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SPALDING, Robert Wilber, 1920-
SOME EFFECTS OF SERVICE PERIOD AND DRY PERIOD ON MILK AND BUTTERFAT PRODUCTION.

The Ohio State University, Ph.D., 1961
Agriculture, animal culture

University Microfilms, Inc., Ann Arbor, Michigan
SOME EFFECTS OF SERVICE PERIOD AND DRY PERIOD
ON MILK AND BUTTERFAT PRODUCTION

DISSERTATION

Presented in Partial Fulfillment of the Requirements
for the Degree Doctor of Philosophy in
the Graduate School of
Ohio State University

By
Robert Wilber Spalding, B. S., M. A.

The Ohio State University
1961

Approved by

Thomas M. Ludwick
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ACKNOWLEDGMENTS

I would like to acknowledge the assistance and helpfulness of the following people who have contributed greatly to the completion of this advanced study:

Dr. Fordyce Ely, chairman of the Department of Dairy Science, Ohio State University;

Dr. Thomas M. Ludwick, my adviser and Professor in the Department of Dairy Science, Ohio State University and Project Leader of the Ohio NC-2 Dairy Cattle Breeding Project, from which my data were derived;

Dr. Dale Van Vleck, in the Department of Animal Husbandry, Cornell University, for programming and aid in statistical analyses;

Dr. K. L. Turk, Head of the Department of Animal Husbandry Cornell University, for his encouragement and cooperation in permitting me to be away from my work, and for the use of the statistical laboratories and electronic data-processing machines in the department.

I would also like to thank the reading committee for their assistance.
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</table>
INTRODUCTION

Many studies have been made on the various environmental factors affecting records, and efforts have been made to standardize for as many of the variables as possible and practical.

Much of the early research was done on the seven-day-test record which was discontinued in 1920. In the early 1930's most studies were on the official records of the breed associations which, for the most part, emphasized 3X-365 day selective testing programs. The USDA sire proving program began in 1925, and during the latter 1930's some studies used DHIA records. These were standardized or corrected for length of lactation, times milked per day, and age.

Many papers have been written on the effect of season of freshening on milk and butterfat production (Johnson 1956). Seasonal changes in milk production are the result of many factors and it is doubtful whether it is necessary or desirable to try to separate the causes. Each region of the country has its own seasonal pattern of production, and areas and herds within regions may be somewhat different, because of the specific feeding and other environmental factors. It is recognized that in evaluating records this seasonal variation can be as high as 5 to 10 per cent of the total record and must be corrected.

More recently, yearly variations in the size of production records have been shown to range from 2 to 5 per cent (Henderson 1949,
McDaniel 1960, Van Vleck et al. 1961) and also must be corrected for in some cases. Methods of taking out the year, season, and other herd effects have been studied and developed (Henderson 1958, Van Vleck et al. 1961).

The specific intent of all of these corrections is to make possible a more accurate evaluation of the records of cows so that genetic differences between cows and between sires can be determined. The fact that as much as 70 per cent of the variation in production records may be due to environment is being more widely accepted. AI sire committees and management personnel are appreciating the necessity of having accurate facts, if possible. It is very important that these environmental factors be determined so that true genetic differences between animals can be estimated with greater accuracy. This type of information is also very useful to dairymen since it aids them in determining how they should manage their herds for maximum efficient production.

Other factors that are known to affect records are length of previous dry period, length of time from calving to conception, calving interval and days carried calf. The period from calving to conception is commonly called service period and some researchers have used the term "days open" to designate this interval.

The purpose of this study is to determine some of the effects of lengths of service periods and dry periods on production.
REVIEW OF LITERATURE

Dry Period

Plum (1935) reported that slightly more than 1 per cent of the total variance disappeared when the effect of variation in the dry period was removed, and he concluded that apparently the length of the dry period is a minor cause of variation. Thompson et al. (1955) and McDaniel and Plowman (1961) found that previous dry period length did not significantly influence production. Ungelenk (1938) determined that milk yield is adversely affected by a short dry period. Lee et al. (1961), using DHIA records, reported negligible effect of the dry period because nearly all the cows he studied had dry periods of 42 to 60 days in length. Woodward (1945) stated that length of preceding dry period significantly affected milk production. Dickerson (1941), using HIR records, reported that milk production increased with dry periods up to about one month and declined for lactations following dry periods of over two months. He found this influence to be small, though significant, and accounted for 3 to 4 per cent of the variation in lactation records. He stated that the increase in production with longer preceding dry periods was greater rather than less for cows in the lower producing herds. Seath et al. (1943) reported higher production with increased length of dry periods up to about 100 days. Arnold et al. (1936) declared that dry periods of less than 30 days cause an early decline in milk yield corresponding perhaps to the
stage of withdrawal of stored nutrients in the body. He reported a
difference in the rates of decline in milk production between groups
of cows on low-calcium and on adequate calcium rations. Goodwin and
Erb (1956) determined that records with previous dry periods of 0-9
days averaged 1459 lbs. less milk than records with 50-59 previous dry
days. Klein and Woodward (1943) claimed differences as high as 13.49
per cent for records with less than one month dry, compared with those
with two to three months dry, in favor of the longer previous dry
period. He computed correction factors with 55 days as a standard and
showed that the factor for no previous days dry was 1.403. Bayley and
Heizer (1952) and Morrow et al. (1945) affirmed increased production
with increased lengths of the previous dry periods. Sanders (1923 and
1928) did some very good early work on the effect of dry period on
production. He standardized for age, service period, and month of
calving, then computed the effect of varying dry period lengths. He
found that the effect on second lactations was greater than other lac­
tations and computed correction factors with 40 days as a standard.
A cow’s first lactation was used as a base (100 per cent). A few
values from his table are given below:

<table>
<thead>
<tr>
<th>Length of Dry Period</th>
<th>Percentage Correction for Second Lactations</th>
<th>Percentage Correction for Other Lactations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0- 9 days</td>
<td>+ 25.1%</td>
<td>+ 14.0%</td>
</tr>
<tr>
<td>20- 29 &quot;</td>
<td>+ 8.0%</td>
<td>+ 4.7%</td>
</tr>
<tr>
<td>50- 59 &quot;</td>
<td>- 4.4%</td>
<td>- 3.3%</td>
</tr>
<tr>
<td>100-109 &quot;</td>
<td>- 12.7%</td>
<td>- 9.4%</td>
</tr>
</tbody>
</table>

He reported that variations in dry period lengths affected low
producers just as much as or more than high producers. He also found
some indication that dry periods of less than 20 days not only lowers the next lactation but the one following, as well, in the case of young cows. He concluded that a cow's production is considerably lowered by a very short dry period, but not greatly increased by a very long one.

Dickerson (1937) states that differences between cows which are hereditary for lengths of dry periods should not be removed. He also used first lactations as a base for comparing later lactations.

Bayley (1950) concluded that as the dry period increased up to eight weeks, there was a marked increase in production. Between eight and 12 weeks there was a slight increase, and he found a decline in production with dry periods longer than 12 weeks.

Starkey (1958) studied 2376 lactation records on DHIA cows in Wisconsin and reported that the relationship between length of dry period and butterfat production appeared to be linear up to eight weeks, but non-linear when dry periods exceeded this length. This would agree somewhat with the data of Bayley (1950). Starkey further stated that 4 per cent of the variation in butterfat production appeared to be associated with length of preceding dry period, but this may be low, since only the linear relationship was measured. Smith and Legates (1961) state that the length of the preceding dry period is practically independent of days open and exerted little influence on either 90-day or 305-day production. However, only 9.4 per cent of the dry periods were less than 40 days and therefore had little impact on the regression equation. In studies with records that had few or no dry periods of less than 40 days, one would expect the effect of dry period on production to be relatively small.
The previous dry period effect on production may vary from cow to cow and herd to herd because of the management practices within the herds. Schmidt and Schultz (1959) demonstrated that heavy grain feeding during the dry period did not result in more production during the subsequent lactation when compared with cows on light grain feeding, provided all cows were in good body condition at the beginning of the dry period. Cows in poor to fair body condition at the beginning of the dry period will show a great response in increased production to increased body weight gains. It seems logical to assume that the effect of the dry period on production may be confounded by the condition of the cow at the beginning of the dry period, and the feeding practices during the dry period. Cows in good condition under good management might not respond greatly to increased dry period lengths, whereas cows in poor to fair body condition might show a great response and their response might vary with the level of feeding during the dry period.

The Effect of Service Period or Days Open, Gestation or Days Carried Calf and Calving Interval on Milk and Butterfat Production

In the literature, service period, days-carried-calf, and calving interval are normally treated as separate entities, in their effect on production. They are all actually measures of a common effect when considering 305-day lactations. Lengthening the service period one day would, on the average, increase the calving interval by one day. The service period and calving interval will therefore be highly correlated. Small deviations in the length of the gestation period will bring about the only variation. There is some variation in the length of the gestation period within a breed, but the standard
deviation is only about five days. When 305-day lactation records were used, the days carried calf should also measure essentially the same effect as service period and calving interval except for cows that for some reason do not milk a complete 305 days. Starkey (1958) pointed out the high correlation between days-carried-calf and calving interval (.86). For every day the service period is lengthened, the days-carried calf while in milk will decrease by one day, on the average. These topics will be reviewed separately for clarity.

Gestation or days-carried-calf.—Eckles (1916) estimated that the nutrients required to equal the dry matter of a Jersey fetus were equivalent to about 110 to 170 lbs. of milk, and for Holsteins, 200-275 lbs. Ragsdale et al. (1924) and Gaines and Davidson (1926) stated that pregnancy becomes apparent in a reduced rate of milk secretion at about the end of the fifth month of pregnancy. Gowen (1924), using AR Guernsey records, stated that gestation had no effect on the percentage of butterfat, but decreased the total production of milk. Hopper (1923) states that cows bred early start to decline in milk production earlier than those bred later in the lactation.

Hammond and Sanders found the correlation between service period and yield to be .33 ± .106. The regression equation was y = 8500 -4250e - .0044x. Rollins et al. (1956) reported a positive correlation between milk production and the time to settle a cow.

Erb et al. (1952) state that the rate of decline in yield was three to four times as fast for cows pregnant 180 to 223 days as for those 101 to 180 days pregnant. They state that the inhibition started at about the same time regardless of the number of times milked
daily, age, breed, month of conception, production or calving interval of the cow. Laben et al. (1956) found that the first lactation FCM yield increased second gestation length 0.03 day per 100 lbs. production increase. Also higher producers tended to take slightly longer to settle.

Bayley (1950) found a linear relationship between days carried calf while milking and production. He suggested a correction of 40 pounds of fat for cows carrying a calf over 257 days, compared with no correction for cows carrying calf 43 days or less. This would correspond to service periods of 48 days or less compared with 262 days.

Starkey (1958) pointed out the high correlation between days carried calf and calving interval. He states that it appears that the calving interval may have a larger influence on butterfat yield than days carried calf. As pointed out earlier this correlation should be close to one and the influences on production should be essentially the same, since they are measures of the same effect. He also found a gradual decline in production as the days carried calf increases. This would be the same as saying that there was a gradual decline in production as the service period length decreases. From his study the butterfat yield associated with calving interval was from three to three and one-half per cent.

Calving interval.—Matson (1929) proposed that the optimum calving interval varies directly with the milking capacity and inversely with age up to maturity. Palfrey (1931) found a negative correlation between calving interval and yield over the current calving interval ($r = 0.134 \pm 0.018$) and a positive correlation over the following calving interval ($r = 0.142 \pm 0.018$). He was studying
Red Danish cattle. He states that while there is a small gain from a short calving interval in the current lactation it is lost in the following lactation. This may be true only for breeds or strains that inherently have short calving intervals.

Chapman and Casida (1935) state that the average daily production and the service period of the same calving interval show a highly significant negative correlation. Their study was based not on total lactation production but rather average daily production, and must be so interpreted.

Dickerson (1937) concluded that when the average interval between calvings is 13 months or more, little was gained by correcting 305-day lactation records for short calving intervals. In this case, "short" is a relative term because with a 13-month calving interval, almost all service periods would be from 100 to 135 days in length which should be considered adequate to long under present practical farming conditions.

Dickerson (1941) shows that the association of total lactation yield with length of calving interval is essentially linear. He found an average linear regression of 0.66 lbs. of butterfat per day increase in calving interval. He concluded that percentage correction factors for calving interval should be satisfactory.

Johansson and Hansson (1940) state that calving interval accounted for 0 to 5 per cent of the variation in individual records. Tyler and Hyatt (1950) report on Ayrshire data that 10 or 11 month calving intervals significantly lower milk and butterfat production. Longer calving intervals of 14 to 15 months did not appear to increase
production during that lactation. The correlation between first and second calving intervals was found to be +0.10.

Mahadeyan (1951) found milk yield to be positively correlated with length of preceding calving interval. Johansson (1953) showed that the highest average milk yield over a period of years is obtained by first calving interval of 14 months, the second of 13 months, and successive ones of 12 months each.

Legates (1954) reported that the heritability of calving interval length was zero and repeatability was 0.133. Carmen (1955) reported the heritability and repeatability values of the service period length to be nearly zero.

Thompson et al. (1957) found with American Red Danish cattle at a production level of 350 to 389 pounds of butterfat that yield increased 2.0 lbs. for each additional month of previous calving interval, and increased 1.0 lb. for each additional day of lactation period.

Herman and Edmondson (1950) found that the average daily milk production did not affect the calving interval length. They found that the age of the cow influences the interval to first heat, being longest for first-calf heifers (75 days) and shortest (50-60 days) for cows from 2½ to 7 yrs. of age.

**Service period or days open.**—Hammond and Sanders (1923) calculated correction factors for short service periods with 100 days as a standard or 100 per cent. Some selected values are given as follows:
Etgen (1958) derived the following multiple regression coefficients for milk and fat on days-open by ages of the cows.

<table>
<thead>
<tr>
<th>Age of Freshening</th>
<th>Multiple Regression Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Milk</td>
</tr>
<tr>
<td>All cows</td>
<td>8.3265</td>
</tr>
<tr>
<td>2 yrs.</td>
<td>5.7414</td>
</tr>
<tr>
<td>3 &amp; 4 yrs.</td>
<td>8.5745</td>
</tr>
<tr>
<td>5+</td>
<td>12.2037</td>
</tr>
</tbody>
</table>

*Significant at 0.01 level of probability.

The difference in milk production from 1263 to 2685 lbs. on a 305-day lactation due to the effect of carrying calf from 0 to 220 days seems to be an important consideration.

Krizenecky and Jelenek (1941) stated that milk yield increased linearly with length of service period up to 140 days. Further increases were without effect. This is explained by the fact that pregnancy does not exert its limiting effect on lactation until after about 150 days. They state that milk yield records for the first 10 months of lactation must be corrected for the length of service period.

Smith and Legates (1961) found little evidence that level of production influences days to conception. They found also that the estimates of genetic variance for days open were all near zero. They derived prediction equations for the effect of days open (X) on 305-day milk production as follows:
They concluded that differences in production that can be attributed to days open should be taken into account when production records are compared. Their equations show that differences in the 305-day milk yield between cows open for 60 to 160 days may be as large as 1000 lbs. and could materially influence contemporary comparison sire summaries, especially young sires with relatively few comparisons.

Lewis and Horwood (1950) report that little variation in calving interval can be associated with age, also that production of the previous lactation was not related to the next service period. There was an increase in service period length associated with high current lactation production.
MATERIAL AND METHODS

These data were taken from the Ohio North Central Dairy Cattle Breeding Project\(^1\) which is a long-range project to improve dairy cattle through breeding.

The cattle used in this project are owned and managed by the Ohio Department of Mental Hygiene and Correction. They are purebred Holstein-Friesians located in three different herds. Herd 1 (London Prison Farm) is a larger herd which has had somewhat better environmental conditions than herd 2 (Toledo State Hospital) or herd 3 (Athens State Hospital).

All cows in these herds that freshened before January 1, 1956, were milked three times a day. After that date all cows were milked twice a day. All 3X records were adjusted to a 2X milking basis by reducing by the factor 0.8. The standard USDA age-conversion factors for Holsteins were used to standardize the records for age differences. Therefore, all records used in this study were standardized to a 2X, 305-day, mature equivalent basis. The record of any cow going dry before 305 days was considered a complete lactation. Any record that was interrupted by an abortion (any calving of more than 151 days or less than 250 days gestation) before the cow had milked 305 days was not used. Only lactations which were obviously abnormal were excluded.

\(^1\) A cooperative dairy cattle breeding project with the U.S.D.A, the Ohio Agricultural Experiment Station and the Ohio Department of Mental Hygiene and Correction.
These included several terminal lactations during which the cows were chronically ill. A large number of cows never conceived on their terminal lactation and the service period length was arbitrarily determined as 305 days. The records used in this study were made during the years indicated for each herd and all cows whose records were used had left the herds when this study was commenced.

Herd 1 - 1949 to 1959
Herd 2 - 1948 to 1959
Herd 3 - 1948 to 1959

The study involves 812 cows with 2764 lactations, as indicated in Table 1. Of this total, 1969 had known dry period lengths and 2696 had known service period length. The number of lactations with known dry periods was reduced considerably because of the first lactations with no previous dry period. There were 1938 lactations with both the service period and dry period known. Only 1933 lactations were used in the analysis as five records were inadvertently left in a machine and discarded. The level of production of all lactations in the three herds is also shown. Herd 2 was considerably lower (378 lbs. butterfat) than herd 1 or 3 with 432 and 439, respectively.

In this study electronic data processing machines (IBM-650 and 1620) were used. The IBM-650 was employed for the descriptive summaries and the 1620 and 650 for the statistical analysis. The adjustments for times milked and age were made by hand, and all other computations were made by electronic data-processing machines.
<table>
<thead>
<tr>
<th>Three Herds</th>
<th>Herd 1</th>
<th>Herd 2</th>
<th>Herd 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number Cows</td>
<td>311</td>
<td>192</td>
<td>309</td>
<td>812</td>
</tr>
<tr>
<td>Number Lactations</td>
<td>938</td>
<td>665</td>
<td>1161</td>
<td>2764</td>
</tr>
<tr>
<td>Number Lactations with Known Dry</td>
<td>643</td>
<td>429</td>
<td>897</td>
<td>1969</td>
</tr>
<tr>
<td>Period Lengths</td>
<td>912</td>
<td>639</td>
<td>1145</td>
<td>2696</td>
</tr>
<tr>
<td>Number Lactations with Known Service Period Lengths</td>
<td>628</td>
<td>422</td>
<td>888</td>
<td>1938</td>
</tr>
<tr>
<td>Number Lactations with Both Service Period and Dry Period Lengths Known</td>
<td>98</td>
<td>158</td>
<td>46</td>
<td>302</td>
</tr>
<tr>
<td>Below 325 lbs. Butterfat</td>
<td>12,197</td>
<td>10,637</td>
<td>12,732</td>
<td>12,047</td>
</tr>
<tr>
<td>Between 325-425 lbs. Butterfat</td>
<td>432</td>
<td>378</td>
<td>439</td>
<td>422</td>
</tr>
<tr>
<td>Above 425 lbs. Butterfat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average all lactations:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pounds Milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12,197</td>
<td>10,637</td>
<td>12,732</td>
<td>12,047</td>
</tr>
<tr>
<td>Pounds Fat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>432</td>
<td>378</td>
<td>439</td>
<td>422</td>
</tr>
</tbody>
</table>
The data were sorted into three arbitrary levels of production to facilitate the study of the influence of service period and dry period at different levels of production.

Regression coefficients were estimated on a within herd-year-season basis. The curvilinear regression model used was as follows:

\[
Y_{ij} = \mu + h_i + b_1 X_{1ij} + b_2 X_{2ij}^2 + b_3 X_{3ij} + b_4 X_{4ij} + b_5 X_{5ij}^2 + b_6 X_{6ij} + e_{ij}
\]

\(Y_{ij}\) - is the age, herd-year-season corrected record of the \(j^{th}\) cow in the \(i^{th}\) herd.

\(\mu\) - is a fixed population parameter—the mean.

\(h_i\) - is the effect of the \(i^{th}\) herd-year-season.

\(X_{1ij}\) - is the service period.

\(X_{2ij}\) - is the service period squared.

\(X_{3ij}\) - is the square root of the service period.

\(X_{4ij}\) - is the dry period.

\(X_{5ij}\) - is the dry period squared.

\(X_{6ij}\) - is the square root of the dry period.

The b's are the coefficient for the regression of \(Y_{ij}\) on the independent \(X\)'s on a within-herd-year-season basis.

The independent variables, service period, and the functions of their square and square root were originally used in computing partial regressions, simple correlations, partial correlations and multiple correlation coefficients squared for milk and butterfat as the dependent variables. These were computed for all lactations and then 16 different combinations of these six variables were calculated to determine which combination produced the largest \(R^2\) values and
therefore accounted for the largest percentage of the sum of squares due to regression. After selecting a practical combination, all regressions and correlations were determined by using these as independent variables.

It was anticipated that the regression of milk and butterfat on both service period and dry period is curvilinear, and therefore a linear regression equation would underestimate their effects. Both the service periods and dry periods were broken into arbitrary intervals as follows:

<table>
<thead>
<tr>
<th>Service Period</th>
<th>Dry Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 0-60 days</td>
<td>1. 0-29 days</td>
</tr>
<tr>
<td>2. 60-79 &quot;</td>
<td>2. 30-39 &quot;</td>
</tr>
<tr>
<td>3. 80-99 &quot;</td>
<td>3. 40-49 &quot;</td>
</tr>
<tr>
<td>4. 100-119 &quot;</td>
<td>4. 50-59 &quot;</td>
</tr>
<tr>
<td>5. 120-139 &quot;</td>
<td>5. 60+ &quot;</td>
</tr>
<tr>
<td>6. 140+ &quot;</td>
<td></td>
</tr>
</tbody>
</table>

Regressions were calculated within these small intervals in an attempt to more clearly define the shape of the regression curve and to determine whether very short dry periods and service periods have a decided depressing effect on the 305-day lactation records.

For convenience, in the tables of this thesis, service period has been abbreviated as SP, and dry period as DP in many places.
RESULTS AND DISCUSSION

An examination of Table 2 shows that the arbitrary levels of production were not well chosen, with only 302 lactations occurring in the low level group and 1169 and 1293 occurring in the medium and high level groups respectively.

Table 3 shows the average production, number of lactations, and average lengths of service periods in 20-day intervals by herds and combined totals. The average length service periods for herds one, two and three were 140, 189 and 151 days. A graphic presentation of these data is shown in Figure 1. The same kinds of information for dry periods are given in Table 4 and Figure 2. The average dry period lengths were 59, 78 and 63 days for herds one, two and three, respectively. Herd 2 with the lowest production had the longest calving intervals and also the longest dry periods, indicating that all phases of herd management in this herd were inferior to that of the other two herds.

Because of the completeness of the data, it was possible to determine the average age at calving and average production by lactation number as shown in Table 5. This information is plotted in Figure 3, which shows that the mature equivalent age-correction factors do not fit the data very well, particularly in herds 1 and 3. First-calf heifers are overestimated in these two herds by as much as 8 or 9 per cent. This will not affect the dry period regressions,
TABLE 2

NUMBER OF LACTATIONS AND AVERAGE PRODUCTION AT ARBITRARY LEVELS OF PRODUCTION, BY HERDS

<table>
<thead>
<tr>
<th>Level of Production</th>
<th>Herd 1</th>
<th>Herd 2</th>
<th>Herd 3</th>
<th>All Herds</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb. butterfat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low (less than 325)</td>
<td>98</td>
<td>8,461</td>
<td>158</td>
<td>8,455</td>
</tr>
<tr>
<td>Medium (325-425)</td>
<td>354</td>
<td>10,951</td>
<td>348</td>
<td>10,590</td>
</tr>
<tr>
<td>High (425+)</td>
<td>486</td>
<td>13,858</td>
<td>159</td>
<td>12,906</td>
</tr>
</tbody>
</table>
### TABLE 3
PRODUCTION AND NUMBER OF LACTATIONS WITH SERVICE PERIODS IN 20-DAY INTERVALS, BY HERDS

<table>
<thead>
<tr>
<th>Service Periods</th>
<th>No. Lacts.</th>
<th>Av. Days</th>
<th>Av. Milk</th>
<th>Av. Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 60</td>
<td>49</td>
<td>44</td>
<td>11235</td>
<td>390</td>
</tr>
<tr>
<td>60-79</td>
<td>146</td>
<td>71</td>
<td>11369</td>
<td>402</td>
</tr>
<tr>
<td>80-99</td>
<td>168</td>
<td>89</td>
<td>12052</td>
<td>432</td>
</tr>
<tr>
<td>100-119</td>
<td>109</td>
<td>109</td>
<td>12031</td>
<td>433</td>
</tr>
<tr>
<td>120-139</td>
<td>84</td>
<td>129</td>
<td>12399</td>
<td>440</td>
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<td>140+</td>
<td>356</td>
<td>219</td>
<td>12750</td>
<td>450</td>
</tr>
<tr>
<td>Total Lactations</td>
<td>912</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Av. Days</td>
<td>140</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
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<th>Herd 2</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Less than 60</td>
<td>8</td>
<td>53</td>
<td>9610</td>
<td>348</td>
</tr>
<tr>
<td>60-79</td>
<td>20</td>
<td>74</td>
<td>10207</td>
<td>361</td>
</tr>
<tr>
<td>80-99</td>
<td>99</td>
<td>90</td>
<td>10016</td>
<td>357</td>
</tr>
<tr>
<td>100-119</td>
<td>78</td>
<td>108</td>
<td>10222</td>
<td>366</td>
</tr>
<tr>
<td>120-139</td>
<td>72</td>
<td>130</td>
<td>10405</td>
<td>375</td>
</tr>
<tr>
<td>140+</td>
<td>362</td>
<td>255</td>
<td>10965</td>
<td>389</td>
</tr>
<tr>
<td>Total Lactations</td>
<td>639</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Av. Days</td>
<td>189</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Herd 3</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Less than 60</td>
<td>9</td>
<td>44</td>
<td>12631</td>
<td>439</td>
</tr>
<tr>
<td>60-79</td>
<td>74</td>
<td>74</td>
<td>11594</td>
<td>401</td>
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<tr>
<td>80-99</td>
<td>289</td>
<td>90</td>
<td>12330</td>
<td>424</td>
</tr>
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<td>100-119</td>
<td>229</td>
<td>109</td>
<td>12803</td>
<td>444</td>
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<tr>
<td>140+</td>
<td>396</td>
<td>211</td>
<td>13178</td>
<td>453</td>
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<tr>
<td>Total Lactations</td>
<td>1145</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Av. Days</td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>All Herds</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Less than 60</td>
<td>66</td>
<td>45</td>
<td>11229</td>
<td>392</td>
</tr>
<tr>
<td>60-79</td>
<td>240</td>
<td>72</td>
<td>11342</td>
<td>398</td>
</tr>
<tr>
<td>80-99</td>
<td>556</td>
<td>90</td>
<td>11834</td>
<td>414</td>
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<td>100-119</td>
<td>416</td>
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<td>12126</td>
<td>424</td>
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<tr>
<td>140+</td>
<td>1114</td>
<td>227</td>
<td>12322</td>
<td>431</td>
</tr>
<tr>
<td>Total Lactations</td>
<td>2696</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Av. Days</td>
<td>151</td>
<td></td>
<td></td>
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</table>
Butterfat - Pounds

Days

390
400
410
420
430

40 60 80 100 120 140 160 180 200 210 220

Fig. 1 -- Effect of Service Period on Butterfat Production - (2764 Lactations)
<table>
<thead>
<tr>
<th>Dry Period in Days</th>
<th>Herd 1</th>
<th>Herd 2</th>
<th>Herd 3</th>
<th>All Herds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Lacts.</td>
<td>Av. Days</td>
<td>Av. Milk</td>
<td>Av. Fat</td>
</tr>
<tr>
<td>0-9</td>
<td>10</td>
<td>2</td>
<td>9191</td>
<td>336</td>
</tr>
<tr>
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<td>17</td>
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<td>430</td>
</tr>
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<td>32</td>
<td>25</td>
<td>10646</td>
<td>382</td>
</tr>
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<td>30-39</td>
<td>52</td>
<td>35</td>
<td>11669</td>
<td>411</td>
</tr>
<tr>
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<td>118</td>
<td>45</td>
<td>11951</td>
<td>418</td>
</tr>
<tr>
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<td>417</td>
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<td>60+</td>
<td>248</td>
<td>82</td>
<td>11910</td>
<td>425</td>
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<tr>
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<tr>
<td>Av. Days</td>
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<td>9470</td>
<td>352</td>
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<td>360</td>
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<td>10655</td>
<td>379</td>
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<td>10377</td>
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<tr>
<td>Av. Days</td>
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<td>55</td>
<td>11672</td>
<td>410</td>
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<td>60+</td>
<td>946</td>
<td>90</td>
<td>11930</td>
<td>418</td>
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<tr>
<td>Total Lactations</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Av. Days</td>
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</tr>
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</table>
Fig. 2 -- Effect of Previous Dry Period on Butterfat Production - (2764 Lactations)
### TABLE 5

**AVERAGE AGE AT CALVING, AND PRODUCTION BY LACTATION NUMBER, WITHIN HERDS**

<table>
<thead>
<tr>
<th>Lact. No.</th>
<th>No. Lact.</th>
<th>Av. Age at Calving</th>
<th>Av. Milk</th>
<th>Av. Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herd 1</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>256</td>
<td>2.34</td>
<td>13376</td>
<td>472</td>
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<td>2</td>
<td>272</td>
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<td>12127</td>
<td>432</td>
</tr>
<tr>
<td>3</td>
<td>178</td>
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<td>11301</td>
<td>405</td>
</tr>
<tr>
<td>4</td>
<td>116</td>
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<td>402</td>
</tr>
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<td>5</td>
<td>57</td>
<td>6.94</td>
<td>11959</td>
<td>422</td>
</tr>
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<td>32</td>
<td>7.91</td>
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<td>390</td>
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<td><strong>Herd 2</strong></td>
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(continued)
## TABLE 5—Continued

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<th>Av. Milk</th>
<th>Av. Fat</th>
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<td>3</td>
<td>12.52</td>
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<table>
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<th>No. Lacts.</th>
<th>Av. Age at Calving</th>
<th>Av. Milk</th>
<th>Av. Fat</th>
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<tr>
<td>10</td>
<td>4</td>
<td>12.76</td>
<td>13216</td>
<td>447</td>
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</table>
Fig. 3 -- Mature Equivalent Production by Lactation Number - (2764 Lactations)
since these records have no previous dry period but it may introduce a slight bias in the service period regression factors. This wide discrepancy in age factors was not anticipated or an attempt would have been made to adjust for it.

The effect of month of freshening on production is shown in Table 6 and graphically presented in Figure 4. The high months were November through April and the low months were May through October. This agrees with the Ohio data for Holsteins (USDA, 1960 and Baldwin and Fechheimer, 1960), as shown in Figure 4. In this study the year was divided into two seasons: season 1 (May through October) and season 2 (November through April). The average difference in favor of season 1 was about 400 lbs. of milk and 16 lbs. of butterfat. This is a sizeable variation and must be accounted for. It should also be mentioned for practical consideration that a dairyman in Ohio should not overlook this fact. Production per cow can be increased about 400 lbs. of milk per cow, on the average, by having most of the cows freshen in the months November through April. This is the period with the highest milk prices usually.

Table 7 shows a tabulation of all lactations with production by year of calving for the 12 years studied. This is shown graphically in Figure 5. Production is shown to increase markedly with time, and there are great fluctuations from one year to the next, being as great as 20 to 25 lbs. of butterfat within a herd between years.

These variations in herds, seasons, and years made it necessary to make this study on a within herd-year-season basis. This made possible 72 herd-year-season groups with three herds, two seasons and 12 different years.
TABLE 6

NUMBER OF LACTATIONS AND PRODUCTION BY MONTH OF CALVING, WITHIN HERDS

<table>
<thead>
<tr>
<th>Month of Calving</th>
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<th></th>
<th></th>
<th></th>
<th>Herd 2</th>
<th></th>
<th></th>
<th></th>
<th>Herd 3</th>
<th></th>
<th></th>
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<th>All Herds</th>
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<th></th>
<th></th>
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<tbody>
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<td>January</td>
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<td>12166</td>
<td>438</td>
<td>68</td>
<td>10640</td>
<td>380</td>
<td>78</td>
<td>12724</td>
<td>438</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>64</td>
<td>12811</td>
<td>456</td>
<td>68</td>
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<td>398</td>
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<td>12664</td>
<td>440</td>
<td>232</td>
<td>11235</td>
<td>432</td>
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<tr>
<td>March</td>
<td>75</td>
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<td>452</td>
<td>96</td>
<td>10486</td>
<td>375</td>
<td>105</td>
<td>13061</td>
<td>457</td>
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<td>12071</td>
<td>427</td>
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<tr>
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<td>431</td>
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<td>364</td>
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<td>11939</td>
<td>419</td>
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<td></td>
<td></td>
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<tr>
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<tr>
<td>July</td>
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<td>408</td>
<td>43</td>
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<td>370</td>
<td>108</td>
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<td>11580</td>
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<td>37</td>
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<td>11971</td>
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<td>414</td>
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<td>10716</td>
<td>378</td>
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<td>12903</td>
<td>447</td>
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<td>12025</td>
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<td>43</td>
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<td>December</td>
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<td>447</td>
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<td>401</td>
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Fig. 4 -- Butterfat Production by Month of Calving for All Lactations - (2764)
### TABLE 7

**NUMBER OF LACTATIONS AND PRODUCTION BY YEAR OF CALVING, WITHIN HERDS**

<table>
<thead>
<tr>
<th>Year of Calving</th>
<th>Herd 1</th>
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<th>Herd 2</th>
<th></th>
<th></th>
<th>Herd 3</th>
<th></th>
<th></th>
<th>All Herds</th>
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<td>113</td>
<td>12917</td>
<td>422</td>
<td>262</td>
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<td>406</td>
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<td>9621</td>
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<td>148</td>
<td>12500</td>
<td>422</td>
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<td>13029</td>
<td>462</td>
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<td>422</td>
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<td>11745</td>
<td>419</td>
<td>94</td>
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<td>439</td>
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<td>1959</td>
<td>18</td>
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<td>12263</td>
<td>425</td>
<td>38</td>
<td>12498</td>
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<tr>
<td><strong>Total Lacts.</strong></td>
<td>938</td>
<td></td>
<td></td>
<td></td>
<td>665</td>
<td></td>
<td></td>
<td>1161</td>
<td></td>
<td>2764</td>
<td></td>
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<tr>
<td><strong>Average Milk &amp; Fat</strong></td>
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<td>432</td>
<td></td>
<td>10637</td>
<td>378</td>
<td></td>
<td>12734</td>
<td>439</td>
<td></td>
<td>12047</td>
<td>422</td>
<td></td>
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</table>
Fig. 5 -- Butterfat Production by Year of Calving for all Lactations - (2764 Lactations)
After the preparation of the descriptive tables discussed above the next phase involved the calculation of the sums of squares and crossproducts as well as the means and their standard deviations. All lactations for which the service periods and dry periods were available were used in these calculations.

Table 8 shows that the mean service period length for all lactations was 155 + 85 days which is surprisingly large. A contributing factor to this may have been the large number of cows that failed to conceive on their terminal lactation. The mean dry period length was 65 + 46 days. Within the three levels of production the dry period length remained constant at 65 days while the service period increased as butterfat production increased. As the lactations were grouped by narrow service period intervals, there seemed to be a slight increase in the dry period length as service period length increased. When they were grouped according to dry period interval there seemed to be also a slight tendency for service period length to increase. The correlation, however, between service period and dry period was only .04 as shown in Table 9.

Fourteen different combinations of the independent variables, service period, dry period and their squares and square roots are shown in Table 10 with the corresponding multiple correlation coefficients squared ($R^2$) for milk. The objective by these calculations was to determine what combination of the functions of these two variables produced the largest $R^2$ values which indicates the proportion of the total sum of squares attributable to regression. The service period, dry period and their square roots were selected as
### TABLE 8

MEANS AND STANDARD DEVIATIONS OF SERVICE PERIODS, DRY PERIODS, MILK AND FAT FOR THE DIFFERENT GROUPINGS OF THE DATA

<table>
<thead>
<tr>
<th></th>
<th>SP Mean ± Std. Dev.</th>
<th>DP Mean ± Std. Dev.</th>
<th>Milk Mean ± Std. Dev.</th>
<th>Fat Mean ± Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Lactations</td>
<td>155 ± 85</td>
<td>65 ± 46</td>
<td>11874 ± 1921</td>
<td>416 ± 70</td>
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<td>Fat Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>145 ± 87</td>
<td>65 ± 39</td>
<td>8541 ± 1053</td>
<td>289 ± 29</td>
</tr>
<tr>
<td>Medium</td>
<td>151 ± 82</td>
<td>65 ± 47</td>
<td>11061 ± 1046</td>
<td>381 ± 27</td>
</tr>
<tr>
<td>High</td>
<td>161 ± 87</td>
<td>65 ± 46</td>
<td>13631 ± 1465</td>
<td>486 ± 47</td>
</tr>
<tr>
<td>Service Period</td>
<td>(Insufficient data)</td>
<td></td>
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</tr>
<tr>
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<tr>
<td>2.</td>
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<td>10955</td>
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<td>3.</td>
<td>90</td>
<td>62</td>
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<td>4.</td>
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<td>5.</td>
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<td>6.</td>
<td>228</td>
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<td>Dry Period</td>
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<td>1.+2.+3.</td>
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<td>4.</td>
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<td>7.</td>
<td>157</td>
<td>90</td>
<td>11933</td>
<td>418</td>
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TABLE 9
WITHIN-HERD-YEAR-SEASON CORRELATIONS BETWEEN SERVICE PERIOD, DRY PERIOD, MILK AND FAT PRODUCTION

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<thead>
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<td>0.01</td>
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<tr>
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<td>0.07</td>
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<td>S.P. X D.P.</td>
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<tr>
<td>S.P. X D.P.²</td>
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<tr>
<td>S.P. X √D.P.</td>
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<tr>
<td>D.P.² X D.P.</td>
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TABLE 10

INDEPENDENT VARIABLES, SERVICE PERIOD AND DRY PERIOD, AND ALTERNATIVE FUNCTIONS WITH $R^2$ VALUES FOR MILK AND FAT ON A WITHIN-Herd-Year-Season Basis for All Lactations

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<th>DP$^2$</th>
<th>$\sqrt{DP}$</th>
<th>$R^2$ for Milk</th>
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<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>.015</td>
<td>.009</td>
</tr>
</tbody>
</table>
practical for this study and gave a $R^2$ value of .078 which compares with .082 obtained by adding their squares. Only four $R^2$ values were determined for butterfat and the selected variables gave $R^2 = .064$, only 0.2 per cent below that obtained by adding the square of both variables.

The within-herd-year-season simple correlations are shown in Table 9. All correlations are relatively small. The square root of service period shows the largest correlation for both milk and fat (.24 and .22 respectively). Dry period, its square and square root gave $r$ values of .03, .00 and .07 explaining a very small portion of the variation in milk or fat production. Also note that the correlation between service period and dry period is close to zero. The $R^2$ values for service period alone with milk and fat (Table 10) were .069 and .059 respectively and the values for dry period alone with milk and fat were .015 and .009. All of these values indicate that service period accounts for much more of the variation in milk and butterfat production than does dry period when calculated on all lactations.

The reduction in sum of squares attributable to regression is given in Table 11 for all groupings of the data. These values were determined for service period, dry period and their square roots as the independent variables. Within fat levels, higher $R^2$ values were obtained for the higher fat levels. This indicates that there is less variation in the low level group as they have an environmental ceiling which tends to suppress the size of the production record. The standard deviation for fat records in the low level group was 29 pounds and in the high level group it was 47 pounds.
### TABLE 11

VALUES OF $R^2$ FOR MILK AND FAT PRODUCTION DUE TO INDEPENDENT VARIABLES, FOR ALL GROUPINGS OF THE DATA

<table>
<thead>
<tr>
<th></th>
<th>$R^2$ for Milk</th>
<th>$R^2$ for Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Lactations</td>
<td>.078**</td>
<td>.064**</td>
</tr>
</tbody>
</table>

#### Fat Level

<table>
<thead>
<tr>
<th></th>
<th>$R^2$ for Milk</th>
<th>$R^2$ for Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>.023</td>
<td>.021</td>
</tr>
<tr>
<td>Medium</td>
<td>.044**</td>
<td>.020**</td>
</tr>
<tr>
<td>High</td>
<td>.062**</td>
<td>.054**</td>
</tr>
</tbody>
</table>

#### Service Period

<table>
<thead>
<tr>
<th></th>
<th>$R^2$ for Milk</th>
<th>$R^2$ for Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (Insufficient data)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>.031</td>
<td>.024</td>
</tr>
<tr>
<td>3.</td>
<td>.031*</td>
<td>.012</td>
</tr>
<tr>
<td>4.</td>
<td>.031</td>
<td>.018</td>
</tr>
<tr>
<td>5.</td>
<td>.022</td>
<td>.016</td>
</tr>
<tr>
<td>6.</td>
<td>.024**</td>
<td>.023**</td>
</tr>
</tbody>
</table>

#### Dry Period

<table>
<thead>
<tr>
<th></th>
<th>$R^2$ for Milk</th>
<th>$R^2$ for Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.+2.+3.</td>
<td>.171**</td>
<td>.129**</td>
</tr>
<tr>
<td>4.</td>
<td>.072</td>
<td>.037</td>
</tr>
<tr>
<td>5.</td>
<td>.073**</td>
<td>.085**</td>
</tr>
<tr>
<td>6.</td>
<td>.095**</td>
<td>.087**</td>
</tr>
<tr>
<td>7.</td>
<td>.072**</td>
<td>.057**</td>
</tr>
</tbody>
</table>

*, **Denote significance at the 5 per cent and 1 per cent level, respectively.
Because of the small number of lactations falling into the dry period intervals 1, 2 and 3 (0-29 days), they were added together and treated as one interval. The $R^2$ values are about twice as high for the dry period intervals as for service period intervals. This is because the data was sorted by narrow dry period intervals and most of the variation in dry period was removed. The $R^2$ then measures predominantly the remaining service period effect. All $R^2$ for dry period intervals are significant at the one per cent level of probability except period 4. The highest value obtained was for dry periods 1 + 2 + 3 with $R^2 = .171$ and .129 for milk and fat respectively. This does indicate that these short dry period intervals have a sizeable influence on production.

Within the service period intervals the $R^2$ values are largely a measure of dry period effect and are smaller than the values for dry period intervals.

An analysis of variance of regression is presented in Table 12 for the regression of milk and fat on service period and dry period for all lactations and also for the three different fat levels. Symbolically the degrees of freedom are as follows:

<table>
<thead>
<tr>
<th>Source</th>
<th>df.</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>k</td>
<td></td>
</tr>
<tr>
<td>Residual</td>
<td>$n - h - k$</td>
<td></td>
</tr>
<tr>
<td>Total (Within-Herd-Year-Season)</td>
<td>$n - h$</td>
<td></td>
</tr>
</tbody>
</table>

The $k$ is the number of independent variables, $n$ is the number of observations and $h$ is the number of herd-year-season groups. The
TABLE 12

ANALYSIS OF VARIANCE OF REGRESSION OF MILK AND FAT ON SERVICE PERIOD

<table>
<thead>
<tr>
<th></th>
<th>Milk</th>
<th>Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>df.</td>
<td>MS</td>
</tr>
<tr>
<td><strong>All Lactations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression</td>
<td>4</td>
<td>133817192</td>
</tr>
<tr>
<td>Residual</td>
<td>1857</td>
<td>3408966</td>
</tr>
<tr>
<td>Total</td>
<td>1861</td>
<td></td>
</tr>
<tr>
<td><strong>Production Level 1</strong> (Less than 325 lbs. Fat)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression</td>
<td>4</td>
<td>1167176</td>
</tr>
<tr>
<td>Residual</td>
<td>178</td>
<td>1108720</td>
</tr>
<tr>
<td>Total</td>
<td>182</td>
<td></td>
</tr>
<tr>
<td><strong>Production Level 2</strong> (325 to 425 lbs. Fat)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression</td>
<td>4</td>
<td>9382202</td>
</tr>
<tr>
<td>Residual</td>
<td>782</td>
<td>1051856</td>
</tr>
<tr>
<td>Total</td>
<td>786</td>
<td></td>
</tr>
<tr>
<td><strong>Production Level 3</strong> (425+ lbs. Fat)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression</td>
<td>4</td>
<td>25984509</td>
</tr>
<tr>
<td>Residual</td>
<td>772</td>
<td>2023694</td>
</tr>
<tr>
<td>Total</td>
<td>776</td>
<td></td>
</tr>
</tbody>
</table>

*, ** Denote significance at the 5 per cent and 1 per cent level, respectively.
reduction in sum of squares due to regression is significant for all lactations and for the medium and high fat levels but not for the low level when tested by the F test.

A similar analysis is presented in Table 13 for 20-day service period intervals. Service period 3, reduction in sum of squares due to regression, was significant at the 5 per cent level for milk, and service period 6 was significant at the 1 per cent level for both milk and fat.

An analysis for the dry period intervals is presented in Table 14 and the reduction in sum of squares for milk and fat due to regression on service period and dry period are significant at the 1 per cent level for all intervals except dry period 4. Of course these values should test significantly the same as the $R^2$ values but are presented to show the degrees of freedom and the relative size of the respective mean squares.

Partial regression coefficients with their standard deviations are shown in Table 15 for milk and Table 16 for fat. They were tested for significance by the $t$ test with $n - h - k$ degrees of freedom. For all lactations, all regression values are significant at the 1 per cent level. For the other groupings of the data the degrees of freedom were generally insufficient. When the regression values were determined for service period and dry period intervals of such a narrow range, it became obvious that the square root function of the respective variable under consideration produced an unrealistic regression coefficient and it was decided to calculate the partial regressions of milk and fat on service period by eliminating the square root of service period as a
### TABLE 13

**ANALYSIS OF VARIANCE OF REGRESSION OF MILK AND FAT ON SERVICE PERIOD AND DRY PERIOD BY ARBITRARY SERVICE PERIOD INTERVALS, ON A WITHIN-HERD-YEAR-SEASON BASIS**

<table>
<thead>
<tr>
<th>Source</th>
<th>Milk</th>
<th>Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>df.</td>
<td>MS</td>
</tr>
<tr>
<td>Regression 1</td>
<td>4</td>
<td>3526641</td>
</tr>
<tr>
<td>Residual</td>
<td>114</td>
<td>3919030</td>
</tr>
<tr>
<td>Total</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>Service Period 2</td>
<td>(60-99 days)</td>
<td></td>
</tr>
<tr>
<td>Regression 2</td>
<td>4</td>
<td>9650439</td>
</tr>
<tr>
<td>Residual</td>
<td>112</td>
<td>3622366</td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td></td>
</tr>
<tr>
<td>Service Period 3</td>
<td>(80-99 days)</td>
<td></td>
</tr>
<tr>
<td>Regression 3</td>
<td>4</td>
<td>4659685</td>
</tr>
<tr>
<td>Residual</td>
<td>118</td>
<td>2678987</td>
</tr>
<tr>
<td>Total</td>
<td>122</td>
<td></td>
</tr>
<tr>
<td>Service Period 4</td>
<td>(100-119 days)</td>
<td></td>
</tr>
<tr>
<td>Regression 4</td>
<td>4</td>
<td>2192318</td>
</tr>
<tr>
<td>Residual</td>
<td>151</td>
<td>2615846</td>
</tr>
<tr>
<td>Total</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>Service Period 5</td>
<td>(120-139 days)</td>
<td></td>
</tr>
<tr>
<td>Regression 5</td>
<td>4</td>
<td>16315094</td>
</tr>
<tr>
<td>Residual</td>
<td>797</td>
<td>3435788</td>
</tr>
<tr>
<td>Total</td>
<td>771</td>
<td></td>
</tr>
</tbody>
</table>

*, ** Denote significance at the 5 per cent and 1 per cent level, respectively.
TABLE 14
ANALYSIS OF VARIANCE OF REGRESSION OF MILK AND FAT ON SERVICE PERIOD AND DRY PERIOD BY ARBITRARY DRY PERIOD INTERVALS, ON A WITHIN-HERD-YEAR-SEASON BASIS

<table>
<thead>
<tr>
<th></th>
<th>Milk</th>
<th>Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>df.</td>
<td>MS</td>
</tr>
<tr>
<td><strong>Dry Period 1 + 2 + 3 (0-29 days)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression</td>
<td>4</td>
<td>24398240</td>
</tr>
<tr>
<td>Residual</td>
<td>148</td>
<td>3192364</td>
</tr>
<tr>
<td>Total</td>
<td>152</td>
<td></td>
</tr>
<tr>
<td><strong>Dry Period 4 (30-39 days)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression</td>
<td>4</td>
<td>7538616</td>
</tr>
<tr>
<td>Residual</td>
<td>104</td>
<td>3717746</td>
</tr>
<tr>
<td>Total</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td><strong>Dry Period 5 (40-49 days)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression</td>
<td>4</td>
<td>14629730</td>
</tr>
<tr>
<td>Residual</td>
<td>198</td>
<td>3771162</td>
</tr>
<tr>
<td>Total</td>
<td>202</td>
<td></td>
</tr>
<tr>
<td><strong>Dry Period 6 (50-59 days)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression</td>
<td>4</td>
<td>28387921</td>
</tr>
<tr>
<td>Residual</td>
<td>319</td>
<td>3406844</td>
</tr>
<tr>
<td>Total</td>
<td>323</td>
<td></td>
</tr>
<tr>
<td><strong>Dry Period 7 (60+ days)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression</td>
<td>4</td>
<td>55127192</td>
</tr>
<tr>
<td>Residual</td>
<td>850</td>
<td>3321849</td>
</tr>
<tr>
<td>Total</td>
<td>854</td>
<td></td>
</tr>
</tbody>
</table>

*, **Denote significance at the 5 per cent and 1 per cent level, respectively.
<table>
<thead>
<tr>
<th></th>
<th>SP</th>
<th>√SP</th>
<th>DP</th>
<th>√DP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b₁</td>
<td>b₂</td>
<td>b₃</td>
<td>b₄</td>
</tr>
<tr>
<td><strong>All Lactations</strong></td>
<td>-13.5**</td>
<td>525.6**</td>
<td>-8.2**</td>
<td>207.7**</td>
</tr>
<tr>
<td></td>
<td>(+3.0)</td>
<td>(+83.7)</td>
<td>(+2.4)</td>
<td>(+49.5)</td>
</tr>
<tr>
<td><strong>Fat Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>- 5.5</td>
<td>167.1</td>
<td>- 2.1</td>
<td>86.0</td>
</tr>
<tr>
<td></td>
<td>(+5.9)</td>
<td>(+161.5)</td>
<td>(+5.3)</td>
<td>(+97.4)</td>
</tr>
<tr>
<td><strong>Medium</strong></td>
<td>- 8.4**</td>
<td>286.0**</td>
<td>- 3.8*</td>
<td>97.7*</td>
</tr>
<tr>
<td></td>
<td>(+2.4)</td>
<td>(+69.5)</td>
<td>(+1.9)</td>
<td>(+41.7)</td>
</tr>
<tr>
<td><strong>High</strong></td>
<td>- 2.6</td>
<td>182.2</td>
<td>- 5.8*</td>
<td>158.4**</td>
</tr>
<tr>
<td></td>
<td>(+3.7)</td>
<td>(+104.4)</td>
<td>(+2.9)</td>
<td>(+61.2)</td>
</tr>
<tr>
<td><strong>Service Period</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1.</strong></td>
<td>(Insufficient data)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2.</strong></td>
<td>- 4.4</td>
<td>.</td>
<td>-39.6</td>
<td>675.8</td>
</tr>
<tr>
<td></td>
<td>(+39.6)</td>
<td>(+23.8)</td>
<td>(+368.2)</td>
<td></td>
</tr>
<tr>
<td><strong>3.</strong></td>
<td>28.5</td>
<td>.</td>
<td>-27.7*</td>
<td>515.2**</td>
</tr>
<tr>
<td></td>
<td>(+18.8)</td>
<td>(+10.7)</td>
<td>(+178.6)</td>
<td></td>
</tr>
<tr>
<td><strong>4.</strong></td>
<td>-32.6</td>
<td>.</td>
<td>- 6.6</td>
<td>191.9*</td>
</tr>
<tr>
<td></td>
<td>(+19.0)</td>
<td>(+4.2)</td>
<td>(+93.9)</td>
<td></td>
</tr>
<tr>
<td><strong>5.</strong></td>
<td>-42.2</td>
<td>.</td>
<td>- 1.9</td>
<td>62.3</td>
</tr>
<tr>
<td></td>
<td>(+23.2)</td>
<td>(+12.4)</td>
<td>(+224.5)</td>
<td></td>
</tr>
<tr>
<td><strong>6.</strong></td>
<td>2.6**</td>
<td>.</td>
<td>- 8.6**</td>
<td>214.2**</td>
</tr>
<tr>
<td></td>
<td>(+.8)</td>
<td>(+3.3)</td>
<td>(+76.2)</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
TABLE 15--Continued

<table>
<thead>
<tr>
<th>Dry Period</th>
<th>SP</th>
<th>VSP</th>
<th>DP</th>
<th>VDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.+2.+3.</td>
<td>-34.9**</td>
<td>1119.2**</td>
<td>43.1**</td>
<td>. .#</td>
</tr>
<tr>
<td></td>
<td>(+9.0)</td>
<td>(+263.4)</td>
<td>(+16.8)</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>-29.7*</td>
<td>899.1*</td>
<td>57.4</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(+15.0)</td>
<td>(+402.2)</td>
<td>(+64.0)</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>-22.7*</td>
<td>751.7**</td>
<td>42.0</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(+8.8)</td>
<td>(+251.4)</td>
<td>(+47.3)</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>-19.7**</td>
<td>713.7**</td>
<td>1.3</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(+7.27)</td>
<td>(+201.6)</td>
<td>(+2.5)</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>-5.4</td>
<td>317.9*</td>
<td>-1.0</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(+4.9)</td>
<td>(+135.4)</td>
<td>(+1.3)</td>
<td></td>
</tr>
</tbody>
</table>

*, ** Denote significance at the 5 per cent and 1 per cent level, respectively.

# This function of the variable was not used.
TABLE 16

PARTIAL REGRESSION COEFFICIENTS WITH THEIR STANDARD DEVIATIONS FOR THE REGRESSION OF FAT ON SERVICE PERIOD AND DRY PERIOD AND THE FUNCTION OF THEIR SQUARE ROOT

<table>
<thead>
<tr>
<th></th>
<th>SP</th>
<th>√SP</th>
<th>DP</th>
<th>√DP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b₁</td>
<td>b₂</td>
<td>b₃</td>
<td>b₄</td>
</tr>
<tr>
<td>All Lactations</td>
<td>-0.45**</td>
<td>17.60**</td>
<td>-0.20*</td>
<td>5.47**</td>
</tr>
<tr>
<td></td>
<td>(+0.11)</td>
<td>(+3.08)</td>
<td>(+0.09)</td>
<td>(+1.82)</td>
</tr>
<tr>
<td>Fat Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>-0.14</td>
<td>3.66</td>
<td>-0.17</td>
<td>3.98</td>
</tr>
<tr>
<td></td>
<td>(+0.16)</td>
<td>(+4.40)</td>
<td>(+0.15)</td>
<td>(+2.65)</td>
</tr>
<tr>
<td>Medium</td>
<td>-0.14</td>
<td>5.02**</td>
<td>0.03</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>(+0.65)</td>
<td>(+1.84)</td>
<td>(+0.05)</td>
<td>(+1.11)</td>
</tr>
<tr>
<td>High</td>
<td>-0.09</td>
<td>5.91</td>
<td>-0.12</td>
<td>3.77</td>
</tr>
<tr>
<td></td>
<td>(+0.12)</td>
<td>(+3.38)</td>
<td>(+0.09)</td>
<td>(+1.98)</td>
</tr>
<tr>
<td>Service Period</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. (Insufficient data)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>0.34</td>
<td></td>
<td>-1.00</td>
<td>18.20</td>
</tr>
<tr>
<td></td>
<td>(+1.36)</td>
<td></td>
<td>(+0.82)</td>
<td>(+12.60)</td>
</tr>
<tr>
<td>3.</td>
<td>0.78</td>
<td></td>
<td>-0.62</td>
<td>11.45</td>
</tr>
<tr>
<td></td>
<td>(+0.71)</td>
<td></td>
<td>(+0.40)</td>
<td>(+6.70)</td>
</tr>
<tr>
<td>4.</td>
<td>-1.10</td>
<td></td>
<td>-0.20</td>
<td>4.63</td>
</tr>
<tr>
<td></td>
<td>(+0.71)</td>
<td></td>
<td>(+0.16)</td>
<td>(+3.52)</td>
</tr>
<tr>
<td>5.</td>
<td>-1.39</td>
<td></td>
<td>0.20</td>
<td>-2.10</td>
</tr>
<tr>
<td></td>
<td>(+0.88)</td>
<td></td>
<td>(+0.47)</td>
<td>(+8.52)</td>
</tr>
<tr>
<td>6.</td>
<td>0.10**</td>
<td></td>
<td>-0.20</td>
<td>5.78*</td>
</tr>
<tr>
<td></td>
<td>(+0.03)</td>
<td></td>
<td>(+0.12)</td>
<td>(+2.84)</td>
</tr>
</tbody>
</table>

(continued)
TABLE 16—Continued

<table>
<thead>
<tr>
<th>Dry Period</th>
<th>SP</th>
<th>√SP</th>
<th>DP</th>
<th>√DP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.+2.+3.</td>
<td>-1.08**</td>
<td>35.66**</td>
<td>1.17</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>(+0.33)</td>
<td>(+9.84)</td>
<td>(+0.63)</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>-0.85</td>
<td>25.32</td>
<td>-1.74</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>(+0.59)</td>
<td>(+15.73)</td>
<td>(+2.48)</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>-0.75*</td>
<td>25.56**</td>
<td>3.41*</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>(+0.31)</td>
<td>(+8.77)</td>
<td>(+1.65)</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>-0.73**</td>
<td>26.07**</td>
<td>0.10</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>(+0.27)</td>
<td>(+7.50)</td>
<td>(+0.10)</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>-0.11</td>
<td>8.72</td>
<td>-0.02</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>(+0.18)</td>
<td>(+5.04)</td>
<td>(+0.05)</td>
<td></td>
</tr>
</tbody>
</table>

*, **Denote significance at the 5 per cent and 1 per cent level, respectively.

# This function of the variable was not used.
variable, and for the partial regressions on dry period, to elimi­
nate the square root of dry period as a variable. All $R^2$ values were
again determined and they agreed with those in Table 11 previously
discussed.

As an example, suppose that the herd-year-season milk pro­
duction average is 9000 pounds and the means for service period ($X_1$)
is 155 days and dry period ($X_2$) is 64 days. The estimate of $Y$ is
expressed as follows:

$$Y = 9000 - 13.5 X_1 + 525.6 \sqrt{X_1} - 8.2 X_2 + 207.7 \sqrt{X_2}$$

If one takes service periods of 64 and 164 days, holding dry period
constant, the equation estimates that there will be about 1170 pounds
difference in the 305-day milk production in favor of the longer
service period.

Holding the service period constant and comparing zero days
dry with 49 days dry, the equation estimates that there will be over
1050 lbs. of milk difference in favor of the adequate dry period.
If this is compared with longer dry periods there is very little to
be gained. Figures 6 and 7 show these calculations graphically. Note
the flatness of the regression curve beyond 50 days, for dry period.
Service period, however, seems to show a more linear relationship
with milk production. This may not be the true relationship because
if one examines the partial regression value in Table 15 for service
period 6 (140+ days) the value is only +2.6 and is highly significant.
Likewise by examining the partial regression value (Table 15) for
dry period 1 + 2 + 3 (0-29 days) the value is +43.1 and highly
significant and much larger than the values for dry period 6 or 7.
Milk - Pounds

\[ Y = 9000 - 13.5X + 525.6 \sqrt{X} \]

Fig. 6 -- Example of Regression of 305 Day Milk on Service Period with Dry Period Constant, for all Lactations - (1933 Lactations)
Fig. 7 -- Example of Regression of 305 Day Milk on Dry Period with Service Period Constant, for all Lactations - (1933 Lactations)
Even though the evidence is inconclusive it appears that there is little to be gained with service periods over 140 days in length and dry periods over 50 days in length. The data were insufficient to show service period relationships under 140 days with production when broken down by the intervals used.

Standard partial regression coefficients are presented in Tables 17 and 18 for the regression of milk and fat on service period, dry period and the function of their square roots respectively. These values for all lactations indicate that service period may be more important in determining milk and butterfat production than dry period.
Table 17

Standard Partial Regression Coefficients for the Regression of Milk on Service Period, Dry Period and the Function of Their Square Root

<table>
<thead>
<tr>
<th></th>
<th>SP</th>
<th>√SP</th>
<th>DP</th>
<th>√DP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b'</td>
<td>b'</td>
<td>b'</td>
<td>b'</td>
</tr>
<tr>
<td><strong>All Lactations</strong></td>
<td>-0.60</td>
<td>0.83</td>
<td>-0.19</td>
<td>0.23</td>
</tr>
<tr>
<td><strong>Fat Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>-0.45</td>
<td>0.50</td>
<td>-0.08</td>
<td>0.17</td>
</tr>
<tr>
<td>Medium</td>
<td>-0.65</td>
<td>0.79</td>
<td>-0.17</td>
<td>0.20</td>
</tr>
<tr>
<td>High</td>
<td>-0.16</td>
<td>0.38</td>
<td>-0.18</td>
<td>0.24</td>
</tr>
<tr>
<td><strong>Service Period</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. (Insufficient data)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>-0.01</td>
<td></td>
<td>-0.55</td>
<td>0.62</td>
</tr>
<tr>
<td>3.</td>
<td>0.08</td>
<td></td>
<td>-0.46</td>
<td>0.51</td>
</tr>
<tr>
<td>4.</td>
<td>-0.11</td>
<td></td>
<td>-0.23</td>
<td>0.30</td>
</tr>
<tr>
<td>5.</td>
<td>-0.15</td>
<td></td>
<td>-0.04</td>
<td>0.07</td>
</tr>
<tr>
<td>6.</td>
<td>0.12</td>
<td></td>
<td>-0.24</td>
<td>0.26</td>
</tr>
<tr>
<td><strong>Dry Period</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.+2.+3.</td>
<td>-1.66</td>
<td>1.81</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>-1.15</td>
<td>1.30</td>
<td>-0.09</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>-1.00</td>
<td>1.18</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>-0.85</td>
<td>1.10</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>-0.23</td>
<td>0.49</td>
<td>-0.03</td>
<td></td>
</tr>
</tbody>
</table>

#This function of the variable was not used.
TABLE 18

STANDARD PARTIAL REGRESSION COEFFICIENTS FOR THE REGRESSION OF FAT ON SERVICE PERIOD, DRY PERIOD AND THE FUNCTION OF THEIR SQUARE ROOT

<table>
<thead>
<tr>
<th></th>
<th>SP</th>
<th>√SP</th>
<th>DP</th>
<th>√DP</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Lactations</td>
<td>-0.54</td>
<td>0.75</td>
<td>-0.12</td>
<td>0.17</td>
</tr>
<tr>
<td>Fat Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>-0.41</td>
<td>0.40</td>
<td>-0.24</td>
<td>0.30</td>
</tr>
<tr>
<td>Medium</td>
<td>-0.43</td>
<td>0.53</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>High</td>
<td>-0.17</td>
<td>0.38</td>
<td>-0.12</td>
<td>0.17</td>
</tr>
<tr>
<td>Service Period</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. (Insufficient data)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>0.02</td>
<td>. .</td>
<td>-0.40</td>
<td>0.49</td>
</tr>
<tr>
<td>3.</td>
<td>0.06</td>
<td>. .</td>
<td>-0.28</td>
<td>0.31</td>
</tr>
<tr>
<td>4.</td>
<td>-0.10</td>
<td>. .</td>
<td>-0.18</td>
<td>0.19</td>
</tr>
<tr>
<td>5.</td>
<td>-0.13</td>
<td>. .</td>
<td>0.11</td>
<td>-0.06</td>
</tr>
<tr>
<td>6.</td>
<td>0.12</td>
<td>. .</td>
<td>-0.15</td>
<td>0.19</td>
</tr>
<tr>
<td>Dry Period</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.+2.+3.</td>
<td>-1.41</td>
<td>1.58</td>
<td>0.14</td>
<td>. .</td>
</tr>
<tr>
<td>4.</td>
<td>-0.86</td>
<td>0.96</td>
<td>-0.07</td>
<td>. .</td>
</tr>
<tr>
<td>5.</td>
<td>-0.96</td>
<td>1.15</td>
<td>0.14</td>
<td>. .</td>
</tr>
<tr>
<td>6.</td>
<td>-0.85</td>
<td>1.09</td>
<td>0.06</td>
<td>. .</td>
</tr>
<tr>
<td>7.</td>
<td>-0.13</td>
<td>0.37</td>
<td>-0.01</td>
<td>. .</td>
</tr>
</tbody>
</table>

# This function of the variable was not used.
SUMMARY AND CONCLUSIONS

This study was undertaken to try to clarify some of the environmental factors affecting records, specifically, service period and dry period. This kind of information is important to dairymen, and artificial breeding associations so that husbandry practices can be adjusted to take advantage of optimum conditions. It is also very important in the evaluation of lactation records to measure a cow's or sire's breeding value. One should know what the environmental effects are, if it is necessary to adjust records for them, and how much these adjustments should be.

Records on 812 cows with 2764 lactation records located in three Ohio institutional herds were utilized in this study. Without modern electronic data processing machines such studies as this are next to impossible.

The literature seems to contain a lack of continuity pertaining to this problem. Service period or days open are easily understood as being a term for one and the same thing. Such terms as the effect of gestation, the effect of days-carried-calf while in milk, and the effect of calving interval on production are all terms defining a single cause, and the same cause of variation in milk production as days open or service period. The literature is not clear on this and papers dealing with one term most frequently cite only references carrying a similar descriptive term. It is also somewhat
difficult to convert such information as specific quantitative decreases in production with an increase in days carried calf, to make it comparable to a finding about calving interval effect or service period effect. It would seem helpful if a standard measure of the effect of gestation on 150 and 305 day production could be derived so that direct comparisons between different research studies dealing with this problem could be made. It would seem logical that the measure best adapted to the modern centrally processed lactation records would be the service period or days carried calf while in milk because this information would be available at the completion of the 305 day record.

One phase of this study dealt with the effect of dry period on the lactations studied, its relation to service period, and its effect on lactations at different levels of production. No doubt the magnitude of its effect will be influenced by the condition of the cow at the beginning of the dry period and by the feeding practices during the dry period but that was not a part of this study. The correlation of service period and dry period was found to be .04 or essentially zero.

This study indicates that the relationship between dry period and 305-day milk and fat production is probably linear up to about 50 days and then also linear beyond this point but the magnitude of the regression coefficients are decidedly different. It appears from these data that there is little to be gained with dry period over 50 days in length. Increasing the previous dry period from 50 to 100 days would only result in about 200 additional pounds of milk for the 305-day lactation. Adequate dry periods seem to be
more important at higher levels of production as judged by the magnitude of the partial regression coefficients and standard partial regression coefficients. The maximum effect of length of dry period on production in the herds studied was about 1300 pounds of milk for a five month dry period, compared with no dry period but the first 50 days dry would increase production 1050 pounds of milk. If this is a true estimate of the magnitude of the effect of dry period it is equally as large as season of freshening and year of freshening and should be considered in the evaluation of records. Nineteen per cent of the dry periods studied were less than 40 days.

The other phase of this study dealt with service period and its effect on 305-day lactation records. It was relatively more important than dry period in its effect on production as indicated by simple correlations, partial regression coefficients and standard partial regression coefficients. Service periods averaged 155 ± 85 days. The regression equation estimated that lengthening the service period by 100 days with 64 days as a standard would result in about 1170 pounds more milk in favor of the longer service period based on all lactations. In breaking up the service periods into intervals, service period 6 (140+ days) gave a regression value for milk on service period of only +2.6 which was highly significant. This would indicate there is little to be gained by service periods over 140 days and that the service period effect on milk and fat production is probably curvilinear up to about 140 days, then becomes essentially linear. Relatively then, service period and dry period might be considered of about equal importance under practical
conditions in influencing milk production. The influence of service period is prevalent for a longer period of time, for example (0 to 140 days) compared with dry period (0-50 days).

In summary, these within-herd-year-season analyses indicate service period to account for much more of the variation of milk and fat than dry period but in relative terms they seem to be of about equal practical importance. Differences of the magnitude found on 305-day lactation records are of sufficient magnitude to be of economic importance and also of sufficient size to materially influence the estimated breeding value of cows, and daughter production levels of sires.

Baldwin, C. and Fechheimer, N. Year and Seasonal Variations in Butterfat Production in Ohio. Unpublished data.


Matson, J. The Effect on Lactation of the Preceding Calving Interval and its Relation to Milking Capacity, to Age, and to Other Factors of Influence. J. Agric. Sci. 15:553. 1929.


Sanders, H. G. The Variation in Milk Yields Caused by Season of the Year, Service, Age and Dry Period and Their Elimination. J. Agric. Sci. 18:209. 1928.


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Production by Year and Month of Freshening for States. USDA-ARS 44-82, September 1960.
I, Robert Wilber Spalding, was born May 27, 1920 at St. James, Missouri, and was reared on a general farm in the central part of Missouri and received my secondary-school education in this area.

I entered the University of Missouri in the fall of 1939 and worked my way through college with employment in the Department of Dairy Husbandry. During the summer of 1941, I worked at the Hatch Dairy Experimental Farm, Hannibal, Missouri, and in 1942 I was a member of the University dairy cattle judging team. In 1943 I received my B. S. in Agriculture.

I volunteered for the Navy in 1943 and went through midshipman school in New York, served in the U. S. Navy for three years as an antisubmarine and radar officer, and was discharged in February, 1946, to the inactive reserve with the rank of Lieutenant.

While doing graduate work at the University of Missouri, I assisted with the teaching of the elementary courses in dairy husbandry, including work in artificial breeding, production testing, feeding and management. For my Master's degree, I made an analysis of 50 years of breeding records on the University of Missouri dairy herd.

I was employed by the Department of Animal Husbandry, Cornell University, in 1947 and have remained in this position where I am now an Associate Professor, doing general dairy extension work with major
emphasis on dairy cattle breeding. In 1957-58 I served 18 months on
the staff at the College of Agriculture, University of the Philippines,
as a part of the International Cooperation Administration Program.

The requirements for my Ph.D. have been achieved while on two
sabbatical leaves and other leaves from my place of employment.