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To the Graduate Council:

I am submitting herewith a thesis written by Charles R. Mosley entitled "The Relationship Between Production Level and Reproductive Efficiency in Dairy Cattle." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Dairying.

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THE RELATIONSHIP BETWEEN PRODUCTION LEVEL AND REPRODUCTIVE EFFICIENCY IN DAIRY CATTLE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Charles R. Mosley

December 1971

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ABSTRACT

Nine measures of production and four measures of reproductive efficiency were compared and analyzed on 453 cows over a five-year period from 1963 to 1968. The purpose was to ascertain the effect of production level on reproductive efficiency. Data were analyzed by correlation and regression analysis and analysis of variance. Correlation analysis revealed a small positive correlation between most production and reproductive traits. Regression analysis revealed that the influence of 120-day FCM on days to conception tended to be linear and was significant at all age levels with the exception of five-year-olds. The analysis of variance also confirmed that milk production exerts a significantly depressing effect on reproductive efficiency. The least significant differences between treatment groups state that reproductive efficiency in the top treatment group is significantly different from reproductive efficiency within the two bottom groups.

Although R^2 values indicate that milk production accounts for only a small portion of the variation in reproductive efficiency, it appears from this study that high levels of milk production do exert a significantly depressing effect on reproductive efficiency as measured by days to conception, days from first service to conception, and services per conception.

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CHAPTER I

INTRODUCTION

Arbitrary values are often chosen as the ideal level of reproductive efficiency, and the actual efficiency of the animal is the comparison of the performance record to the predecided standard or ideal. Two of the most widely used measures of reproductive performance are age at first calving, and the subsequent calving interval. The most often used standards for these two measures are two years of age and every twelve months, respectively. The economic importance of these two factors lies in the fact that the dairyman begins to reap the returns on his investment of raising the replacement sooner, and frequent calving is essential, regardless of the value of the calf, to renew the stimulus of milk secretion and to maximize on the economy of milk production (11).

For an animal to maintain the desired level of reproductive efficiency means that she must be successfully bred by the time she reaches fifteen months of age and to be successfully rebred by the eighty-fifth day postpartum. Under most management conditions it seems fairly easy to have a cow successfully bred by the time she is fifteen months old, but in the best managed herd, it is very difficult to obtain and maintain the eighty-five day postpartum service interval. Many dairymen are convinced that the cause of this lengthened service interval is due to production stress and believe that the higher producing cows require longer service interval, resulting in more services per conception.

As of yet research along this line is of little help in proving or disproving the opinions held by dairymen. Most research suggests a trend toward longer service intervals as production increases, but the trends obtained in past research are not conclusive evidence. Due to the economic importance of this question and the confusion which exists between dairymen and researchers alike, it seemed appropriate to scan the literature and conduct a study of this problem.

CHAPTER II

REVIEW OF LITERATURE

Lactation anestrus or the quietescence of ovarian activity during the period of milk production is a common occurrence among many species of laboratory and domestic animals. Swine (21), sheep (25), and goats (9), as well as women (8) are reported to undergo almost complete ovarian quietescence during the period of peak lactation and, in some instances, for the complete lactation.

Clapp (6) stated that the interval from calving to first heat was 46 days for the cows not on tests, compared to 69 and 72 days, respectively, for the cows on test and milked four times a day or nursed cows. This is in full agreement with research work done at the University of Wisconsin in which twice as many non-suckled as suckled cows had shown estrus by day 40 postpartum (5). While Clapp (6) and Casida et al. (5) believed that high production may inhibit the cyclic pattern of estrus, Espe (9) reported that lactational stress tends to suppress the normal functioning of the ovary, and thereby, prevents conception and implantation following what appears to be a normal estrus.

Lewis and Norwood (15) found that the preceding lactation had no effect on reproductive efficiency when measured by days to conception or services to conception; however, their work did indicate that cows beginning their present lactations at higher levels were not rebred as quickly nor did they conceive as readily as their herdmates who produced at a lower level. Carmen (3) stated that the preceding

lactation does have some carry-over effect on the animals' present reproductive state. His work indicated that days to first estrus was not significantly correlated with the present level of production, but as present production increases, the days to first estrus increase likewise. Carmen's work also showed that the correlation between days to first estrus and the days to conception is zero. Working with one herd Carmen found that for each additional 512 pounds of milk produced, one additional service was required.

Touchberry et al. (26) found no evidence in their data set which would suggest that a biological relationship existed between services per conception and current butterfat production.

Gaines (11) studied the production and reproductive records on 4,671 animals in the Guernsey Herd registry. The coefficient of correlation between the production level and the service period showed a small positive correlation at all age classes except for the three and one-half-year-olds. The overall correlation for all ages, $r = 0.039 \pm 0.010$, was, in Gaines' opinion, due to the fact that breeders of registered stock tend to hold high producers open longer to avoid the effects of gestation on production. From his research he concluded that high initial levels of milk production are not antagonistic to the reproductive abilities of the dairy animal.

Milk Production, Cystic Ovaries, and Reproductive Efficiency

Cystic ovaries, that is, when a graafian follicle fails to ovulate and becomes atretic, have several very drastic effects on reproductive efficiency. In one study 75 percent of the cystic cows

showed signs of nymphomania, and the other 25 percent underwent a period of anestrus (1). Wiltbank (30) found that the service period for cystic animals was considerably longer than for non-cystic cows. This extended service period was to the extent that a cystic cow would lose one year of reproductive life for every three calves born. Wiltbank also found that 13.6 percent of the cows with a history of cystic ovaries aborted compared to 6.2 percent of the non-cystic cows.

Several research workers have stated that the incidences of cystic ovaries are directly related to the level of milk production (4). Casida and Chapman (4) compared the instances of cystic ovaries in dry cows, cows milking but not on tests, and cows on tests. They found the instances of cystic ovaries to be 3.4 percent, 6.8 percent, and 10.6 percent, respectively. Roberts (22) found that 74 percent of the cysts occurred during the five month period from November to March, which corresponds with the period of peak milk production. When the cows containing cystic ovaries were stratified by ages, it was found that 54 percent occurred in the five- to six-year-old group which is the age with maximum production. From these reports it is easy to see how production increases the incidences of cystic ovaries and how cystic ovaries affect an animal's reproductive capabilities.

Reproduction--Milk Production and the Animal's Nutritional Well-Being

Espe (9) proposed that following the onset of lactation the impulse to secrete milk is so strong that frequently the udder functions at the expense of the rest of the body. There is a sharp increase in the blood flow to the udder and a drop in blood flow to the rest of the

body (27). In this drive to produce milk a cow may excrete seven times her body weight in organic matter in a single 305-day lactation (16). Work with beef cattle definitely suggests that restricted energy levels cause erratic estrous cycle activity and a lengthening of the service period (32). As cited by King (14), Webster stated that there is a general tendency to feed the average cow and thereby overfeed the low producers and underfeed the top cows of the herd. It is this author's contention that the top producers which respond the greatest to the impulse of production and are still fed the average ration approach the nutritional state of the low energy fed beef cow.

Miller et al. (19) found that high production places cattle under a stress condition. This stress results in weight loss with the higher producing cattle losing the most weight. King (14) studied the production level, reproductive efficiency, and body-weight change on 179 Ayrshire cows on three different farms. In this study cattle were divided as to weight gained or lost between parturition and mating, and the production level and reproductive traits were compared. The 81 which lost weight produced more milk and maintained a lower conception rate than did the 98 which gained weight. It is interesting to note than all 16 cows which gained at least 56 pounds over the four-week periods conceived, and none of the 8 which lost at least 58 pounds over the same period held to service. Hollon and Branton (13) investigated 1,172 pregnancies and 2,057 services. When cattle were divided into groups according to weight lost or gained, conception rate and services per conception were 41 percent and 2.45 and 64 percent, and 1.63, respectively. This report is in agreement with those of McClure (17), Steele et al. (24), and Menges et al. (18).

Production, Hormones, and Reproduction

Milk production is known to have an effect on the reproductive cycle of lower animals. Boyd (2) reported that Hammond (12) has shown that when lactation proceeds at high levels in the rabbit, pregnancy is apparently inhibited. Sawin (23) stated that high levels of milk production in mice and women are associated with low LH and FSH secretion. Warnick et al. (27) found that the follicular volume was smaller in lactating sows than in non-lactating sows. Wiltbank and Cook (31) found that there is a tendency for greater instances of quiet ovulations in nursed compared to non-nursed cattle. Whitten (29) showed that injections of gonadotropic hormones or estrogen into lactating mice caused an increase in ovary weight to approximately that of non-lactating mice. The difference in reproductive performance between two groups of animals might either be the result of decreased supply of gonadotropic hormones or a decreased sensitivity of the ovaries to normal levels. While where are species differences, the evidence collected suggests that lower gonadotropic hormone levels could affect the reproductive activity of nursed or high-producing cows.

Summary

It seems evident from this review of literature that lactational stress does exert a suppressing effect on reproductive efficiency in certain species of domestic animals. Research conducted to date with dairy cows has failed to present a convincing answer to this question which bears heavily on the dairyman's economic stability. A closer look at previous research reveals that in actuality lactational stress

on the average cow was studied. In this research animals will be stratified into four production levels and the reproductive efficiency between the extreme groups and their deviation from the mean will be compared.

CHAPTER III

MATERIALS AND METHODS

The data for this experiment consisted of the records of the registered Holstein cows of the University of Tennessee Cherokee Experiment Station Farm at Knoxville, Tennessee. All animals freshening between October 1, 1963, and October 1, 1968, which were successfully rebred by day 300 postpartum were chosen as the subjects for this experiment. A total of 453 lactations was studied, of which 151 were two-year-olds, 119 were three-year-olds, 74 were four-year-olds, and 109 were five years old or older. During the five-year period in which the data were collected, the herd was under the supervision of the same manager. Also, during this period the herd size averaged 88 cows, and production averaged 15,002 pounds of milk.

The cows were bred artificially with semen of progeny tested bulls which was obtained through commercial sources. The herdsman and/or a graduate student serving as the assistant herdsman were responsible for inseminating the cows, with the herdsman performing about 75 percent of the services during the five-year period.

The general practice was to have all the first calf heifers freshen in the late summer or fall and to rebreed all animals on the first estrus after 60 days postpartum, unless vaginal discharge or other reproductive abnormalities were evident.

Production variables were expressed as 60-day milk and fat, 120-day milk and fat, and as 60-day and 120-day fat corrected milk. The production trait used in stratifying the cows into production

levels was milk production for the first 60 days of the lactation. This production trait was used for two reasons. First, the purpose of this experiment was to ascertain the effects of milk production on reproductive efficiency, and extending the production interval beyond 60 days may have introduced the inverse effects of pregnancy on milk production. Secondly, it was believed that 60-day milk production would be representative of all production traits due to the highly significant correlation ($r>.82$) between production traits. Production records were obtained from D.H.I.A. herdbooks and interpolated by back-crediting to yield the 60-day and 120-day level.

Reproductive variables were expressed as days to first service, days to conception, days from first service to conception, and services per conception. The reproductive data were obtained from the herdsman's record book. The effects of production stress on reproductive efficiency were assessed by utilizing correlation regression analysis, and with analysis of variance by least square analysis on animals stratified into four levels of production and by least significant differences.

For the regression analysis two models were devised to weigh the influence of various independent variables on days to conception. All production traits were adjusted by least square constants to remove the influence of year and season on variation in milk production. In both Model I and Model II first 60-day FCM, second 60-day FCM, and 120-day FCM were included as major independent variables, but only Model I contained year and season as major independent variables, exerting an influence on days to conception. To evaluate the curvilinear

effect of milk production on days to conception a regression model using 120-day FCM, 120-day FCM squared and 120-day FCM cubed was devised.

CHAPTER IV

RESULTS AND DISCUSSION

The 453 cows in this experiment were divided into four age groups depending on their age at the time of freshening. Within each age group cows were divided into four production levels so that approximately 25 percent of the animals in a normally distributed population would fall into each production level. Means and standard deviations of representative production and reproductive traits within age and production level can be found in Tables I, II, III, and IV. In all four age groups, as production level increased, the days to conception increased likewise. The extended service interval for cows producing within the top one-fourth of their age group was significantly different from the service interval of cows producing within the bottom one-half of their age group. This tendency suggests a depressing effect of increased milk production on days to conception. It should be pointed out that as production level within an age group increases the standard deviation of days to conception tends to increase. This would suggest that management tolerates lower reproductive efficiency in higher producing cows.

As production levels within age groups increase, there is no significant change in days to first service or standard deviation of days to first service. Partial cause for this lack of difference is due to the large influence management exerts on this measure of reproductive efficiency.

TABLE I

MEANS AND STANDARD DEVIATIONS FOR CERTAIN PRODUCTION AND REPRODUCTIVE TRAITS WITHIN 2-YEAR-OLD PRODUCTION GROUPS

Production Level	Number of Animals	60-Day FCM		120-Day FCM		Days to First Service		Days to Conception		Days from First Service to Conception
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean
Top Quartile	28	3342	471	6254	896	90	46	157	116	67
2nd Quartile	50	2835	242	5403	507	74	14	107	50	33
3rd Quartile	39	2760	286	5096	431	76	14	102	36	26
4th Quartile	34	2346	229	4679	576	80	23	122	68	42

TABLE II

MEANS AND STANDARD DEVIATIONS FOR CERTAIN PRODUCTION AND REPRODUCTIVE TRAITS WITHIN 3-YEAR-OLD PRODUCTION GROUPS

Production Level	Number of Animals	60-Day FCM		120-Day FCM		Days to First Service		Days to Conception		Days from First Service to Conception
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean
Top Quartile	24	4378	530	8185	629	79	17	122	63	41
2nd Quartile	30	3833	338	7118	740	79	23	111	60	31
3rd Quartile	36	3577	324	6750	663	68	15	127	62	50
4th Quartile	29	3165	429	6047	810	79	22	93	32	13

TABLE III

MEANS AND STANDARD DEVIATIONS FOR CERTAIN PRODUCTION AND REPRODUCTIVE TRAITS WITHIN 4-YEAR-OLD PRODUCTION GROUPS

Production Level	Number of Animals	60-Day FCM		120-Day FCM		Days to First Service		Days to Conception		Days from First Service to Conception
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean
Top Quartile	14	5190	503	9746	1307	86	11	168	94	82
2nd Quartile	21	4134	487	8004	1062	79	24	124	89	46
3rd Quartile	20	3860	444	7534	854	77	14	102	46	25
4th Quartile	19	3254	707	6448	932	75	13	102	45	27

TABLE IV

MEANS AND STANDARD DEVIATIONS FOR CERTAIN PRODUCTION AND REPRODUCTIVE TRAITS WITHIN 5-YEAR-OLD AND OVER PRODUCTION GROUPS

Production Level	Number of Animals	60-Day FCM		120-Day FCM		Days to First Service		Days to Conception		Days from First Service to Conception
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean
Top Quartile	27	5253	723	9544	1261	86	28	154	89	67
2nd Quartile	25	4238	419	7905	1076	87	23	161	118	73
3rd Quartile	25	3701	379	7154	1139	92	49	137	85	45
4th Quartile	32	3149	476	6434	896	90	45	147	76	56

Regression Analysis

In the regression analysis two models were used to determine the cause of variation in days to conception (Table V). Both Model I and Model II contained first 60-day FCM, second 60-day FCM, and 120-day FCM as independent variables, but only Model I contained year and season effects as major independent variables. Year and season variation in milk production were removed by least square constants. In Model I which contains year-season effects, 120-day FCM accounts for the largest proportion of variation in days to conception. In this study production traits exerted more influence on days to conception within the four-year-old group than at any other age group. First 60-day FCM accounted for less variation in days to conception than did any other measure of production. The variation in days to conception was definitely more influenced by factors included in the model in older animals than in two-year-olds.

After comparing the change in reproductive traits, as production level increases as found in Tables I, II, III, and IV, it appears that milk production has a curvilinear influence upon reproductive efficiency. To evaluate the linear or curvilinear effects of production on reproductive efficiency, a regression model containing year, season, 120-day FCM, 120-day FCM squared, and 120-day FCM cubed as the independent variables, and days to conception as the dependent variable was devised. Probability of a greater F value for the linear, quadratic, and cubic terms within each age group can be found in Table VI. In this case F was a measure of the impact of the linear, quadratic and cubic terms in the model.

TABLE V

R^2 VALUES FOR THE AMOUNTS OF VARIATION IN DAYS TO CONCEPTION CONTROLLED BY VARIOUS MODELS

	Model I			Model II		
	First 60-Day FCM	Second 60-Day FCM	120-Day FCM	First 60-Day FCM	Second 60-Day FCM	120-Day FCM
2-Year-Olds	.074	.113	.125	.036	.066	.090
3-Year-Olds	.102	.132	.146	.040	.059	.074
4-Year-Olds	.250	.278	.307	.150	.162	.205
5-Year-Olds	.113	.146	.123	.019	.043	.033

TABLE VI

CURVILINEAR EVALUATION OF DEPENDENT VARIABLE CONCEPTION FOR INDEPENDENT VARIABLE 120-DAY FCM (PROBABILITY > F)

	Year	Season	Production	Production^2	Production^3
2-Year-Olds	.34	.78	.01	.50	<.01
3-Year-Olds	.50	.11	.01	.06	.80
4-Year-Olds	.71	.06	<.01	.51	.12
5-Year-Olds	.12	.57	.62	.23	.30

The linear effect of production was significant at all age levels with the exception of five-year-olds or older. Production squared approached significance only at the three-year-old level, and production cubed was significant only in the two-year-old group, but approached significance in the four-year-old group. Variation in reproduction due to season effects was not significant at any age level, and variation due to year effects was significant only at the four-year-old level. From this analysis it would appear that production exerts a linear effect on days to conception, but within certain age groups the influence on days to conception is curvilinear.

In comparing the production levels between age groups, it appears obvious that two-year-old milk production was far inferior to that of more mature cows. It appears highly unlikely that production within the two-year-olds could exert the same stress effects as projected for older animals. To remove this large group of lower producing animals and obtain a more homogenous producing group of animals a composite group of all animals three years old or older was formed. These 302 mature cows were divided into four production levels. Milk production for the first 60 days was used to divide the cows, and cows were divided so that approximately 25 percent of a normally distributed curve would fall into each production level. Each production level was designated as a treatment, and mean production and reproductive traits can be found in Table VII. An analysis of variance in three reproductive traits was conducted between treatment groups. The percent of variation in each reproductive trait due to treatment and the last line in Table VIII indicates the corresponding probability

TABLE VII

TREATMENT GROUP MEAN VALUES FOR COMPOSITE 3-, 4-, AND 5-YEAR-OLDS

	60-Day Milk	120-Day Milk	Days to First Service	Days from First Service to Conception	Days to Conception	Services per Conception
Top Quartile	5434.9	10077.4	85.5	70.4	155.9	2.8
2nd Quartile	4408.0	8395.0	85.2	43.7	129.0	2.1
3rd Quartile	3809.3	7242.1	78.3	35.2	113.5	2.0
4th Quartile	3101.1	6236.0	82.1	38.9	121.1	1.8

TABLE VIII

R^2 VALUES FOR THE AMOUNT OF VARIATION IN CERTAIN REPRODUCTIVE TRAITS ATTRIBUTED TO TREATMENT GROUPS

	Days to First Service	Days from First Service to Conception	Days to Conception	Services per Conception
R^2	.011	.034	.042	.044
Probability > F	.316	.015	.005	.003

of a greater F than can be realized by comparing the sum of squares due to regression and about the regression line. Treatment accounted for 3.4 percent of the variation in days from first service to conception, 4.2 percent of the variation in days to conception, and 4.4 percent of the variation in services per conception. All three variations were significant at the .01 level. Days to first service was not significantly affected by treatment. This is probably due to the large influence management exerts on this trait. When compared by least significant differences, the means of reproductive traits for the top production treatment were significantly different from the mean reproductive traits of the bottom two production levels.

Correlation Analysis

Correlation between the four phenotypic measures of reproduction and the nine measures of production can be found in Table IX. The means and standard deviations of these traits are found in Tables I, II, III, and IV, pages 13-16.

The correlation coefficients between number of services, days to conception, and days from first service to conception were all large and very significant, $R>0.82$ (probability<0.0001). This was expected since these are basically three expressions or measures of the same trait. The correlation coefficient between days to first service and the days to conception was 0.30, and the correlation coefficient between days to first service and number of services per conception was a small negative value, $r=-0.09$. These two values indicate that time of initial postpartum services had very little effect on the length

TABLE IX

CORRELATION BETWEEN PRODUCTION AND REPRODUCTIVE TRAITS WITHIN THE COMPOSITE 3-, 4-, AND 5-YEAR-OLD GROUP

	Days to First Service	Days from First Service to Conception	Days to Conception	Services per Conception
60-Day Fat	.069[a]	.167[c]	.185[c]	.179[c]
60-Day Milk	.056[a]	.169[c]	.216[d]	.181[c]
60-Day FCM	.127[a]	.177[c]	.193[d]	.203[d]
120-Day Fat	.071[a]	.248[d]	.263[d]	.249[d]
120-Day Milk	.071[a]	.250[d]	.264[d]	.274[d]
120-Day FCM	.075[a]	.263[d]	.278[d]	.273[d]
Previous Fat	.142[c]	.313[d]	.350[d]	.249[d]
Previous Milk	.170[c]	.295[d]	.343[d]	.228[d]
Previous FCM	.156[c]	.309[d]	.351[d]	.243[d]
Days Dry	.069[a]	.140[b]	.158[c]	.136[b]

[a]Not significant. [b]Significant at .05.

[c]Significant at .01. [d]Significant at .001.

of the service period and actually increases the expense of breeding slightly.

Correlations between production traits within the present lactation were large, $r>0.75$, and comparison of production traits within either the first 60-day or 120-day production period was very large, $r>0.90$. The correlation of the 60-day and 120-day production traits of the present lactation and the production traits for the entire preceding lactation reveal that the 120-day production was more related to the preceding lactation yield than the 60-day production, $r=0.42$ and 0.35, respectively. The correlation coefficients between the different phenotypic measures of production is found in Table X.

The correlation coefficients between production traits and reproductive traits are found in Table XI. The correlation between all reproductive and production traits was positive and highly significant with the exception of the correlation between present production and days to first service. Days to first service was significantly correlated to the production traits within the previous lactation.

A possible reason for this is that the cows which produced the most milk during the previous lactation were in poorer physical condition at the end of the lactation. Cows were all fed the same ration during the dry period, regardless of previous production, and these cows which produced the most milk in the previous lactation began the present lactation with a disadvantage in general condition.

Effect of 60-day production on reproductive efficiency. The correlation between all three measures of production and the measures

TABLE X

CORRELATION BETWEEN PRODUCTION TRAITS[a]

	60-Day Fat	60-Day Milk	60-Day FCM	120-Day Fat	120-Day Milk	120-Day FCM	Previous Fat	Previous Milk	Previous FCM
60-Day Fat		.796	.968	.812	.752	.831	.361	.330	.352
60-Day Milk	.792		.921	.729	.890	.835	.346	.361	.357
60-Day FCM	.968	.921		.820	.848	.876	.374	.360	.372
120-Day Fat	.812	.729	.820		.791	.967	.431	.396	.421
120-Day Milk	.752	.890	.848	.791		.921	.398	.408	.407
120-Day FCM	.831	.835	.876	.967	.921		.440	.438	.422
Previous Fat	.361	.346	.374	.431	.398	.440		.948	.990
Previous Milk	.330	.361	.360	.396	.408	.422	.948		.983
Previous FCM	.352	.357	.372	.421	.407	.438	.990	.983	

[a]Significant at .001.

TABLE XI

CORRELATION BETWEEN REPRODUCTIVE TRAITS WITHIN THE COMPOSITE 3-, 4-, AND 5-YEAR-OLD GROUP

	Days to First Service	Days from First Service to Conception	Days to Conception	Services for Conception
Days to First Service		-.056[a]	.308[c]	-.097[a]
Days from First Service to Conception	-.056[a]		.932[c]	.905[c]
Days to Conception	.308[c]	.932[c]		.827[c]
Services for Conception	-.097[a]	.905[c]	.827[c]	

[a]Not significant.

[b]Significant at .05.

[c]Significant at .01.

of reproductive efficiency expressed as days from first service to conception, days to conception, and services per conception was positive and very highly significantly. The correlation coefficients were in the range of $0.167<r<0.216$. There is no true difference between the correlation of any 60-day production traits and forementioned reproductive traits. This is as would be expected since correlation between reproductive traits was $r>0.9$, and correlation within production traits was $r>0.9$. These values indicate a small but definite relationship between production level for the first 60 days of lactation and reproductive efficiency.

Effect of 120-day production on reproductive efficiency. The correlation between phenotypic measures of production for the first 120 days and measures of reproductive efficiency were all positive and highly significant, with the exception of days to first service. Days to first service was positively correlated to the production traits, but it was not significant at the 5 percent level of probability. The reason for this lack of significance is possibly due to the high degree of influence management exerts on this trait. Again, there was essentially no difference in the values of correlation coefficients between different production and reproductive traits. This is as would be expected, due to the high correlations within both production and reproductive traits, $r>0.92$. The correlations between production traits and reproductive efficiency found in this experiment tend to be somewhat higher than those found in previous experiments (2, 10, 11, 26).

By comparing the correlations found between reproductive traits and 60-day or 120-day production, one can see the trend toward higher correlations between the 120-day production level. This is probably due to the fact that mean conception was 119 days with a standard deviation of 73. This large number of animals which conceived before the end of the 120-day period results in the effect of conception on milk production, and thereby, a higher correlation.

There is also a slightly higher correlation between reproductive efficiency and previous production traits than with present production. Due to the increasing variance and standard deviation of reproductive traits, as production level increases, one would assume that lower reproductive efficiency is tolerated in higher producing animals. In all profit-oriented herds the lower producing cows are culled to upgrade the herd at any sign of reproductive efficiency. This management trait forces a higher correlation between previous production traits and reproductive efficiency.

CHAPTER V

SUMMARY AND CONCLUSIONS

Nine measures of production and four measures of reproductive efficiency were compared and analyzed on 453 cows over a five-year period from 1963 to 1968. The purpose was to ascertain the effect of production level on reproductive efficiency. Data were analyzed by correlation and regression analysis and analysis of variance. Correlation analysis revealed a small positive correlation between most production and reproductive traits. Regression analysis revealed that the influence of 120-day FCM on days to conception tended to be linear and was significant at all age levels with the exception of five-year-olds. The analysis of variance also confirmed that milk production exerts a significantly depressing effect on reproductive efficiency. The least significant differences between treatment groups state that reproductive efficiency in the top treatment group is significantly different from reproductive efficiency within the two bottom groups.

Although R^2 values indicate that milk production accounts for only a small portion of the variation in reproductive efficiency, it appears from this study that high levels of milk production do exert a significantly depressing effect on reproductive efficiency as measured by days to conception, days from first service to conception and services per conception.

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