeding*

Sources	Holstein D.F.	Holstein M.S.	Guernsey D.F.	Guernsey M.S.
Among month	11	1,175	11	6,528
Within month	5,674	6,644	5,928	6,286

B. First breeding to conception*

Sources	Holstein D.F.	Holstein M.S.	Guernsey D.F.	Guernsey M.S.
Among month	11	10,389*	11	4,930
Within month	5,674	4,419	5,928	4,498

*Significant at .01% level

not significant for Guernseys when breeding efficiency was measured as days from first breeding to conception.

Years Effect

The major changes in management which could influence breeding efficiency could best be expressed if the data were divided into years. Artificial breeding at Adohr Farms was very primitive during the first few years it was practiced. As technology of handling semen advanced, breeding efficiency improved. Table 5 shows the combined Holstein and Guernsey data indicating the year effect on breeding efficiency. One major management change made during the years these data were taken: a longer post-partum interval was allowed before first service. The post-partum interval increased from 57 days in 1949 to 78 days in 1958. This was accompanied by a decrease in the yearly mean for the days from first breeding to conception of 95 days in 1949, to 23 days in 1958. As days from parturition to first breeding increased, a decrease in the days from first breeding to conception was noted. This resulted in a decrease in the days from parturition to conception. The data presented in table 6 indicates that there was a significant yearly effect on first breeding to conception for both Holsteins and Guernseys. The year effect on breeding efficiency as measured by parturition to first breeding was significant for Holsteins, but not Guernseys at the .01 level of significance.

It could be concluded from these data that the effect of year to year management change could influence post-partum interval. The largest change in days from parturition to first breeding occurred between 1950 vs. 1951, while there was little change in days from first breeding to conception and days from parturition to conception.

Table 5. Effect of year on breeding efficiency

Year	Number of conceptions	Days from parturition to first breeding	Days from first breeding to conception	Days from parturition to conception
1949	195	57	95	152
1950	461	57	84	141
1951	609	79	66	145
1952	965	79	37	116
1953	1,282	70	29	99
1954	1,452	69	24	93
1955	1,562	72	21	93
1956	1,527	76	24	100
1957	1,622	77	24	101
1958	1,659	78	23	101
1959	181	75	4	79

Table 6. Analysis of variance of yearly effect on breeding efficiency

A. Parturition to first breeding

Source	Holstein D.F.	Holstein M.S.	Guernsey D.F.	Guernsey M.S.
Between years	14	9,636	15	282,974*
Within years	5,671	6,450	5,924	5,586

B. First breeding to conception

Source	Holstein D.F.	Holstein M.S.	Guernsey D.F.	Guernsey M.S.
Between years	14	166,732*	15	119,536*
Within years	5,671	3,677	5,924	4,208

*Significant at .01% level

Parity Number

The age of cow was indicated by parity number. Grouping by parity number assures that all the cows within a group have all had the same number of pregnancies. The stress on the cow's reproductive tract which could result in a change of breeding efficiency is better measured by parity number than by age.

Information on first parity was available for only 250 of the cows, because most of the heifers were pasture bred and breeding records were not available.

Of the 4,008 cows which had two pregnancies, only 1,181 had five pregnancies or more; 75 had ten pregnancies or more; and 3 cows had fourteen pregnancies.

The data in table 7 shows the number of cows for each parity number, the mean for both measures of breeding efficiency, and the total days from parturition to conception. Number of days from first breeding to conception was the longest, 50 days, for the twelfth parity, with only fifteen records available. The shortest number of days for first breeding to conception was 17 days for the first parity, with 250 records.

Parity numbers 1, 2, 3, 4, 5, 6, 7, 8, and 10 all were below the arithmetic mean of the population for days from first breeding to conceptions. Number of days from parturition to first breeding was longest, 85 days, for parity 14 with only three records, and shortest, 70 days, for parity 12 with fifteen records. Parity number two had a longer parturition through first breeding, 79 days; first breeding to conception, 40 days. Both are considerably larger than the arithmetic mean for the two measures of breeding efficiency.

Parity numbers 2, 3, 9, 13 and 14 were all longer for parturition to first breeding than the arithmetic mean. Parity numbers 5, 7, 8 and 12 were below the arithmetic mean.

Table 8 shows that parity effect on breeding efficiency was significant for first breeding to conception for both breeds. Parturition to first breeding was significantly affected by parity for the Holsteins. Parity effect for Guernseys was not significant for parturition to first breeding.

These results indicate that parity number does influence the number of days from first breeding to conception, and it could influence days from parturition to first breeding. The mean days from parturition to conception did not appear to be influence by parity number.

Service Sire

Adohr Farms used 86 Holstein and 127 Guernsey service sires during the ten year and ten month period when these data were obtained.

The largest number of conceptions for a Holstein service sire was

Table 7. Effect of parity on breeding efficiency.

Parity no.	Number of conceptions	Parturition to 1st breeding (Days)	1st breeding to conception (Days)	Parturition to conception (Days)
1	250*	--	17	--
2	4,008	79	40	119
3	2,617	74	27	101
4	1,720	73	25	98
5	1,181	72	25	97
6	777	73	28	101
7	499	72	25	97
8	289	72	30	102
9	149	77	33	110
10	75	73	29	102
11	36	73	37	110
12	15	70	50	120
13	7	75	45	120
14	3	85	42	127

*Most heifers were pasture bred for first pregnancy.

911, and 1,074 for a Guernsey sire. With less than six conceptions there were 71% of the Guernsey service sires and 50% of the Holstein service sires. Only cows with two or more reproductive records were used for this study, so it is possible for those bulls reported with less than six conceptions to actually have more. Also this study came from a fixed ten year and ten month period; therefore, some of the service sires were on the beginning or end of their service period in the herd.

Table 8. Analysis of variance of parity effect on breeding efficiency.

A. Parturition to first breeding

Source	Holstein D.F.	Holstein M.S.	Guernsey D.F.	Guernsey M.S.
Between years	13	59,136*	13	1,022
Within years	5,672	6,513	5,926	6,298

B. First breeding to conception

Source	Holstein D.F.	Holstein M.S.	Guernsey D.F.	Guernsey M.S.
Between years	13	32,329*	13	79,517*
Within years	5,672	4,366	5,926	4,335

*Significant at .01 level

The analysis of variance of service sire effect on breeding efficiency is presented in table 9. A significant difference is shown when breeding efficiency is measured by the number of days from first breeding to conception. Parturition to first breeding is not significant, as would be expected, because the service sire would have no effect on days from parturition to first breeding. Bulls used in artificial insemination units are usually selected for their ability to transmit for production rather than on their transmitting ability for fertility. If heritability for fertility in bulls is low, then except for the need for good conception, there would be no advantage in selecting for bulls with better than average transmitting ability for fertility.

These results indicate that the service sire does influence the days from first breeding to conception, but has no influence on the days from parturition to first breeding. Service sire influence on days from first breeding to conception is through the fertility level of the service sire.

Table 9. Analysis of variance of service sire effect on breeding efficiency.

A. Parturition to first breeding

	Holstein		Guernsey	
Source	D.F.	M.S.	D.F.	M.S.
Between years	85	8,609	126	3,404
Within years	5,600	6,782	5,813	6,349

B. First breeding to conception

	Holstein		Guernsey	
Source	D.F.	M.S.	D.F.	M.S.
Between years	85	19,920*	126	12,182*
Within years	5,600	4,195	5,813	4,332

*Significant at .01 level.

Sire of Dam

Sixty-nine percent of the sires of the Guernsey dams and sixty percent of the sires of the Holstein dams had less than ten daughters used in this study.

Table 10 shows the analysis of variance for effect of sire of dam on breeding efficiency. The sire of the dam had no effect on breeding efficiency when measured by number of days from parturition to first breeding. A significant difference was found when days from first breeding to conception was used as the measure of breeding efficiency.

Multiple Births

The Holstein herd had 126 sets of twins born in 5,686 calvings for a twinning rate of 2.2%. The Guernsey herd had 116 sets of twins in

5,944 calvings for a 1.9% twinning percentage. The effect which multiple births have on breeding efficiency during the pregnancy following the multiple birth, was measured by "t" testing for a significant difference between the population and reproductive record following the multiple births.

Table 10. Analysis of variance of sire of the dam effect on breeding efficiency.

A. Parturition to first breeding

Source	Holstein D.F.	Holstein M.S.	Guernsey D.F.	Guernsey M.S.
Between years	96	1,525	144	1,665
Within years	5,589	6,721	5,795	6,401

B. First breeding to conception

Source	Holstein D.F.	Holstein M.S.	Guernsey D.F.	Guernsey M.S.
Between years	96	10,763*	144	7,707*
Within years	5,589	4,321	5,795	4,419

*Significant at .01 level

The days from first breeding to conception were significant for the Holsteins, but not for the Guernseys. There was no significant difference for days from parturition to first breeding in either breed. These data are shown in table 11.

These results indicate that multiple birth has no effect on breeding efficiency when measured by number of days from parturition to first breeding. The number of days from first breeding to conception was significant for Holsteins but not Guernseys. The number of days from first breeding to conception was approximately 10 days longer for both breeds, indicating a loss of one-half a service for each conception following a multiple birth.

Table 11. The effect of multiple births on breeding efficiency.

A. Holstein

Measure of breeding efficiency	Reproduction records following a multiple birth		Holstein herd	
	No. of births	Mean (days)	No. of births	Mean (days)
Parturition to 1st breeding	126	77.2	5,686	74.7
First breeding to conception	126	43.1*	5,686	30.6

B. Guernsey

Measure of breeding efficiency	Reproduction records following a multiple birth		Guernsey herd	
	No. of births	Mean (days)	No. of births	Mean (days)
Parturition to 1st breeding	116	76.8	5,944	72.4
First breeding to conception	116	41.6	5,944	31.8

*Significant for "t" test at .01 level of significance.

Estimates of Heritability

Some methods used to estimate heritability compare animals which are closely related with animals which are less closely related than the average of the population. An estimate of heritability is necessary if one is to select accurately for a trait such as breeding efficiency. A low heritability estimate would indicate that the variation in this measure of reproductive efficiency would not be common, since nature has selected and continues to select for improved reproductive efficiency.

The correlation of paternal half-sibs is used to estimate heritability of breeding efficiency with any of the previously discussed units of measurement, service per conception non-return rate, calving interval, etc. Paternal half-sibs have only one-fourth of their genes in common, as they are only one-fourth related. The correlation of paternal half-sibs must be multiplied by four to estimate heritability.

Daughter-dam correlations have been used to estimate heritability of breeding efficiency. The relationship of daughters to their dams is one-half; therefore the correlation must be multiplied by two. The daughter-dam correlation is the fraction of the phenotypic variance that is additive genetic.

The within sire regression of daughter to dam is another common method of calculating heritability. Daughter-dam regression can be used on single record or an average of all records to estimate heritability. The within sire daughter-dam regression is multiplied by two to estimate heritability.

The correlation between full sibs or identical twins can also be used to estimate heritability of breeding efficiency.

The range is from minus one to plus one if the method used to estimate heritability is a correlation. When correlations are used to estimate heritability, correlation coefficients between minus one and zero are zero for all practical purposes.

Heritability estimates of reproductive efficiency were calculated by doubling the correlation between the dam's performance and the performance of their daughters.

Correlations were calculated for the second reproductive performance of both dam and daughter. Correlations were also calculated from all the records of the dam and daughter. Second records were used instead of first records, because most of the cows were pasture bred at first pregnancy; therefore reproductive performance records were not available. When a dam had more than one daughter, the dam's record was repeated for each daughter used in the correlation. There were 958 daughter-dam comparisons for the Guernseys, and 913 for the Holsteins when all records were used in the correlations. These comparisons were reduced to 950 Guernsey daughter-dam comparisons and 912 Holsteins used when second records only were used. The number of records used for each breed was not the same, because some cows were purchased after their second reproductive record.

Estimates of heritability when days from parturition to first breeding was used to measure breeding efficiency, varied from .03 to .10. When breeding efficiency was measured by number of days from first breeding to conception, heritability estimates varied from .00 to .06. When only second reproductive records were used, heritability estimates were lower than if all records had been used. These data are shown in table 12. These results indicate that most of the variation in days from parturition to first breeding and days from first breeding to conception among dairy cattle is non-genetic.

Estimate of Repeatability

Repeatability is a measure of the tendency for observations on the same cow to be more alike than observations on different cows. Repeatability is also a measure of the upper limits of heritability. It has been assumed that length of reproductive cycle or reproductive performance is repeatable, and that a cow with a poor reproductive performance during her first reproductive record will have similar repro-

Table 12. Estimate of heritability by doubling the regression of daughter on dam.

Holstein	All records	Second records only
First breeding to conception	.020	.064
Parturition to first breeding	.056	.102
Guernsey		
First breeding to conception	---.034	---.034
Parturition to first breeding	.026	.082

ductive performances throughout her life.

In this study repeatability was measured as the regression of the second reproductive record on succeeding records for the same cow. Repeatability was measured also as the regression of the mean of any reproductive record on the mean of any following record.

Table 13 shows the estimate of repeatability for all records and table 14 only second records. Estimate of repeatability was near .10 or 10%. Therefore, it appears from these data that a single breeding record of a cow is not a good measure of her future reproductive performance, and little weight should be given to it in any selective or culling program.

Table 13. Estimate of repeatability using all records.

Holstein	Correlation
Days from parturition to first breeding	.0999
Days from first breeding to conception	.0947
Guernsey	
Days from parturition to first breeding	.0999
Days from first breeding to conception	.0965

Table 14. Estimate of repeatability by correlation of second record with each of the subsequent records.

2nd record/subsequent record	Days from first breeding to conception		Days from parturition to first breeding	
	Holstein	Guernsey	Holstein	Guernsey
2/3	.0989	.0989	.0999	.0999
2/4	.0998	.0993	.0999	.0999
2/5	.0997	.0984	.0999	.0999
2.6	.0996	.0990	.0999	.0999
2/7	.0997	.0985	.0999	.0999
2/8	.0955	.0987	.0998	.0999
2/9	.0979	.0991	.0997	.0999
2/10	.0958	.0994	.0998	.0997
2/11	.0981	.0818	.0999	.0999
2/12	.0758	.0999	.0999	.0996
2/13	--	.0999	--	.0999

SUMMARY AND PRACTICAL APPLICATION

The breeding records of 4,008 Guernsey and Holstein cows with 5,940 Guernsey and 5,686 Holstein calving records have been studied to determine the effects different environmental factors could have on breeding efficiency. The environmental factors measured were breed, month, year, parity, service sire, sire of dam and multiple birth. Breeding efficiency was measured as number of days from first breeding to conception and number of days from parturition to first breeding. The heritability and repeatability of breeding efficiency was also estimated.

The results of this study indicated that breed, season as measured by mean monthly temperature and multiple birth do not effect breeding efficiency. Year, parity, service sire, and sire of dam did effect breeding efficiency depending upon which measure of breeding efficiency was used.

The estimate of heritability was found to be between .06 to .10. The low heritability would indicate that selection for breeding efficiency (fertility) when measured by days from first breeding to conception and parturition to first breeding can not be very effective and would only decrease the effectiveness of selection for such economical traits as milk production.

Evidence from this study indicates the repeatability of days from first service to conception and days from parturition to first breeding to be low .10. It is not practical to predict with any degree of accuracy the reproductive performance of a dairy cow from her past performance.

BIBLIOGRAPHY

1. Adler, Af. H. C. 1952. "Undersogelser ouer ikke-omloberpiocent som mal for insemineringstyres fruglbarheil". Nord. Veterinary-Medicine, 4:116.

2. Barrett, G. R., L. E. Casida and C. A. Lloyd. 1948. Measuring breeding efficiency by pregnancy examination and by non-return. Journal of Dairy Science, 31:682.

3. Becker, R. B. and P. T. D. Arnold. 1953. Tenure and turnover of desirable dairy bulls in artificial studs. Journal of Dairy Science, 36:575.

4. Bowling, G. A., D. N. Putnam and R. H. Ross. 1940. Age as a factor influencing breeding efficiency in a dairy herd. Journal of Dairy Science, 23:1171-1176.

5. Boyd, L. J., D. M. Seath and Durward Olds. 1954. Relationship between level of milk productive and breeding efficiency in dairy cattle. Journal of Animal Science, 13:84.

6. Branton, Cecil, W. S. Griffith, H. W. Norton and J. G. Hall. 1956. The influence of heridity and environment on the fertility of dairy cattle. Journal of Dairy Science,39:923.

7. Brown, L. O., R. M. Durham, E. Cobb and J. H. Knox. 1954. An analysis of the components of variance in calving intervals in a range herd of beef cattle. Journal of Animal Science, 13:511-516.

8. Carman, G. M. 1955. Interrelations of milk production and breeding efficiency in dairy cows. Journal of Animal Science, 14:755.

9. Casady, R. B., R. M. Myers and J. E. Legates. 1953. The effect of exposure to high ambient temperature on spermatogenesis in the dairy bull. Journal of Dairy Science,36:14-23.

10. Christian, R. E., L. C. Ulberg and L. E. Casida. 1951. The response of low-fertility cows to insemination with seman from bulls of another breed. Journal of Dairy Science, 34:988-991.

11. Clapp, H. 1927. A factor in breeding efficiency of dairy cattle. American Society Animal Production Proceeding, 259-265.

12. Cushman, C. G., J. W. Kelly and V. Hurst. 1958. V. Breeding efficiency standards for dairy cows and heifers. Clemson Agricultural College Circular No. 449., October.

13. Dairy Herd Improvement Association Report. United State Department of Agriculture, September 1938.

14. Davis, H. P. 1951. Reproductive efficiency in a Holstein herd, 1897-1950. Journal of Dairy Science, 34:495.

15. Davis, H. P. and B. Brost. 1953. Studies of herd management records. I. Services required for conception for first to tenth calving. Journal of Dairy Science, 36:1112-1116.

16. Dunbar, R. S., Jr. and C. R. Henderson. 1953. Heritability of fertility in dairy cattle. Journal of Dairy Science, 34:1063-1071.

17. Dunbar, R. S., Jr., H. O. Henderson and D. A. Hutchinson. 1958. Reproduction in the West Virginia University diary herd. West Virginia University Agricultural Experiment Station Bulletin 412T, May.

18. Erb, R. E. 1955. Causes and prevention of breeding failure in dairy cattle. Western Regional Project Reprot, 7.

19. Erb, R. E. and A. O. Shaw. 1948. Breeding failure survey in Washington: A Summary. Proceedings Western Division American Dairy Science Association.

20. Erb, R. E., J. W. Wilbur and J. H. Hilton. 1940. Some factors affecting breeding efficiency in dairy cattle. Journal of Dairy Science,23:549.

21. Fincher, M. G. and W. L. Williams. 1926. Arrested development of the mullerian ducts associated with inbreeding. Cornell Veterinary, 16:1-19.

22. Gaines, W. L. 1927. Milk yield in relation to recurrence of conception. Journal of Dairy Science, 10:117-125.

23. Gibbons, W. J. 1950. Symposium. Proceedings American Veterinary Medicine Association, 87:350.

24. Gildow, E. N. 1946. Breeding efficiency in dairy cattle. Fifteenth Annual State College of Washington Institute of Dairying Proceeding, Pullman, Washington, 119-129.

25. Gowen, J. W. and U. F. Dove. 1941. Fertility in dairy cattle. Maine Agricultural Experiment Station Bulletin, 360:170-172.

26. Harvey, W. R. 1951. Repeatability of breeding efficiency in dairy cows. Proceeding Western Division of American Dairy Science Association.

27. Herman, H. A. 1956. Age-fertility relationships in cattle serviced by artificial insemination. Proceeding III International Congress of Animal Reproduction, Cambridge, England.

28. Herman, H. A. and J. H. Edmondson. Factors affecting the interval between parturition and first estrus in dairy cattle. Missouri Agriculture Experiment Station Research Bulletin 462.

29. Hutchinson, D. A., R. S. Dunbar, Jr. and C. R. Henderson. 1958. Reproduction in the West Virginia University dairy herd. West Virginia University Agricultural Experimental Station; Bulletin 412T:11, May.

30. Hilder, R. W., M. H. Forhman and R. R. Graves. 1944. Relation of various factors to the breeding efficiency of dairy cattle and the sex ratio of the offspring. Journal of Dairy Science, 27:981-992.

31. Hofstad, M. S. 1941. A study of breeding records of one large herd of dairy cattle postpartum breedings and removal of the corpus luteum. Cornell Veterinarian, 31:379.

32. Legates, J. E. 1954. Genetic variation and services per conception and calving interval in dairy cattle. Journal of Animal Science, 13:81-88.

33. Lewis, R. C. and R. E. Horwood. 1950. The influence of age, level of production and management on the calving interval. The Quarterly Bulletin. Michigan Agricultural Experiment Station, 32:546-549.

34. McCullough, M., D. M. Seath and D. Olds. 1950. The repeatability and effect of age on yearling breeding efficiency of sires used in artificial breeding. Journal of Dairy Science, 34:548-553.

35. Mercier, E. and G. W. Salisbury. 1947. Seasonal variations in hours of daylight associated with fertility level of cattle under natural breeding conditions. Journal of Dairy Science, 30:747-756.

36. Michigan Artificial Breeders Co-op. 1962. Monthly service summary by breeds. Michigan Artificial Breeders Cooperative.

37. Michigan Dairy Herd Improvement Records Annual Report, Cooperative Extension Service, Michigan State University. 1963.

38. Miller, F. W. and R. R. Graves. 1932. Reproduction and health records of the Beltsville herd of the Bureau of Dairy Industry. United States Department of Agriculture Technical Bulletin 32.

39. Morgan, R. F. and H. P. Davis. 1938. Influence of age of dairy cattle and season of the year on the sex ratio of calves and services required for conception. Nebraska Agricultural Experiment Station Bulletin 104.

40. Morrison, R. A. and R. E. Erb. 1957. Prolificacy of cattle. Washington Agricultural Experiment Station Technical Bulletin 25, June.

41. Olds, D., H. B. Morrison and D. M. Seath. 1949. Efficiency of natural breeding in dairy cattle. Kentucky Agricultural Experiment Station Bulletin, 539.

42. Olds, D., E. C. Troutman and D. M. Seath. 1952. The effect of age and size on the fertility of dairy heifers. Journal of Dairy Science, 35:620-622.

43. Olds, D. and D. M. Seath. 1950. Predicting the breeding efficiency of dairy cows. Journal of Dairy Science, 33:377.

44. Olds, D. and D. M. Seath. 1953. Repeatability heritability and the effect of level of milk production on the occurrence of first estrus after calving in dairy cattle. Journal of Animal Science, 12.

45. Pfau, K. O., J. W. Bartlett and C. E. Stuart. 1948. A study of multiple births in a Holstein-Friesian herd. Journal of Dairy Science, 31:241-254.

46. Pov, J. W., C. R. Henderson, S. A. Asdell, J. F. Sykes and R. L. Jones. 1953. A study of the inheritance of breeding efficiency in the Beltsville dairy herd. Journal of Dairy Science, 36:909.

47. Regan, W. M., S. W. Mead and P. W. Gregory. 1947. The relation of inbreeding to calf mortality. Growth, 11:101-131.

48. Rice, V. A., F. N. Andrews, E. J. Warwick and J. E. Legates. 1957. <u>Breeding and Improvement of Farm Animals</u>. 5th Edition, McGraw-Hill Book Company, Inc., New York, Toronto and London.

49. Salisbury, G. W. 1949. Some aspects of reproductive efficiency in cattle. North American Veterinary, 30:20-24.

50. Scott, J. W. 1952. Uncontrolled matings cause loss of dairy production. Agricultural Gazette of New South Wales, 63:177-180.

51. Seath, D. M., C. H. Staples and E. W. Neasham. 1943. A study of breeding records in dairy herds. Louisiana Agricultural Experiment Station Bulletin, 370.

52. Swenson, Thure. 1952. The conception rate at different intervals between calving and first insemination. Report II. International Congress Physiology Pathology Animal Reproductive and Artificial Insemination, 3.

53. Tanabe, T. Y. and L. E. Casida. 1949. The nature of reproductive failures in cows of low fertility. Journal of Dairy Science, 32:237-246.

54. Trimberger, G. W. 1954. Conception rates in dairy cattle services at various intervals after parturition. Journal of Dairy Science, 37:1042-1049.

55. Trimberger, G. W. 1945. Predictability of breeding efficiency in dairy cattle from their previous conception rate and from their heridity. Journal of Dairy Science, 28:659-669.

56. VanDemark, N. L and G. W. Salisbury. 1950. The relation of the post-partum breeding internal to reproductive efficiency in the dairy cow. Journal of Dairy Science, 9:307-313.

57. White, G. S., R. E. Johnson, L. F. Rettger and J. G. McAlphine. 1925. Some economic phases of bacterium abortus infections and other observations in dairy herds. Storrs Agricultural Experiment Station Bulletin 135.

58. Wilcox, C. W. Jr., K. O. Pfau and J. W. Bartlett. 1957. An investigation of the inheritance of female reproductive preformance and longevity, and their interrelationship within a Holstein-Fresian herd. Journal of Dairy Science, 40:942.

59. Woodward, T. E. 1946. Results of inbreeding grade Holstein-Friesian cattle. United States Department of Agricultural Technical Bulletin 927.

60. Woodward, T. E. and R. R. Graves. 1933. Some results of inbreeding grade Guernsey and grade Holstein-Friesian cattle. United States Department of Agricultural Technical Bulletin 339.

ROOM USE ONLY