SOME FACTORS ASSOCIATED WITH THE
ESTRUS CYCLE OF THE DAIRY COW

by

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INTRODUCTION

Estrus, or period of heat, is a normal function of the dairy cow. However, much is still unknown about its effects even though it occurs regularly in all non-pregnant cows in a dairy herd, and in some gravid cows.

An efficient farmer's dairy cow, as far as reproduction is concerned, is one that calves for the first time at about two years of age and then drops a calf every 12 months. Although there are breed differences, by using an average 283-day gestation length, it can be seen that in order to bear a calf every year the cow must conceive within 82 days of parturition. Thus, if estrus does not occur until after 82 days, or if it does occur but with an abnormal cycle, the cow is not utilizing her reproductive powers to the fullest because she will not drop a calf every 12 months. Breeding efficiency is lowered when the post-partum to first estrus period is too long (Chapman and Casida, 6).

In order to obtain a calving interval of 12 months it is imperative that cows return to breeding condition as soon as possible after freshening. In beef cattle herds this interval must be regulated to manage the herd for the maximum fertility and production (Warnick, 35). Regulation is possible only if some of the variables controlling or affecting the post-partum period are known.

Another factor concerned with the estrus period is milk production on the day of heat. The fact that a cow gives more or less milk on any given day is of small importance to most dairymen. But, if she varies her milk flow on test day the dairyman is concerned. Therefore, it is important for him to know if production is altered when a cow is in heat.

REVIEW OF LITERATURE

Although various studies have been made, both in this country and abroad, researchers working with different breeds, in different climates, and in different seasons do not agree very closely as to the average span of time from parturition to the first estrus, or to the effects of estrus on milk production.

Days Post-partum to First Estrus

Evidence points to a great deal of variability in the period from calving to first estrus. Casida and Venzke (5) found that the average interval from freshening until the uterus involuted was 26.2 $\pm$ 1.0 days; until follicular development started, was 28.8 $\pm$ 1.3 days; and until the first estrus period and ovulation, was 40.7 $\pm$ 2.1 days.

After investigating 968 normal calvings by 347 dairy cows, Herman and Edmondson (17) reported an average of 57 days to be the length of time from parturition to first heat, with a standard deviation of 28 days. Fifty-nine per cent of the cows came into heat within 60 days after calving. Thirty per cent showed heat for the first time during the next 30 day period, 7.6 per cent in the next 30 days, and 3.4 per cent after 120 days.

Studying the efficiency of natural breeding in dairy cattle, Olds, Morrison, and Seath (24) determined 30 days to be about the interval to first estrus, with a range in 480 calvings of 1 to 190 days. During the first six weeks following freshening, 81 per cent of the cows came in heat for the first time.

Branton, _et al_. (2), said the days to first heat following parturition in a dairy herd were 57, with a range of 2 to 120 days and with a standard deviation of 27 days.

Time to post-partum estrus is an experimental herd of 322 Holstein-Friesian cows was found to average 33 days by Buch, Tyler, and Casida (3).

Olds and Seath (25) studied 472 normal parturitions of 210 cows. They found the average interval from freshening to first estrus to be 32.1 ± 18.6 days, and concluded this interval influences reproductive efficiency.

Time from parturition to first heat in 179 normal cows was reported to be 69 days by Chapman and Casida (6). The standard deviation was 39 days. In this work they agree with other workers that a cow to be efficient must have a fairly short period following post-partum to first heat.

Working with two Holstein-Friesian herds in Iowa, the Iowa State College herd, and the State Board of Control herd, Carman (4) was able to utilize relatively larger numbers of cows and records than other workers. He studied in both herds, the records of 763 cows with 1646 gestations. Although both herds were of the same breed and located in the same general locality, great variation in days fresh to first heat was apparent. He lists an average of 55.4 ± 1.1 days for the Iowa State College and an average of 71.0 ± 1.8 days for the State Board of Control herd. Standard deviations were 30 and 50 days, respectively.

As a comparison, the work of Warnick (35) with beef cattle can be cited. He found that 97 Hereford cows had a post-partum to first heat interval of 62.7 days and 54 Aberdeen-Angus cows, 59.2 days.

Also in beef cattle, Lasley and Bogart (21) observed 711 intervals ranging from 1 to 200 days. They report the mean interval length to be 80.2 ± 1.30 days. They considered this interval to be extremely long, and to have undesirable economic implications to the farmer.

Trimberger (33) randomly selected 400 cows, which were separated into control and experimental groups. Days after calving to first apparent estrus in the experimental group was 49.4 days, while the time to first heat as actually determined from palpation of ovaries was only 43.7 days. The control group averaged 50.9 days.

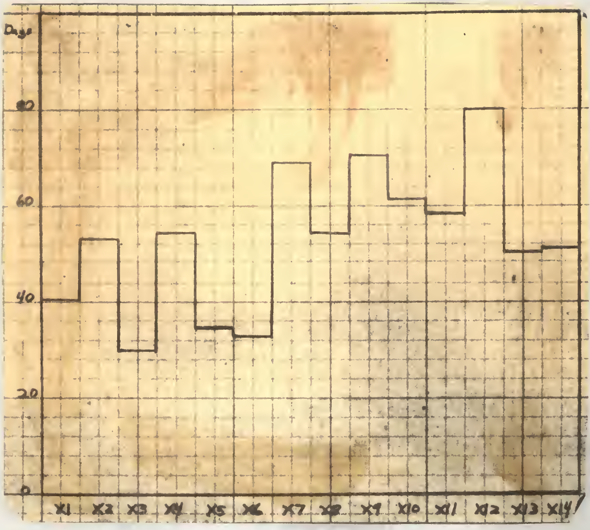
He reported that 30 per cent of the cows came in heat during the first 30 days, following calving, 51.5 per cent during the next 30 days, 15.5 per cent during the next 30 day period, and the remaining 3 per cent after 90 days. Cumulatively, 81.5 per cent had exhibited estrus by 60 days and 97 per cent by 90 days.

Figure 1 shows the wide variation in means of days from calving to first heat obtained by different workers.

Herman and Edmondson (17) found no relation between season of the year and the interval from parturition to estrus. Warnick (35) reported that in beef cattle there was a difference in the interval between cows calving during the first half of a season and the last half.

Buch, Tyler, and Casida (3) present data showing a significant difference between cows calving in different seasons. They list the interval for winter as 38 days; spring, 32 days; summer, 28 days; and fall, 32 days. Thus, they concluded, cows calving in summer tended to come in heat earlier than in other seasons, with winter freshers having the longest interval.

Also believing that there are seasonal differences is Carman (4). In his study, cows calving in March averaged 74 days until the first heat period as compared with a September average of 51 days. He says these data support the theory that the breeding behavior of the dairy cow is influenced by hours of daylight, because the optimum breeding period appeared to be at that time of



WORKERS

X1 Casida and Venzke (5)
X2 Herman and Edmondson (17)
X3 Olds, Morrison, and Seath (24)
X4 Branton, et al. (2)
X5 Buch, Tyler, and Casida (3)
X6 Olds and Seath (25)
X7 Chapman and Casida (6)
X8 Carman, Herd 1 (4)
X9 Carman, Herd 2
X10 Warnick, Breed 1 (35)
X11 Warnick, Breed 2
X12 Lasly and Bogart (21)
X13 Trimberger, Experimental Group (33)
X14 Trimberger, Control Group

Fig. 1. Average number of days after freshening to first estrus as reported by various workers.

year when daylight hours are becoming fewer and the main summer heat is diminishing.

Warnick (35) found a highly significant difference in the interval from freshening to first heat due to different years. He presented no explanation for this. Carman (4), on the other hand, decided that year, parity, and age differences accounted for only a small part of the total breeding efficiency variance.

In his work with beef cattle, Warnick (35) found no apparent trend associated with age. Buch, Tyler, and Casida (3) agree with this. They found no significant differences between parity groups or the interaction between parity and season.

However, Hammond, and Sanders (15) are in disagreement. They found that the interval from parturition to first estrus became shorter until after a cow's third or fourth calf. Then the interval began to increase again, until after the sixth or seventh calf it became longer than after the initial freshening. They say, "This curve probably represents the vigor or 'curve of life' of the cow. Before the third lactation the full reproductive activities of the animal are curtailed by co-incident growth, and after this time senile decay gradually begins."

At a later date, Herman and Edmondson (17) concluded that age of the cow is a factor influencing the interval from calving to heat. For the time between freshening to first heat they list the following intervals: first-calf, 63 days; second-calf, 53 days; third-calf, 55 days; fourth-calf, 50 days; and fifth-calf, 60 days. They state that the dairy cow is in her prime at her third or fourth lactation as far as reproduction is concerned.

Warnick (35) found a difference in days fresh to first heat between

Hereford cows calving with bull and heifer calves. Those dropping bull calves averaged 61.5 days and while cows with heifer calves averaged 61.0 days to first estrus. This was not a significant difference.

Casida and Venzke (5) reported that when follicular development during the post-partum period started in the opposite ovary from the one that contained the pregnancy corpus, the interval from calving until a half-mature follicle in size was produced was 8.1 $\pm$ 2.5 days shorter than when development started in the ovary containing the corpus luteum of pregnancy.

Olds, Morrison, and Seath (24), found an indication that cows coming in heat within 18 days or less of freshening were likely to be started on an abnormal estrus cycle.

Branton, _et al_. (2) reported that there is little correlation between milk production and days fresh to first heat period. Herman and Edmondson (17) arrived at the same answer. They said the average daily milk production for the entire lactation, and also the average daily milk production in the interval between calving and heat did not appear to affect the length of the interval. However, even though it had no marked effect, they found a slight tendency for the interval to be increased in some of the higher yielding cows in their study.

Carman (4) reported, though, that the period between calving and first estrus is correlated with the level of production in the previous lactation. Correlation of milk yield with the interval was carried out by Mares, Menge, and Tyler (22). After all records were adjusted for parity and season it was found that the correlation was 0.29 ($P < 0.05$) for inbred cows and 0.09 for outbred cows. Butterfat percentage was not found to be related to post-partum interval.

Olds and Seath (25) cite a correlation between milk production for the first 120 days (ME 4% F.C.M.) and the interval from parturition to heat as 0.095 ($P < 0.05$). They indicate that for each additional 1,000 pounds of 4 per cent F.C.M. produced during the first 120 days of lactation, a period of about 1.5 days is added to the interval.

There appears to be a tendency for a cow to have a characteristic interval after calving before coming into heat, according to Casida and Venzke (5).

Analysis of variance is shown by Olds and Seath (25) to demonstrate that there is significantly more variation among cows than within records of the same cow. This, they say, indicated that individual cows had a tendency to repeat a similar length of time between calving and first heat in successive calvings. For single records of the same cow they found repeatability to be 29 per cent.

Chapman and Casida (6) agree that a cow tends to repeat a similar interval from freshening to estrus in different lactations, although they present no supporting data. Warnick (35) reported that in beef cattle the repeatability of three records was -4 per cent; two records, 14 per cent; and a combined, 16 per cent.

Working with two herds of Holstein-Friesian cattle in Iowa, Carman (4) estimated repeatability to be 15 per cent in one herd and 27 per cent in the other.

Carman (4), also estimated heritability to be -6 per cent ± 11 per cent in one herd and -3 per cent ± 18 per cent in the second. The doubled intrasire regression of offspring on dam within herd method of estimating heritability was used. He comments that if repeatability and heritability are really as low as his estimates seem to show, selection for breeding efficiency can not be too effective. He concludes that it would be better to select for other economic traits for which repeatability and heritability are a good deal higher.

Olds and Seath (25) calculated an estimated heritability for days post-partum to first estrus, too. Using the method of intra-sire regression of daughter on dam with only the first available records for each animal, they obtained a value of 27 per cent. When all records were used, the heritability estimate was 32 per cent. This, it must be remembered, is the same method used by Carman, who found a much smaller value.

Using the paternal half-sib method of estimating heritability, they found heritability was too small to be measured when based on single records, but when all records were used it gave an estimate of 31 per cent. The estimates reported by Olds and Seath seem to be in direct conflict with Carman's estimates. If the heritability of the interval is really 30 per cent or greater, it can be selected for with at least the same effectiveness as milk production, if desired.

Effect of the Estrus Period on Milk Production

The concensus among dairymen, according to Smith (31), is that there is, although temporary, a decline in milk production on the day of heat. Research workers are divided in opinion. Most believe estrus causes a drop in milk production, while others say there is little or no lessening of milk flow. Most workers qualify their conclusions by stating that the drop is at most inconsequential.

Even the basic texts used in the elementary dairy technology course and elements of dairying course at Kansas State University tend to hedge on the question of estrus lowering milk yield. Olson (26) stated in his text that the quantity and composition of milk may be affected during heat due to physiological changes.

Herrington (18) said in his text that light exercise often stimulates milk production without a large change in butterfat percentage. But he added that heavy exercise may cause a decrease in milk flow. He also said it is not possible to predict changes in milk yield when a cow is excited. He speculated that if the hormone inducing estrus passes into the milk, then the milk from a "contented cow," or one not in heat, might be better for child feeding.

Schropp and Lohner (30) have observed that milk yield was depressed on the day of heat when compared with the mean production for several days or one day before and after estrus.

Polidori (28) agrees with this because he found milk production to be highest before heat and lowest during time of heat in a European herd of dairy cows. Production on the day or days after heat was midway between days before and day of estrus in his experiment using 13 cows.

The influence of estrus on milk yield was studied by Jordão and Assis (20). They utilized data from 400 heat periods of 195 Holstein-Friesian cows in South America. Their records showed production for seven days in the estrus cycle of a cow, three days before, day of heat, and three days after. They found milk production dropped an average of 5.4 per cent on the day of estrus. By the seventh day, though, production had climbed back to almost the same level as the first three days.

McCandlish (23) reported that individual cows showed wide differences in production during heat. He said, "It is generally believed that estrum or the period of heat has a depressing influence on the production of dairy cows. However, there is little direct evidence by which the validity of this can be tested." He compared production on the three days preceding heat, the day of heat, and the three days following heat in 868 cases.

He concluded that there is a decrease in milk production on the day of estrus, which he called the day of breeding, and the day afterward. However, according to his conclusions, an apparently compensating increase took place two days before estrus so that the average weekly production was not affected. If cows were tested for D.H.I.A. purposes on the day of heat they probably would not be credited for the actual amount of milk produced during the testing period. McCandlish believes one possible explanation of this phenomenon is the increased production of some galactogenic hormone.

Using 2,025 Jersey records in an extensive test of the effect of estrus on milk production, Copeland (7) reported that the effect is really quite limited. He said the reason most dairymen think estrus lowers milk yield is because they observe only a limited number of cows, and probably remember best the notable exceptions.

In 211 comparisons he found 75 cows increased and 131 cows decreased milk yield. The average variation in milk during heat as compared to two days before and two days after heat was 1.67 pounds. The standard deviation was 2.354 $\pm$ 0.077 pounds. The variation was less than two pounds for three-quarters of the cows. On all tests the average decrease in milk on the day of heat was 0.63 pound. For 112 of the cows, milk production for the two days before heat was greater than for the two days after heat. In the 99 other instances production was higher on the two days following heat. For 136 of the cows the differences in yields between the two two-day periods were less than three pounds.

Copeland concluded that most cows tend to decline slightly in milk yield during heat, but individual cows may vary in either direction, or not at all. He did not find the same compensating increase in milk production prior to estrus that McCandlish (23) did.

Hooper and Bacon (19) concluded that no very decided fluctuations in milk flow occurred during heat. In their test with 29 cows, they found yield to be down an average of one-and-a-half pounds on the day of heat. But some cows increased in production and several were not affected. They summed up by saying the amount of milk produced on the day of heat is usually about the same as on other days.

An extremely detailed and comprehensive study of the effect of estrus on milk yield was made by Erb, et al. (12). They studied 80 estrus periods of 19 Holstein-Friesian cows which were observed for milk flow from eight days before until 11 days after heat. To sum up their conclusions it can be said that although production during estrus may decline slightly, the milk flow two days before and two to three days after heat was generally higher than for any other time during the estrus cycle. A sharper decline on the day of heat occurred when cows had been milking for over 100 days, with an even longer lactation making this decline more apparent. Thus, an illusion of a marked drop in milk flow may be given. They indicated that testing cows, especially cows lactating less than 100 days, on day of heat may be advantageous to the cows. Production records based on one test per month may be too high for cows tested around the time of heat, rather than too low they said.

Erb, et al. (12) also found that the fat test was higher for the five day period centered around the time of heat than for any other period of the estrus cycle, regardless of laction length.

Czako and Guba (8) using Hungarian Spotted cows in 100 tests, showed that estrus had no consistent, predictable effect on butterfat percentage. The conclusion they gave was that the results of fat tests on milk production in estrus should not be used in official butterfat recording.

Doane (10) said none of the cows in his test showed a fat test lower than normal during time of estrus.

In 211 tests, Copeland (17) reported that the butterfat test was up in 126 cases and down in 81 instances. The average variation was 0.43 per cent and the average increase was 0.13 per cent with a standard deviation of 0.449 ± 0.015 per cent. Butterfat test was found to be in the same pattern in 13 cows by Polidori (28), too. No uniform influence of estrus on butterfat test was reported by Patow (27). Although the butterfat test most frequently rose, it sometimes declined or remained unchanged. The absolute variation was -1.36 to +1.98 per cent.

Olson (26) said that when milk yield is greatly reduced, the fat test is usually affected too. Compared with the means of several days before or afterward, the butterfat percentage was either not affected or very slightly increased in a study by Schropp and Lohner (30).

Herrington (18) said that when a cow is excited her fat test may go either up or down. Generally, he said, when milk production goes up, fat test will go down, and vice versa.

Smith (31) believes that the increased activity usually accompanying estrus may affect the quality of the milk, too. From his data and chemical analysis, Doane (10) reported that milk from cows in heat is in a practically normal condition, and is fit for human consumption. He analyzed milk from five cows in heat and compared it with "normal" milk.

Polidori (28), found total solids percentage to be lowest on the day of heat. He noted very little difference in percentage of ash, and little variation in pH, specific gravity, protein, lactose, and iodine value.

Eckles (11) doubts if any harmful effects could result from using milk obtained during estrus. He, too, said that unusual excitement may change milk composition, and so agreed with other workers. But, he added that the heat period is not an unnatural or abnormal thing, and so should be classed as a normal function of the dairy cow.

Erb, et al. (12) reported on many effects of estrus. They concluded that the age of the cow appears to be far less important as a source of variation than stage of lactation. Cows milked twice a day demonstrated more variability in milk production, but less variability in yield of F.C.M., butterfat, and fat test than did cows milked three times a day. They observed no major breed differences. They summed up a portion of their research by saying that age, month, and length of estrus cycle appeared to have little consistent effect on patterns of milk production during the estrus cycle.

Beach (1) made the general statement that there is sufficient evidence that gonadal hormones exert specific and powerful effects upon sexual behavior in all mammalian forms. The female's period of receptivity occur when mature follicles are present and the estrogen level is high.

That cows in heat mount others more frequently than was thought before is pointed out by De Alba and Asdell (9). They say mounting is common in the cow, where it is a manifestation of intense heat. They theorize that mounting is so frequent because the less intense reactions are realized at a very low hormonal level, or in other words, the cow has a lower estrogen threshold.

They said length of heat is restricted to a certain period of time even though estrogen is injected into the cow for several days, due to an "estrous block" which restricts the period of heat.

The cow also shows the phenomena of heat when she mounts other cows when she herself is not in heat. The effects of this have not been studied by any workers, although injuries can be assumed to happen.

That a cow's temperament can also account for individual differences in the effects of heat can be gleaned from the work of Hall (14). He has said that such traits as timidity, sexuality, aggressiveness, spontaneity, speed of reaction, variability, and activity are all examples of temperamental traits.

Farris (13) has demonstrated that a cow is much more active during estrus than at any other time in her estrus cycle. Studying the pedometer readings of 13 cows, he found less activity as compared to the mean of the cycle in activity the day before heat, an extreme increase the day of estrus, and another reduction in activity the day after heat below the mean of the cycle. Clinical signs of heat usually coincided within one day of the increase in estrus activity.

Tummon (34) points out that cows should be brought into the milking yard with as little running and excitement as possible. "Dogging and the use of whips should be avoided." He found these practices resulted in a lower yield of milk.

Milk production can decrease in a herd by as much as five per cent when a new cow is introduced into it (16). The excitement, butting, and kicking, all make production suffer. It can be speculated then if this excitement causes a lowered milk yield on a herd basis, then a cow in heat could also affect a milking herd in the same manner. Hooper and Bacon (19) add that sensitive or nervous cows are greatly affected by the estrus period.

EXPERIMENTAL PROCEDURE

Data for this study were taken from the Kansas State University dairy herdbook and the daily dairy barn milk sheets. The herdbook provides, on all cows, complete records concerning date of calving, age of cow, and estrus periods. Milk is weighed after each twice-daily milking and is entered in the milk records to the tenth of a pound.

Due to limited facilities cows that come in heat are allowed to run with the rest of the herd all day if they are not bred. Cows to be bred are kept in stanchions until artificially inseminated, then turned out. During particularly bad weather in winter, some cows may be kept in the barn in stanchions most of the day.

Days Post-partum to First Estrus

Every previous calving date and initial heat period after freshening was noted for every cow, now living, of the four dairy breeds milked at the University from 1952 to 1960. Data were recorded for 91 parturitions by 52 Holstein cows, 50 parturitions by 25 Ayrshire cows, 45 parturitions by 24 Guernsey cows, 36 parturitions by 21 Jersey cows, and 222 parturitions by the 122 cows of the four combined breeds.

The data were then divided into groups for comparison by breed, parity, season, and year. From the analyses of variance repeatability estimates for days post-partum to first heat were calculated for parities, breeds, and all combined breeds. Analysis of variance was used to find the variance ratio of the interactions of season and parity in the Holstein-Friesian breed. The same method was used to find the interactions of breed, season, and parity in the combined Holstein-Friesian, Guernsey, and Jersey breeds. To test the equality of the means, the F test as outlined by Snedecor (32) was used.

Effect of the Estrus Period on Milk Production

Milk production on the day before heat, the day of heat, and the day after heat was noted for every heat period in the life of the 38 Holstein-Friesian cows in the herd. Covering the years 1954 until the early part of 1960, 325 estrus periods were recorded for the 38 cows. This was an average of 8.55 heats noted for each cow. Broken down as to parity, there were 129 heats of first-calf heifers, 63 heats of second-calf cows, 78 heats of third-calf cows, 37 heats of fourth-calf cows, and 18 heats for cows calving with their fifth-or-sixth calf.

The data were broken down into groups by parity, season, year, stage of lactation, and production class. Stage of lactation was further divided into all heats in the time period from parturition to 60 days, and all heats after 60 days post-partum. Production class was broken down into five classifications of daily milk yield: 0 to 14 pounds, Class 1; 15 to 29 pounds, Class 2; 30 to 44 pounds, Class 3; 45 to 59 pounds, Class 4; and 60 pounds and over, Class 5.

The effect of heat on daily milk production was measured by an approximate non-parametric ranking method. The daily production records of each cow on the day before heat, day of heat, and day after heat were ranked in order from greatest to least. There are six different ways in which these three days of production might be ranked. These rankings and the identifying letter assigned to each are shown in Table 1. If there were no change in production associated with heat, each of the six different rankings should occur with equal frequency, providing, of course, that the well-known trends in production from parturition to drying-off are of little importance in so short a time span as three days.

Table 1. The six different ways in which production on the day before heat, day of heat, and day after heat can be ranked with the assigned identifying letter.

Day before estrus	Day of estrus	Day after estrus	Classification
1	2	3	A
1	3	2	B
2	1	3	C
2	3	1	D
3	1	2	E
3	2	1	F

The chi-square table in Snedecor (32) was used.

RESULTS

Days Post-partum to First Estrus

The mean number of days after freshening to first estrus, cows per breed, standard deviation, and coefficient of variation for the four breeds studied are listed in Table 2.

The means range all the way from 29.8 for the Guernsey breed, to 48.6 in the Holstein-Friesian breed, with the all-breed mean being 43.3. Probably a truer picture is presented by the Holstein-Friesian breed which has the greatest numbers.

Two things seem to be apparent from Table 2. First, there appears to be a difference in breeds as to how soon a cow returns to breeding activity after parturition. Second, there is much variation within a breed as can be seen from the standard deviations, and especially, the coefficients of variation.

From these data it would seem that the dairyman would have little chance to estimate when a cow would "come in" heat for the first time after calving. Taking the four breeds observed into consideration, it would seem that about

Table 2. Days post-partum to first estrus in Kansas State University cows.

Breed	Cows	Days post-partum to first estrus: Mean Days	Standard deviation Days	Coefficient of variation
Holstein	91	48.6	30.1	62.0
Ayrshire	50	45.8	25.2	55.0
Guernsey	45	29.8	16.7	56.0
Jersey	36	43.5	22.1	50.8
All breeds	222	43.3	26.4	60.8

half the cows in a mixed herd would exhibit their first post-partum estrus within six weeks of freshening and the other half of the cows after six weeks.

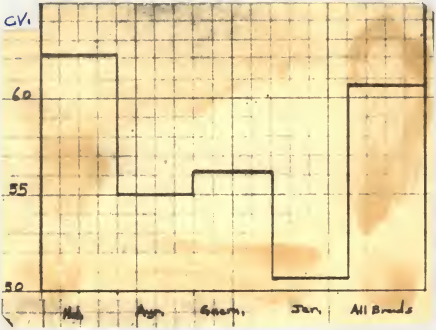


Fig. 2. Coefficients of variation by breed days post-partum to first estrus in the Kansas State University cows studied.

Table 3 illustrates the percentage of cows of all breeds that came in heat during various periods of time after calving. In this study, the range in days fresh to first heat was 6 to 159 days. As shown in Table 3, the greatest percentage of cows came in heat within a period of 30 to 60 days after freshening.

The second greatest percentage of cows came in heat before 30 days.

Table 3. Days fresh to first estrus in the 222 cows of all breeds studied.

Days post-partum to first estrus	Number of cows	Percentage of cows	Cumulative percentage of cows
0-30 days	83	37.4	37.4
30-60 days	92	41.4	78.8
60-90 days	32	14.4	93.2
90-120 days	12	5.4	98.6
> 120 days	3	1.4	100.0

Cumulatively, three-quarters of the cows had had an estrus period within 60 days of parturition. Approximately seven per cent had not yet come in heat after 90 days. These cows would lengthen their calving interval, and would be less efficient reproductively.

This raises the annual cost per cow, and the cost per calf.

Within a time period of one week before and one week after the mean of 43 days after calving, 17.6 per cent of the cows came into heat.

Table 4 shows the effect of parity on days fresh to first estrus. Again there seems to be a good deal of variation. When checking the listing for all breeds against that of any single breed, it must be remembered that the Holstein-Friesian breed makes up almost 41 per cent of the total, and so unduly influences it.

Some of the variation can be explained by pointing out that certain breeds were lacking in numbers in certain seasons of the year, and, as will be shown later, season of the year affects days post-partum to first estrus. However, in the analysis of data on three of the four breeds, it was shown that parity does have some effect on the time of the first post-partum estrus.

A more graphic and easily understood presentation of the effect of parity on the first estrus after parturition is given in Figure 3.

Table 4. Effect of parity on days fresh to first estrus.

Breed	Parity number												All parities	
	1		2		3		4		5		6			
	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
All breeds	98	40.2	54	48.8	34	41.6	18	44.9	11	44.3	5	50.2	222	43.3
Holstein	39	40.0	22	60.4	16	48.1	8	59.2	4	53.0	2	39.5	91	48.6
Ayrshire	23	47.0	11	51.1	5	44.6	4	24.0	3	36.7	2	67.5	50	45.8
Guernsey	21	33.0	12	23.1	7	26.8	3	45.0	2	23.5	—	—	45	29.8
Jersey	15	40.6	9	52.2	6	39.0	3	34.3	2	59.0	1	37.0	36	43.5

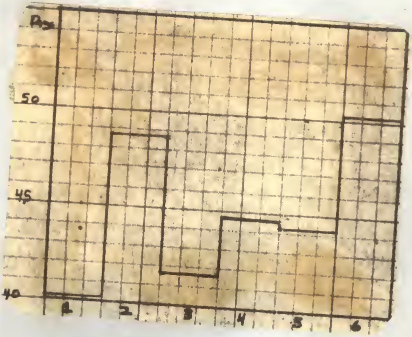


Fig. 3. Effect of parity on the days post-partum to first estrus in the four breeds studied.

Table 5 lists the number of cows and mean days to first estrus by breed and season. The totals and means for all seasons are also shown for three breeds: Holstein-Friesian, Guernsey, and Jersey; analysis of variance showed that there was an effect of season on days after calving to first estrus. However, for the Holstein-Friesian breed alone there was no indication of a significant effect of season.

From the table itself, it would appear that, with the exception of the Guernseys, in general the interval from parturition to first heat is longer in the spring and summer, and shorter in fall and winter.

In this study the months March through August comprised spring and summer, and the months September through February made up fall and winter.

Table 5. Effect of season of year on days fresh to first estrus.

Breed	Days fresh to first estrus									
	Winter		Spring		Summer		Fall		All seasons	
	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
All breeds	54	39.8	56	49.9	41	50.7	71	36.6	222	43.3
Holstein	25	44.6	18	57.0	22	57.4	26	39.2	91	48.6
Ayrshire	6	37.3	13	49.6	15	43.2	16	48.3	50	45.8
Guernsey	10	38.6	12	34.8	2	29.5	21	22.7	45	29.8
Jersey	13	32.5	13	54.2	2	54.5	8	41.2	36	43.5

A more diagramatic presentation of the effect of season of the year on days fresh to first estrus is shown in Figure 4.

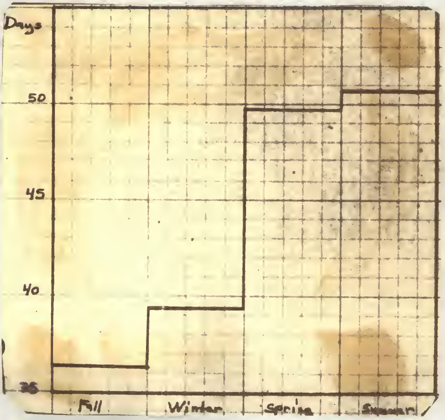


Fig. 4. Effect of season of year on the interval from parturition to first estrus in the four breeds observed.

In Table 6 are listed the effects of years on days fresh to first estrus period. For the numbers observed the period from calving to first heat seems to be a fairly consistent from one year to the next. Variations could be explained by general weather conditions and management differences.

In Table 7 the effect of season and parity on days after calving to first estrus in all four breeds studied is given. There was no difference in the response of cows of different parity to differences in season.

Table 6. Effect of year on days fresh to first estrus.

Breed	Days fresh to first estrus																			
	1960*		1959		1958		1957		1956		1955		1954		1953		1952		All years	
	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
All breeds	13	33.9	77	44.9	52	42.1	35	42.1	24	42.8	13	45.4	5	43.0	3	42.0	—	—	222	43.3
Holstein	7	31.3	24	48.5	21	54.0	17	46.9	13	51.5	6	53.8	2	41.0	1	34.0	—	—	91	48.6
Ayrshire	2	41.5	22	47.4	12	36.5	5	60.6	3	37.0	3	54.3	2	52.0	—	—	1	44.0	50	45.8
Guernsey	2	37.0	18	32.7	11	25.9	7	33.3	5	23.4	2	20.5	—	—	—	—	—	—	45	29.8
Jersey	2	32.5	13	50.6	8	54.4	6	23.5	3	42.7	2	31.5	1	29.0	1	48.0	—	—	36	43.5

*Includes only winter.

Table 7. Effect of season and parity on days post-partum to first estrus on all four breeds.

	Days post-partum to first estrus							
	Winter		Spring		Summer		Fall	
Parity	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
1	28	35.9	20	49.2	12	38.2	40	39.4
2	10	47.7	16	56.5	12	56.9	16	35.9
3	8	29.2	12	41.3	7	64.3	7	33.6
4	4	69.2	5	50.8	4	31.5	5	30.2
5	2	40.5	1	79.0	5	53.0	3	20.7
6	2	39.5	2	38.0	1	96.0	—	—

Table 8 lists the effect of year and parity on days fresh to first estrus in all four breeds studied. Due to insufficient numbers in certain years and several parity classes, no analysis of variance was run. However, when compared with Table 6 there does appear to be more variation within parity groups than for the breed or breeds as a whole.

According to Table 9, an analysis of variance of the mean days post-partum to first estrus in the Holstein-Friesian breed, there was no significant differences in season, parity, or the interaction of season and parity.

Table 9. Analysis of variance of Holstein-Friesian means, days fresh to first estrus.

	d.f.	S.S.	M.S.	F value
Season	3	1,292.17	430.72	2.15
Parity	3	1,224.04	408.01	2.04
Season X parity	9	2,283.22	253.69	1.27
Total	15	4,799.43	—	—
Error	75	59,904.00	—	—

n_0 = 3.9924

Error term = 200.06

Table 8. Effect of year and parity on days fresh to first estrus in all breeds.

	Days fresh to first estrus																	
	1960*		1959		1958		1957		1956		1955		1954		1953		1952	
Parity	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
1	8	33.0	34	40.7	22	36.3	10	43.6	13	40.5	6	49.0	4	48.0	2	41.0	1	44.0
2	2	33.5	18	51.0	9	63.6	12	45.6	6	39.0	6	46.0	1	23.0	—	—	—	—
3	1	31.0	10	41.9	10	41.8	8	38.1	4	55.5	1	20.0	—	—	—	—	—	—
4	—	—	6	59.5	7	41.3	4	29.8	1	43.0	—	—	—	—	—	—	—	—
5	—	—	7	34.3	3	60.0	2	40.0	—	—	—	—	—	—	—	—	—	—
6	2	39.5	2	66.5	1	39.0	—	—	—	—	—	—	—	—	—	—	—	—

*Includes only winter.

When the mean number of days to first estrus in the Holstein-Friesian, Guernsey, and Jersey breeds were subjected to analysis of variance, as shown in Table 10, it was discovered that the effect of season and the effect of parity are significant at the 0.05 level of probability.

Table 10. Analysis of variance of means, days fresh to first estrus, for Holstein-Friesian, Guernsey, and Jersey breeds.

	d.f.	S.S.	M.S.	F value
Breeds	2	954.93	477.47	2.03
Seasons	1	999.98	999.98	4.24 ($P < 0.05$)
Parity	3	2,328.04	776.01	3.29 ($P < 0.05$)
Breed X season	2	579.66	289.83	1.23
Breed X parity	6	1,420.03	236.67	1.00
Season X parity	3	302.04	100.68	.43
Breed X season X parity	6	435.95	72.66	.31
Total	23	7,020.63	---	---
Error	67	38,624.5	576.48	---

$n_0 = 2.4462$
Error term = 235.66

An estimate of the repeatability of days fresh to first estrus was made between parity groups, among breeds, and pooled for an estimate for all breeds and parities. As is shown in Table 11, for some unaccountable reason the estimate of repeatability, with the exception of the Guernsey breed, was highest between the second and third parities. According to the table the Guernsey breed, in general, had the highest estimate of repeatability.

The pooled repeatability estimate for the four breeds was 2.7 per cent.

Effect of the Estrus Period on Milk Production

As can be seen from the following tables, no significant results were obtained in the chi-square tests. From this we can assume that estrus does

Table 11. Estimate of repeatability on days fresh to first estrus.

Breed	Number of cows	Parity	Repeatability (Per cent)
Holstein	52	Pooled	0
	22	1 & 2	0
	16	2 & 3	12.5
	8	3 & 4	0
	4	4 & 5	4.8
	2	5 & 6	0
Ayrshire	25	Pooled	19.8
	11	1 & 2	0
	5	2 & 3	77.8
	4	3 & 4	0
	3	4 & 5	75.0
	1	5 & 6	0
	1	6 & 7	0
Guernsey	24	Pooled	31.0
	12	1 & 2	11.1
	7	2 & 3	0
	3	3 & 4	53.3
	2	4 & 5	77.4
Jersey	21	Pooled	26.5
	9	1 & 2	0
	6	2 & 3	82.2
	3	3 & 4	0
	2	4 & 5	63.2
	1	5 & 6	0
All breeds	122	Pooled	2.7

not materially affect milk production.

Although nonsignificant, it is evident in Table 12 that there is a slight tendency for milk production to be highest the day before heat and lowest on the day of estrus. If not due to "chance" variation, this could be caused by hormonal action.

Table 12. Number of times milk flow was in a certain yield class for three days centered around estrus.

Milk yield	Day before estrus	Estrus	Day after estrus
1. Highest	110	101	104
2. Medium	101	107	107
3. Lowest	104	117	104

Table 13 indicates that there is no effect of parity on milk production during estrus. Third and fourth-calf cows came closest to being significantly different in production.

When all 325 estrus periods were considered, it was found that production was not statistically altered by the occurence of heat.

Table 13. Effect of parity on milk production during estrus.

Parity	X^2(5d.f.)	Ranking A	B	C	D	E	F	Total
1	2.77 ($P < .75$)	21	18	25	23	17	25	129
2	1.67 ($P < .90$)	10	12	7	11	11	12	63
3	6.63 ($P < .25$)	10	19	17	10	9	13	78
4	7.27 ($P < .25$)	4	8	2	10	8	5	37
5 and over	2.67 ($P < .75$)	4	4	4	2	1	3	18
Total	2.93 ($P < .75$)	49	61	55	56	46	58	325

As Table 14 illustrates, no significant differences were found when the effect of production class on milk production during estrus was considered.

This would mean that a cow gives essentially the same amount of milk during her heat period as during the rest of her estrus cycle, and that the amount of milk she usually gives does not affect her milk yield on day of heat.

Table 14. Effect of production class on milk production during estrus.

Production class lb/milk/day	X^2(5d.f.)	Ranking A	B	C	D	E	F	Total
0-14	I.N.*	0	1	0	0	0	0	1
15-29	4.50 ($P < .50$)	5	11	9	11	5	9	50
30-44	4.08 ($P < .75$)	25	28	23	24	16	28	144
45-59	0.58 ($P < .99$)	15	18	16	17	18	15	99
> 60	2.85 ($P < .75$)	4	3	7	4	7	6	31

*I.N. = Insufficient numbers.

As can be seen from Table 15, there were no significant differences in milk production during estrus due to stage of lactation. However, there was an indication that production was higher, proportionally, on the day of heat when the cow had been in lactation fewer than 60 days, than when she had been milking longer than 60 days.

Table 15. Effect of stage of lactation on milk production during estrus.

Days fresh	X^2(5d.f.)	Ranking A	B	C	D	E	F	Total
< 60	5.66 ($P < .50$)	17	8	16	11	18	12	82
> 60	8.23 ($P < .25$)	32	52	39	46	31	43	243

There was no significant differences in milk production during estrus due to season of year. Production during estrus may be affected by the fall season, but this is doubtful.

Table 16. Effect of season on milk production during estrus.

Season	X^2(5d.f.)	Ranking A	B	C	D	E	F	Total
Winter	2.89 ($P < .75$)	15	20	20	15	14	13	97
Spring	2.17 ($P < .90$)	10	13	8	13	14	12	70
Summer	2.95 ($P < .75$)	9	15	11	16	14	11	76
Fall	6.55 ($P < .50$)	15	13	16	12	6	18	80

No single year seemed to have any significant effect on estrus milk yield, as shown in Table 17.

Table 17. Effect of year on milk production during estrus.

Year	X^2(5d.f.)	Ranking A	B	C	D	E	F	Total
1960*	5.50 ($P < .50$)	7	3	9	6	4	3	32
1959	5.42 ($P < .50$)	16	27	23	17	14	20	118
1958	1.81 ($P < .90$)	8	10	9	12	12	13	64
1957	5.98 ($P < .50$)	5	8	2	9	4	4	32
1956	2.67 ($P < .75$)	7	7	9	5	8	11	47
1955	2.20 ($P < .90$)	4	4	3	5	2	2	20
1954	3.00 ($P < .75$)	2	1	1	2	4	2	12

*Only winter is included.

DISCUSSION

Days Post-partum to First Estrus

Studying 222 instances of initial heat after parturition in four dairy breeds, it was found that the mean number of days for all breeds was 43.3, with a standard deviation of 26.4 days, a coefficient of variation of 60.8, and a range of 6 to 159 days.

These figures are in general agreement with most of the sources itemized in the review of literature, where means ranged from 32 to 82.2 days, and standard deviations from 27 to 50 days.

No coefficients of variation were given by any of the sources, but for comparison coefficients of variation have been computed from the data they listed. Coefficients of variation are for: Herman and Edmondson (17) 49.1, Branton, et al. (2) 47.4, Carman's (4) first herd 54.1, Carman's second herd 70.4, and Chapman and Casida (6) 56.5. Coefficients of variation ranged in this study from 50.8 to 62.0, and so would seem to be in agreement with other work.

Means vary among different herds as a result of different breeds and environmental conditions. The means obtained in this study were toward the lower end of the range when compared with the other works, yet were still in close harmony with other means.

There seemed to be a breed difference in the time a cow took from parturition to first heat. Also, there was a great deal of variation within a breed. Olds and Seath (25) found much variation among cows, too.

In the data presented here, 37.4 per cent of the cows had come in heat within 30 days of calving, 41.4 per cent after 30 to 60 days, 14.4 per cent after 60 to 90 days, 5.4 per cent after 90 to 120 days, and 1.4 per cent after 120 days.

Cumulatively, 37.4 per cent had exhibited heat by 30 days, 78.8 per cent by 60 days, and 93 per cent by 90 days. This compares closely with work done by Trimberger (33), who found 30 per cent of the cows came in heat by 30 days, 81.5 per cent by 60 days, and 97 per cent by 90 days.

Herman and Edmondson (17) reported that 59 per cent of the cows they worked with showed estrus within 60 days of parturition, 30 per cent more by 90 days, 7.6 per cent more by 120 days, and 3.4 per cent more after that time.

On the whole, cows in this study tended to be slightly slower in showing estrus after freshening than Trimberger's work indicated, and slightly quicker than the results obtained by Herman and Edmondson.

Carman (4) concluded that parity and age differences are responsible for only a small part of variations found in the period post-partum to heat. Warnick (35), and Buch, Tyler, and Casida (3) agree with this finding.

Hammond and Sanders (15) and Herman and Edmondson (17) however, are in disagreement with this statement. This study tends to side with the last two reports. A great deal of variation was found, but it did seem that parity had some effect on the length of the period from calving to heat.

Season, too, appeared to affect the interval from freshening to estrus, with the interval being longer in spring and summer, and shorter in fall and winter. Herman and Edmondson (17) could find no effect of season of year on the time from calving to estrus.

Buch, Tyler, and Casida (3) showed a significant difference between cows calving in different seasons. So did Carman (4). He stated the theory that the length of daylight hours influences breeding behavior.

Although in agreement that there is a seasonal effect, the results from this work are in active discord with the latter two workers as to which seasons have the longest and shortest intervals.

Carman (4) thought years had little effect on the time from parturition to estrus. On the other hand, Warnick (35) demonstrated an effect due to years, but did not elaborate. In this study, although some variation was found, the interval from calving to heat appeared to be about the same year after year.

Estimates of repeatability calculated in this work agreed best with the results reported by Warnick (35) in beef cattle. He found the repeatability estimate of three records to be -4 per cent; two records, 14 per cent; and combined estimate, 16 per cent.

Estimates of repeatability in this study tended to vary by parity and by breed from 0 to 31 per cent. The pooled estimate for all breeds was 2.7 per cent. Olds and Seath (25), reported a repeatability of 29 per cent for single records. Working with two herds, Carman (4) estimated it to be 15 per cent and 27 per cent.

Effect of the Estrus Period on Milk Production

There appeared to be a slight tendency for milk yield to be highest the day before heat and lowest on the day of heat in this work, when the three days centered on day of heat only are considered, although it was not statistically significant. Estrus did not seem to affect milk production substantially though. This is in general agreement with conclusions drawn by Schropp and Lohner (30), Polidori (28), Jordão and Assis (20), McCandlish (23), Copeland (7), Hooper and Bacon (19), and Erb, et al. (12).

Erb, et al. (12) reported that the age of the cow and month of estrus cause less variation in milk flow on day of heat than does stage of lactation. They found that cows declined more in production on that day if they had been lactating over 100 days. No effects of parity or season were found in this study either. Also in agreement with the above cited work was the fact that, although nonsignificant, cows milking less than 60 days tended to produce more on the day of heat, and to drop more after 60 days of lactation.

SUMMARY

A study was made of the interval from parturition to subsequent first estrus in a herd composed of four breeds of dairy cows. Also studied was the effect of estrus on milk production in the Holstein-Friesian breed. Data were obtained from a reliable herdbook and daily milk records.

The results of the study on days post-partum to first heat generally agreed with previous work. Including all four breeds, the mean was 43.3 days; the standard deviation, 26.4 days; the coefficient of variation, 60.8 days; and the range, 6 to 159 days.

Most cows came in heat within 30 to 60 days after freshening. Three-quarters of the cows exhibited estrus within 60 days of calving. It would seem that half the cows in a mixed herd come into heat within six weeks of parturition, and the other half after six weeks. After three months only seven per cent of the cows had not yet shown an estrus period.

Parity does seem to have some effect on the period from calving to estrus, although there is so much variation that the effect is not much.

The effect of season on days fresh to first heat appears to be substantial. On the average, the time from calving to first estrus is longer in the spring and summer, and shorter in fall and winter. This last finding disagrees with results reported by other workers.

There is little yearly effect on the post-partum to first heat period. Cows in this study were consistent from year to year.

Repeatability estimates were made between parity groups, among breeds, and pooled for all parities and breeds. As a breed, the Guernseys had the highest estimate, the Holstein-Friesians, the lowest. For the four breeds, the pooled estimate of repeatability was 2.7 per cent.

The effect of the estrus period on milk yield was shown to be extremely slight, in fact negligible. There was a nonsignificant tendency for production to be highest the day before heat and lowest the day of heat.

There was no detectable effect of parity, production class, season, or year on production during the three days centered on the day of heat.

Stage of lactation had no significant effect on production either, but it appeared that cows in lactation fewer than 60 days gave more milk the day of estrus, and that cows milking for more than 60 days had a reduced flow of milk on the day of heat.

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A P P E N D I C E S

Table 18. Effect of season and parity on days fresh to first estrus in Holsteins.

Parity	Days fresh to first estrus							
	Winter		Spring		Summer		Fall	
	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
1	10	39.4	9	54.2	6	27.2	14	36.7
2	6	51.7	5	63.8	8	67.9	3	52.3
3	4	30.0	3	42.7	4	81.5	5	39.2
4	2	85.0	1	91.0	2	45.0	3	41.0
5	1	42.0	—	—	2	70.5	1	29.0
6	—	—	—	—	—	—	2	39.5

Table 19. Effect of season and parity on days fresh to first estrus in Ayrshires.

Parity	Days fresh to first estrus							
	Winter		Spring		Summer		Fall	
	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
1	6	37.3	4	40.0	4	57.2	11	50.0
2	—	—	5	60.8	3	25.7	3	60.3
3	—	—	2	49.5	3	41.3	—	—
4	—	—	1	43.0	2	18.0	1	17.0
5	—	—	—	—	2	43.0	1	24.0
6	—	—	1	39.0	1	96.0	—	—

Table 20. Effect of season and parity on days fresh to first estrus in Guernseys.

Parity	Days fresh to first estrus							
	Winter		Spring		Summer		Fall	
	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
1	6	39.7	5	40.4	1	22.0	9	25.7
2	2	31.5	2	13.5	—	—	8	23.4
3	1	30.0	4	29.8	—	—	2	19.5
4	1	55.0	1	69.0	—	—	1	11.0
5	—	—	—	—	1	38.0	1	9.0
6	—	—	—	—	—	—	—	—

Table 21. Effect of season and parity on days fresh to first estrus in Jerseys.

Parity	Days fresh to first estrus							
	Winter		Spring		Summer		Fall	
	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
1	6	24.7	2	67.0	1	46.0	6	46.8
2	2	52.0	4	63.5	1	63.0	2	24.5
3	3	28.0	3	50.0	—	—	—	—
4	1	52.0	2	25.5	—	—	—	—
5	1	39.0	1	79.0	—	—	—	—
6	—	—	1	37.0	—	—	—	—

Table 22. Effect of year and parity on days fresh to first estrus in Holsteins.

	Days fresh to first estrus															
	1960*		1959		1958		1957		1956		1955		1954		1953	
Parity	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
1	3	29.0	11	32.4	7	38.8	5	49.4	7	45.4	3	54.0	2	41.0	1	34.0
2	1	22.0	5	66.2	4	88.8	6	46.0	3	61.3	3	53.7	—	—	—	—
3	1	31.0	3	53.0	6	40.7	3	56.0	3	56.0	—	—	—	—	—	—
4	—	—	3	82.3	2	60.5	3	35.3	—	—	—	—	—	—	—	—
5	—	—	2	35.5	2	70.5	—	—	—	—	—	—	—	—	—	—
6	2	39.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—

*Includes only winter.

Table 23. Effect of year and parity on days fresh to first estrus in Ayrshires.

	Days fresh to first estrus																	
	1960*		1959		1958		1957		1956		1955		1954		1953		1952	
Parity	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
1	2	41.2	11	49.2	7	35.9	1	35.0	1	38.0	1	91.0	1	81.0	—	—	1	44.0
2	—	—	6	49.2	1	34.0	1	28.0	1	30.0	1	52.0	1	23.0	—	—	—	—
3	—	—	1	51.0	1	79.0	2	36.5	—	—	1	20.0	—	—	—	—	—	—
4	—	—	1	17.0	2	18.0	—	—	1	43.0	—	—	—	—	—	—	—	—
5	—	—	2	21.5	—	—	1	67.0	—	—	—	—	—	—	—	—	—	—
6	—	—	1	96.0	1	39.0	—	—	—	—	—	—	—	—	—	—	—	—

*Includes only winter.

Table 24. Effect of year and parity on days fresh to first estrus in Guernseys.

Parity	Days fresh to first estrus											
	1960*		1959		1958		1957		1956		1955	
	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
1	2	37.0	7	38.6	5	20.8	2	53.5	3	32.3	2	20.5
2	—	—	5	27.2	2	24.0	3	24.3	2	10.0	—	—
3	—	—	3	27.0	2	27.0	2	26.5	—	—	—	—
4	—	—	1	55.0	2	40.0	—	—	—	—	—	—
5	—	—	2	26.5	—	—	—	—	—	—	—	—

*Includes only winter.

Table 25. Effect of year and parity on days fresh to first estrus in Jerseys.

Parity	Days fresh to first estrus															
	1960*		1959		1958		1957		1956		1955		1954		1953	
	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean	Cows	Mean
1	1	20.0	5	43.8	3	57.3	2	23.5	2	37.0	—	—	1	29.0	1	48.0
2	1	45.0	2	76.5	2	67.5	2	35.0	—	—	2	31.5	—	—	—	—
3	—	—	3	42.7	1	41.0	1	11.0	1	54.0	—	—	—	—	—	—
4	—	—	1	38.0	1	52.0	1	13.0	—	—	—	—	—	—	—	—
5	—	—	1	79.0	1	39.0	—	—	—	—	—	—	—	—	—	—
6	—	—	1	37.0	—	—	—	—	—	—	—	—	—	—	—	—

*Includes only winter.

Table 26. Effect of parity and production class on milk production during estrus.

Parity	X^2(5d.f.)	Production class	Ranking A	B	C	D	E	F	Total
1	I.N.*	1	—	—	—	—	—	—	—
	3.00 (P < 0.75)	2	3	6	5	6	2	5	27
	4.27 (P < 0.75)	3	14	10	16	11	9	17	77
	2.50 (P < 0.90)	4	4	2	4	5	6	3	24
	I.N.	5	—	—	—	1	—	—	1
	2.77 (P < 0.75)	Total	21	18	25	23	17	25	129
2	I.N.	1	—	—	—	—	—	—	—
	I.N.	2	1	2	1	2	—	—	6
	3.40 (P < 0.75)	3	4	1	2	4	5	4	20
	3.39 (P < 0.75)	4	4	8	3	4	3	5	27
	3.19 (P < 0.75)	5	1	1	1	1	3	3	10
	1.67 (P < 0.90)	Total	10	12	7	11	11	12	63
3	I.N.	1	—	—	—	—	—	—	—
	I.N.	2	1	2	2	1	—	2	8
	I.N.	3	4	9	5	4	—	5	27
	1.87 (P < 0.90)	4	4	7	6	4	8	5	35
	I.N.	5	1	1	4	—	1	1	8
	6.63 (P < 0.25)	Total	10	19	17	10	9	13	78
4	I.N.	1	—	1	—	—	—	—	1
	I.N.	2	—	—	1	2	3	2	8
	I.N.	3	2	6	—	4	2	2	16
	I.N.	4	1	—	—	2	1	—	8
	1.00 (P < 0.975)	5	1	1	1	2	2	1	8
	7.27 (P < 0.25)	Total	4	8	2	10	8	5	37

Table 26. (concl.)

Parity	X^2(5d.f.)	Production class	Ranking						Total
			A	B	C	D	E	F	
5 & above	I.N.	1	—	—	—	—	—	—	—
	I.N.	2	—	1	—	—	—	—	1
	I.N.	3	1	2	—	1	—	—	4
	I.N.	4	2	1	3	1	—	2	9
	I.N.	5	1	—	1	—	1	1	4
	2.67 ($P < 0.75$)	Total	4	4	4	2	1	3	18

*I.N. means insufficient numbers.

Table 27. Effect of parity and stage of lactation on milk production during estrus.

Parity	X^2(5d.f.)	Stage of lactation in days	Ranking						Total
			A	B	C	D	E	F	
1	6.91 ($P < 0.25$)	< 60	8	1	9	6	8	5	37
	2.44 ($P < 0.90$)	> 60	13	17	16	17	11	18	92
2	2.20 ($P < 0.90$)	< 60	3	3	1	2	4	2	15
	1.00 ($P < 0.975$)	> 60	7	9	6	9	8	9	48
3	3.00 ($P < 0.75$)	< 60	3	3	3	2	3	3	17
	7.93 ($P < 0.25$)	> 60	7	16	14	8	6	10	61
4	0.71 ($P < 0.99$)	< 60	1	1	1	1	2	1	7
	8.40 ($P < 0.25$)	> 60	3	7	1	9	6	4	30
5 & 6	I.N.*	< 60	2	—	2	—	1	1	6
	I.N.	> 60	2	3	2	3	—	2	12

*I.N. means insufficient numbers.

Table 28. Effect of parity and season on milk production during estrus.

Parity	X^2(5d.f.)	Season	Ranking A	B	C	D	E	F	Total
1	2.93 ($P<0.75$)	W.	7	10	11	6	6	7	47
	1.60 ($P<0.90$)	Sp.	6	3	6	4	6	5	30
	4.96 ($P<0.50$)	Su.	2	3	2	7	4	5	23
	3.51 ($P<0.75$)	F.	6	2	6	6	3	6	29
2	1.40 ($P<0.95$)	W.	3	2	1	3	3	3	15
	I.N.*	Sp.	1	3	—	2	4	3	13
	2.76 ($P<0.75$)	Su.	3	4	3	5	3	1	19
	1.98 ($P<0.90$)	F.	3	3	3	1	2	4	16
3	4.01 ($P<0.75$)	W.	2	4	6	3	2	2	19
	2.14 ($P<0.90$)	Sp.	2	5	2	3	4	3	21
	6.01 ($P<0.50$)	Su.	2	5	5	1	1	3	17
	2.71 ($P<0.75$)	F.	4	5	4	3	1	4	21
4	I.N.	W.	1	2	—	2	2	—	7
	I.N.	Sp.	—	1	—	3	—	1	5
	6.49 ($P<0.50$)	Su.	2	3	1	3	6	1	16
	I.N.	F.	1	2	1	2	—	3	9
5 & 6	1.00 ($P<0.975$)	W.	2	2	2	1	1	1	9
	I.N.	Sp.	1	1	—	1	—	—	3
	I.N.	Su.	—	—	—	—	—	1	1
	I.N.	F.	1	1	2	—	—	1	5

*I.N. means insufficient numbers.

Table 29. Effect of parity and year on milk production during estrus.

Parity	X^2(5d.f.)	Year	Ranking A	B	C	D	E	F	Total
1	5.00 ($P<0.50$)	1960 W.	5	3	7	4	4	1	24
	4.63 ($P<0.50$)	1959	6	8	9	4	3	8	38
	8.60 ($P<0.25$)	1958	1	1	1	6	2	4	15
	I.N.*	1957	—	1	—	3	—	2	6
	3.09 ($P<0.75$)	1956	4	2	4	2	4	6	22
	I.N.	1955	3	2	3	2	2	—	12
	3.00 ($P<0.75$)	1954	2	1	1	2	4	2	12
2	I.N.	1960 W.	—	—	1	2	—	—	3
	1.20 ($P<0.95$)	1959	2	1	2	3	4	3	15
	I.N.	1958	4	3	1	—	4	2	14
	2.00 ($P<0.90$)	1957	3	3	1	2	2	1	12
	I.N.	1956	—	3	2	1	2	3	11
	I.N.	1955	1	2	—	3	—	2	8
	I.N.	1954	—	—	—	—	—	—	—
3	I.N.	1960 W.	—	—	—	—	—	1	1
	2.90 ($P<0.75$)	1959	5	10	8	6	5	6	40
	5.67 ($P<0.50$)	1958	1	5	5	2	1	4	18
	I.N.	1957	1	2	1	—	1	—	5
	0.52 ($P<0.995$)	1956	3	2	3	2	2	2	14
	I.N.	1955	—	—	—	—	—	—	—
	I.N.	1954	—	—	—	—	—	—	—
4	I.N.	1960 W.	1	—	—	—	—	—	1
	7.44 ($P<0.25$)	1959	1	6	2	2	1	2	14
	I.N.	1958	1	—	1	4	5	2	13
	I.N.	1957	1	2	—	4	1	1	9
	I.N.	1956	—	—	—	—	—	—	—
	I.N.	1955	—	—	—	—	—	—	—
	I.N.	1954	—	—	—	—	—	—	—

Table 29. (concl.)

Parity	X^2(5d.f.)	Year	Ranking A	B	C	D	E	F	Total
5 & 6	I.N.	1960 W.	1	—	1	—	—	1	3
	1.55 ($P < 0.95$)	1959	2	3	2	2	1	1	11
	I.N.	1958	1	1	1	—	—	1	4
	I.N.	1957	—	—	—	—	—	—	—
	I.N.	1956	—	—	—	—	—	—	—
	I.N.	1955	—	—	—	—	—	—	—
	I.N.	1954	—	—	—	—	—	—	—

*I.N. means insufficient numbers.

SOME FACTORS ASSOCIATED WITH THE
ESTRUS CYCLE OF THE DAIRY COW

by

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B. S., Kansas State University, 1959

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Estrus, or period of heat, is a normal function of the dairy cow. Although it is observed frequently in all open cows, much is still unknown about its effects or what influences it.

Breeding efficiency is lowered when the period from parturition to first estrus is too long. Therefore, it is necessary to know when dairy cows return to breeding condition. Farmers generally agree that cows in heat vary their milk flow from normal, yet previous research generally has shown the effects of estrus to be inconsequental.

Data studied were taken from the Kansas State University dairy herdbook, and daily milk record sheets. All living cows of the four dairy breeds kept by the University were studied, with the history of all calving dates and initial heat periods post-partum being recorded. The data were studied and compared by breed, parity, season, and year. Repeatability estimates were calculated. Milk production for the three days centered on day of heat was noted for every heat period in the life of the 38 Holstein-Friesian cows in the herd. The data were broken down into groups of parity, season, year, stage of lactation, and production class.

Mean days post-partum to first estrus ranged from 29.8 days in the Guernsey breed, to 48.6 in the Holstein-Friesian breed. The all-breed mean was 43.3 days, the standard deviation, 26.4 days, and the coefficient of variation, 60.8 days. There appeared to be a breed difference, with much variation within a breed. The range was 6 to 159 days.

The greatest percentage of cows exhibited estrus within a period of 30 to 60 days after parturition. The second greatest percentage came in heat before 30 days of lactation. Cumulatively, three-quarters of the cows had an estrus within 60 days of calving. After 90 days, approximately seven per cent had not yet had a heat period.

Although much variation was found, there appeared to be an influence on days after freshening to first heat due to parity and season. Longer intervals were found in spring and summer months, shorter intervals in fall and winter months. No effect due to years was found, the time from calving to first estrus being consistent from year to year.

Estimates of repeatability from one parity to the next ranged between breeds from 0 to 31 per cent. The pooled estimate for all four breeds was 2.7 per cent.

It was assumed that estrus either does not materially affect milk production, or the influence is negligible since no significant differences were found due to parity, production class, stage of lactation, season, or year.

However, although not significant, there was a slight tendency for milk production to be highest on the day before heat and lowest on the day of heat when the day before, the day of heat, and the day after were considered. If not due to random variation, this may have been due to hormonal actions.

Milk production on day of heat seemed to be higher in cows that had been lactating fewer than 60 days, and lower in cows in milk longer than 60 days. Although nonsignificant, this indication agrees with other reported work.