REPRODUCTION, MILK PRODUCTION, AND CULLING IN DAIRY COWS INSEMINATED AT FIRST ESTRUS AFTER 40 OR 60 DAYS POSTPARTUM

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ABSTRACT

REPRODUCTION, MILK PRODUCTION, AND CULLING IN DAIRY COWS INSEMINATED AT FIRST ESTRUS AFTER 40 OR 60 DAYS POSTPARTUM

By

David Seay Harrison

Cows in twelve cooperating dairy herds in south central Michigan were assigned to be bred at either first estrus after 40 days (Treatment I) or 60 days (Treatment II) postpartum. Cows clinically abnormal at parturition were assigned to be bred when diagnosed as normal by the herd veterinarian (Treatment III). Thirteen percent of the cows calving were assigned to Treatment III with retained placenta and uterine infection accounting for 68 percent of those assignments. Fewer cows in Treatment I were culled then in Treatments II and III. Low production was the greatest cause for culling in all groups. Sterility and inferitility was the second major cause.

Interestrual intervals and intervals between inseminations averaged 31 days for all cows, an indication that 50 percent of the expected estrous periods were not observed. Interval to first estrus was 58 days, and was not affected by treatments.

Cows assigned to Treatment I averaged 73 days to first insemination which was shorter than the 82 and 83

days for Treatments II and III, respectively. In eleven herds cows assigned to Treatment I had shorter intervals to first insemination than those assigned to Treatment II. All cows averaged 84 days to first insemination in 1972 which was the pretreatment control period. Treatment and herds within herd size significantly affected interval to first insemination as determined by least squares analysis.

Interval to conception was 99 days for cows in Treatment I which was less than 112 days for cows in Treatment III, but not different than 105 days for cows in Treatment II. These correspond to 12.5 to 13 month calving intervals. Only one herd achieved a twelve month calving interval, but ten herds had calving intervals shorter or similar to those for 1972. Therefore, breeding some cows early reduced overall days open. Interval to conception was affected by interval to first insemination and interval from first insemination to conception and their interactions with other reproductive measurements as determined by least squares analysis.

Intervals from first insemination to conception and inseminations per conception for cows were similar between treatments and years indicating no detrimental effects of early breeding. Least squares analysis revealed that interval to first insemination, interval to conception, and the interactions of 150 day milk yield with interval to first estrus and interval to conception significantly affected the interval from first insemination to conception.

Inseminations per conception were affected by housing type, interval to conception, and 150 day milk yield's interactions with interval to first insemination, interval from first insemination to conception, and interval to conception. Conception rate for all inseminations was 55 percent or above, and was not affected by treatments.

When the data were grouped by 20 day intervals to first insemination, ignoring treatments, a significant effect was noted for all intervals studied. As the interval to first insemination increased, there was an associated increase in interval to first estrus, and interval to conception, but a decrease in interval from first insemination to conception and inseminations per conception. However, cows first inseminated less than 40 days postpartum had more days open than cows first inseminated from 40-60 days postpartum, indicating that breeding before 40 days was undesirable.

No effects on milk yield per day for the first 180 days of lactation were observed for treatments or intervals to conception. Lactation curves for the first 180 days of lactation were not affected by treatments or intervals to conception. Least squares analysis of 150 day milk yields revealed significant treatment, and herds within herd size effects.

Season affected none of parameters measured. Age at calving affected only 150 day milk production. Herd variation existed for all parameters measured. At the end of the study, eleven of the cooperating dairymen planned to continue breeding some cows early, an indication that their participation in the study convinced them of the benefits of early breeding.

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INTRODUCTION

In today's highly competitive agriculture, every effort must be made to achieve the maximal and/or most efficient production from every farm enterprise. While the dairy industry is the most efficient producer of animal protein, there is at least one achievable, desirable characteristic of a dairy enterprise that is seldom realized. A twelve month calving interval for dairy cows is considered best for highest milk yield per day of production and most calves per lifetime. However, the average dairy herd calving interval in Michigan is 13 months. It appears that one of the causes (if not the main cause) for long calving intervals is the failure of dairymen to begin breeding their cows soon enough after parturition. In Michigan, the average interval from calving to first insemination for dairy cows is 94 days, but a cow must conceive again within 85 days to maintain 12 month calving intervals. While the recommended interval to first postpartum breeding is 60 days, various studies have concluded that, for normal cows, 40 days is an acceptable period to wait for postpartum breeding without resulting in increased reproductive problems.

Therefore, it was decided to compare in selected Michigan dairy herds the reproductive performance of cows that were bred either at first estrus after 40 or 60 days postpartum.

REVIEW OF LITERATURE

A dairy cow should have a twelve month or less calving interval to maximize milk and calves produced per lifetime (Speicher and Meadows, 1967; Louca and Legates, 1968). Cows that maintain twelve month calving intervals produce less milk in 305 day lactations than cows with longer calving intervals, but they yield more milk per day of calving interval and productive life because they produce at a higher level of milk production for a greater percentage of time (Olds and Seath, 1965). Cooper (1966) estimated that milk per day of calving interval would be 0.4 kg higher for each month calving interval is shortened to eleven months. Louca and Legates (1968) observed a decline of 3.6 kg of milk for each additional day open for second and third lactation cows. They also observed an increase of 1.16 kg of milk for each additional day open up to 120 days for first lactation cows. They attributed the difference to higher persistencies in first lactation cows. For optimal milk production they suggested the calving interval should be as short as possible for second and later lactation cows, and thirteen months for cows in first lactation. Data from the Milk Marketing Board (1968-69) indicated that optimal milk production actually occurred with a 350 day calving interval.

Speicher and Meadows (1967) reported that over a five year production span cows with twelve month calving intervals produced one more calf (4.9 vs 3.8) than cows that had fourteen month calving intervals.

Decreased possible incomes of $.50-1.00 per day of calving interval over twelve months are generally quoted (Speicher and Meadows, 1967; Louca and Legates, 1968; Olds, 1969). Britt (1975) adjusted prices used by Speicher and Meadows to 1974 prices and found a possible loss in potential income of $1.00-2.00 a day. Hafs et al. (1973) estimated a total yearly loss of over $500 million to the nation's dairymen due to sterility and infertility of dairy cows, and postulated that one-half of this loss could be avoided by proper management.

Several variables are involved in the actual achievement of a calving interval. Intervals from parturition to first ovulation, estrus, insemination, and conception are important factors. Ovulation is of primary importance, and is usually preceded by estrus. The dairyman (or bull) has to detect the cow in estrus for insemination to occur. Properly timed artificial or natural breeding with subsequent fertilization and normal gestation will result in a newborn calf in about 280 days.

Interval to First Ovulation and Estrus

Silent and non-standing estrus are common in the early postpartum period. Morrow *et al.* (1966) found the average interval from parturition to first silent or standing estrus to be fifteen days for normal cows. They reported a 79 percent incidence of silent estrus at first ovulation. Saiduddin *et al.* (1968) monitored 213 first postpartum ovulations of cows by weekly palpations and found that 46.5 percent of the cows ovulated without estrous activity, and of the 53.5 percent that ovulated with estrous activity 32.5 percent was of the non-standing type. Whitmore *et al.* (1974) compared two breeding intervals (bred at first estrus, and bred at first estrus after 74 days postpartum), 2 genetic levels of milk production (high and low), and 2 levels of nutrition (average and 150% average), and found that interval to first ovulation for all cows was approximately 30 days. They also found that interval to first estrus averaged 35 to 42 days among groups, and noted significantly shorter intervals for average nutrition, and low production groups compared with high nutrition, and high production groups. Thatcher and Wilcox (1972) reported an average interval to first estrus of 43 days for 577 cows in 1,398 postpartum intervals. They also reported that as the number of estrous periods before 60 days increased, inseminations required per conception declined. This effect appeared to be mostly due to the number of estrous periods prior to 30 days postpartum. A summary of six studies on interval to first ovulation, and 17 studies on interval to first estrus for dairy cows found average ranges of 20-45 days and 30-72 days postpartum, respectively (Wisconsin Research Bulletin 270, 1968). Pelissier (1972) reported that 42 percent of the cows in a California study had not been detected in estrus by 60 days postpartum, and that 12.5 percent had not been detected in estrus by 90 days postpartum.

Detection of Estrus

Failure of a cow to be detected in estrus can generally be attributed to physiological or managerial causes. Physiological causes include pyometra, ovarian follicular cysts, metritis, etc. (Pelissier, 1972). Silent and short estrous periods also occur, especially in the first few weeks postpartum (Morrow *et al*., 1966; Whitmore *et al*., 1974). However, Zemjanis (1969) proposed that 90 percent of anestrous cases are due to failure in observation of estrus (i.e., management). Hall *et al*. (1959) reported that 20 percent of the expected estrous periods were missed when cows were observed for estrus twice daily, but only 10 percent were missed when cows were observed four times daily. Hurnik *et al*. (1974) used a videorecorder and continuously monitored two groups of twelve Holstein cows for estrous behavior during a nine week period. They found that 75 percent of mounting activity occurred at night and they were able to detect

94 percent of the cows at their first estrus (second ovulation), and 100 percent at second estrus (third ovulation).

Interval to First Insemination

The interval from parturition to first insemination is one of the most important factors in determining calving interval length (Bozworth *et al*., 1972; Pelissier, 1972). Hafs *et al*. (1973), and others, recommended breeding at first estrus after 60 days. This is the current recommendation of most bull studs, universities, and dairymen. It is commonly believed that cows bred before 60 days postpartum have a greater incidence of abortions and infertility as reported by Hofstad (1941) in a study of five cows. Trimberger (1954) found that cows first bred at less than 50 days were open longer than cows first bred at 50-90 days due to repeat breeders, but he did not find an increased incidence of abortions, retained placenta, or uterine infections among the early bred cows. VanDemark and Salisbury (1950) recommended not to breed cows before 60-80 days postpartum, and considered the 101-120 day postpartum period as the time of maximum fertility because cows first bred at that period required fewer inseminations per conception and had higher percent conception at first insemination. Olds and Cooper (1970) and Whitmore *et al*. (1974) studied large numbers of cows and determined that there is not an increased occurrence of abortion, infertility, and delayed returns for cows bred before 60 days.

Pelissier (1972) found that 33 percent of the cows in 24 commercial California dairy herds had not received a first insemination by 90 days postpartum, the time they should have conceived to maintain 12 month calving intervals. Britt (1975) reported an average interval to first insemination of 94 days for cows on Michigan Dairy Herd Improvement Association (DHIA) test.

Fertility at First Insemination

Fertility at first insemination is lower in cows bred before 60 days postpartum than in cows bred after 60 days. Britt (1975) summarized data from seven studies on early postpartum breeding, and used unweighted means to calculate 20 day postpartum interval fertility levels. He concluded that fertility was lowest during the first 20 days postpartum, and increased to 60 days postpartum where it stabilized at about 60 percent. He further concluded that a 10 percent rise in fertility occurred from 50 to 60 days postpartum. Olds and Cooper (1970) and Whitmore *et al*. (1974) found that by third insemination fertility was just as high in early bred cows as in later bred cows. A cow should conceive by 85-90 days postpartum to maintain a 12 month calving interval. Beginning breeding at 40 days would give one more chance for conception before 90 days. Olds and Cooper (1970) concluded that "to advise against breeding at less than 60 days is to remove the most effective means available to a dairyman for shortening calving intervals."

Inseminations per Conception

Several investigators have found that as interval to first insemination increases, number of inseminations required per conception decreases, at least up to 100 days postpartum. Olds and Cooper (1970) found a decrease from 1.83 inseminations per conception for cows first bred at 1-20 days postpartum to 1.37 inseminations per conception for cows bred first at 91-100 days after calving. VanDemark and Salisbury (1950) found 2.86 and 1.88 inseminations per conception for similar periods. Whitmore et al. (1974) compared animals bred at first estrus ($\bar{X}$=39 days) with those bred at first estrus after 74 days and found that 2.2 and 1.6 inseminations per conception were required for each group, respectively. The Milk Marketing Board Annual Report (1968-69) used interval to first insemination and probability of conceiving at that and succeeding inseminations as variables and calculated 2.0 inseminations per conception for cows first bred at 11-31 days postpartum, and 1.46 inseminations per conception for cows first bred at 95-115 days postpartum. Studies involving over 12,000 cows in Israel averaged 1.73 inseminations per conception for cows first bred at an average of 48 days (bred at less than 60 days) postpartum, and 1.55 for cows first bred at an average of 81 days (bred after 60 days; Hasherut A. I.

Annual Report, 1971-72). From 1969 to 1972 the percentage of cows first bred before 60 days in the Israeli study has changed from 24 to 60 percent, practical evidence that early breeding is an acceptable management practice.

Interval from First Insemination to Conception

Olds *et al*. (1966) reported that 60 percent of the variation in length of calving interval was due to variation in the period from first insemination to conception. They considered returns to insemination of 26 days or longer as delayed returned, and attributed 29 percent of the variance in delayed returns to difference among herds. Olds (1969) reported that 45 percent of all returns are delayed returns, and that 16.7 percent of all returns occurred more than 60 days post-breeding. He estimated that 20 percent of delayed returns could be prevented by better management. Hall *et al*. (1959) reported that 69 percent of the cycles they observed were in the normal 16-24 day range. Pelissier (1970) estimated that one in six estrous periods was missed after first estrus was recorded. Olds (1969) summarized three studies on one cause of delayed returns, embryonic death, and concluded that 28.5 percent of delayed returns are due to embryonic death. Lassiter and Seath (1955) attributed a 5-6 percent loss of pregnancy to abortion, another cause of delayed returns. Another seeming cause of delayed returns, post-conception estrus, occurred in 14 percent of the cows observed by Hall *et al*. (1959).

Calving Interval

While a twelve month calving interval is the goal of dairymen, it frequently is not achieved. Pelissier (1972) reported an average calving interval of 13.5 months for cows in the United States enrolled in the DHIA programs. Others have reported average calving intervals of about thirteen months (Legates, 1954; Everett et al., 1966; Norman and Thoele, 1967; Miller et al., 1967; Olds and Cooper, 1970). Studies in Michigan reported by Britt (1975) showed that the average calving interval for Holstein cows enrolled in DHIA was also about thirteen months. Spike (1973) studied Michigan herds on DHIA from 1953-1970 and found the average calving interval to be 395 ± 77 days.

Cows with Postpartum Disorders

Admittedly not all cows have returned to a clinically normal reproductive state by forty days postpartum. Cows that had dystocia, twins, and uterine infections at parturition, or retained placenta, metritis and other reproductive problems afterwards were considered abnormal by Morrow et al. (1966). They found that abnormal cows had a significantly longer interval to first estrus, interval to conception, and required more inseminations per conception than normal cows (cows without reproductive problems), and recommended an interval to first insemination for abnormal cows of 75-90 days postpartum. Ayalon et al. (1971) and Hasherut A.I. Annual Report (1971-72) studied herds in Israel and recommended an interval to first insemination of 61-75 days for abnormal cows. All of these investigators stressed that abnormal cows be treated for their reproductive problems.

Season

Several investigators have studied the effect of season, light, and temperature upon reproductive performance. Gwazdauskas et al. (1975) reported an extensive study of variables associated with seasonal effects. They used twenty-one climatological measurements for least squares analysis of reproductive fertility. They analyzed 5,062 services that occurred within an eleven year period in the Florida Agricultural Experiment Station dairy herd. The five most important measures were: (1) maximum temperature day after insemination, (2) rainfall day of insemination, (3) minimum temperature day of insemination, (4) solar radiation day of insemination, and (5) minimum temperature day after insemination. They also observed higher conception rates (40.1 vs 33.7%) in cool months (November through May) than hot months (June through October).

Records that covered a twenty year period at the Purdue University herd were analyzed by Erb (1940). He found considerable seasonal variation in percent conception per month, the highest being May (74.3%) and the lowest in August (58.2%). Hall et al. (1959) found that duration of estrus was significantly shorter in April and May than in September and December, but they did not attribute this difference to a seasonal pattern. Stott (1961) analyzed data that covered a ten year period in Arizona, and found a significant difference in fertility among months. The biggest decline occurred from June to July with a subsequent similar rise in September to October, and another decline in early winter. In a North Carolina study, Britt and Ulberg (1970) found the lowest percentage of a herd conceived in July and August, and the highest percent conceived in March and April.

Carman (1955) studied two herds for a ten year period and found that cows that calved in March took significantly longer to come into estrus than cows that calved in September. He found no difference in time to first insemination and inseminations per conception, however. In a California study that covered a ten year period and included over 10,000 records, Armstrong (1964) found no significant difference among months for breeding efficiency, interval to first estrus, interval from first insemination to conception, and days open. Morrow et al. (1966) reported a nonsignificant influence of season on interval to first estrus, but did find a significantly higher incidence of cystic corpora lutea in August to January than February to July, and more ovarian follicular cysts in November to January. In an Israeli study, Ayalon et al. (1971) reported a nonsignificant effect of season on fertility at different first insemination intervals. Spike (1973) noted that cows that calved in the winter and spring had longer calving intervals than cows that calved in the summer and fall. He attributed part of this difference to dairymen who attempted to have cows at peak lactation during the base price period.

Level of Milk Production

Milk production levels have also been investigated as to their effect on reproduction. Marion and Gier (1968) found an effect of milk production on interval from parturition to first ovulation and estrus. They reported intervals of 13.1, 14.0, and 15.5 days to first ovulation for cows that produced less than 22, 22-30, and over 30 kg milk per day, respectively, and reported 28.4, 33.1, and 36.9 days to first estrus for the three groups. Carman (1955) found that interval from parturition to conception increased as production increased, however, he found that days to first insemination had no relation to milk production level. Cows that produced over 7270 kg had a higher number of ovulations without standing estrus, longer calving intervals, and more inseminations per conception than cows that produced less in a study reported by Morrow et al. (1966). Boyd et al. (1954) found no difference in inseminations per conception by production levels among 519 cows. Large herds in Israel were studied by Ayalon et al. (1971) and they found no difference in conception rate at first insemination for average and high production herds. However, they reported that culling for infertility among normal cows was significantly higher in high production herds, while culling for infertility among abnormal cows was significantly higher in average production herds. Cows in a University of Wisconsin herd during 1965-71 were divided into groups for high or low genetic ability for milk production (Whitmore et al., 1974). They reported significantly shorter intervals to first ovulation, and estrus for low genetic ability cows, as well as less incidence of retained placenta. Fertility at first insemination, and the incidence of metritis, dystocia, abortions and infertility were not significantly different between groups. Spike (1973) noted that Michigan herds that averaged over 6364 kg of milk had longer calving intervals (401 vs 392 days) than did herds that produced less.

Herd Size

Herd size also apparently has an associated effect on herd reproduction. Spike (1973) reported that small (less than 25 cows) and large (greater than 100 cows) Holstein herds in Michigan had approximately one week longer calving intervals (400 vs 393 days) than did herds of 26-99 cows. Olds and Deaton (1968) reported that herd fertility declined .08 percent for each increase of one cow in herd size in a study of 505 herds that ranged in size from 20 to 111 cows. Ayalon *et al*. (1971) compared reproductive efficiency in large and small herds (average herd sizes of 197 and 10.5 cows), and reported that small herds had a significantly higher conception rate at first insemination, but that there was no difference in percent of cows culled for infertility between groups. These results may not be a true indication of herd size effects because these herds had much different management systems and herd milk production levels.

Nutrition

The exact relationships between nutrition and reproduction have not been clearly defined (Boyd, 1970). However, puberty is delayed in underfed heifers (Reid *et al*., 1957), and anestrus may result in underfed cows (Hignett, 1960). Deficiencies in certain minerals, most notably phosphorus, may also affect reproduction as shown by Salisbury and VanDemark (1961).

Lamb *et al*. (1965) found that cows fed alfalfa hay only, and cows fed alfalfa hay plus .45 kg grain for each 1.6 kg milk produced had similar intervals to first estrus and insemination, interval to conception, number of estrous periods before insemination, and inseminations per conception. Two levels of grain feeding did not affect interval to first estrus, interval to conception, and inseminations per conception in cows observed by Fuquay *et al*. (1966).

Whitmore *et al*. (1974) fed two levels (average and 150% of average) of 16 percent concentrate and found that average level cows had significantly shorter intervals to first ovulation and estrus, less incidence of retained placenta, and acute metritis, but he did not find a difference in fertility at first insemination or inseminations per conception. These results may be confounded because they found significant interaction between milk production levels and nutrition levels.

Boyd (1970) concluded that "in general, if nutrition requirements for milk production and general health of the cow are met, then the cow's nutritive requirements for reproduction should be adequate."

MATERIALS AND METHODS

Herd Selection

A representative sample of Southern Michigan Holstein herds on DHIA was needed for the study. Agricultural Extension Agents in counties within a fifty mile radius of Michigan State University were sent an explanation of the experimental objectives and were asked to submit names of cooperative dairymen who might be interested in participating. These dairymen and their herd veterinarians were sent letters that explained the study, and those that indicated an interest in participating were visited by extension and research staff to further explain the experimental procedures. Fifteen farms started the study with herd sizes that ranged from 35 to 150 cows. All herds but one had a regular herd health program that included postpartum examinations, pregnancy diagnosis, and treatment of reproductive problems.

Pretreatment Data

Data from a pretreatment period were needed to determine the dairymen's usual reproductive management practices. Therefore, participating farms were visited and reproductive and milk information for all cows that calved in 1972 were obtained from herd and DHIA records. Age at calving, calving month, lactation number, and cull reasons for cows sold were determined. Interval from parturition to first insemination, interval from parturition to conception, interval from first insemination to conception, inseminations per conception, and percent conception at the first through fourth inseminations were calculated from the data obtained. Cows that were open longer than 250 days, and those that failed to calve in 1972 were excluded from the calculations. If available, 305 day milk yield for that lactation was recorded (any lactation over 250 days was projected to a 305 day record using factors given by McDaniel et al., 1965). Pregnancies that occurred during 1972 were confirmed by rectal palpation or by actual parturition.

Analysis of variance was used to partition main effects and interactions and variances were tested by the f-test (Fisher's variance ratio). The standard t-test, Dunnett's t, or Scheffe's interval were used to test differences among means. In means involving percentages, significance was determined by Chi Square test. The analysis of variance, f-tests, and correlations were calculated by a statistical program package of Michigan State University's CDC 6500 computer system. Tests of differences among means were done by hand calculation.

Treatment Groups and Procedures

Herds were started on the study with cows that calved in August-September 1973, and concluded with cows that calved in August-September 1974. Cows that calved during this period were assigned within the first month postpartum to one of three treatment groups. All cows which calved without clinical complications were randomly assigned to be bred at first estrus after forty days (Treatment I), or sixty days (Treatment II). These times were chosen because forty days is as early as acceptable fertility occurs (Britt, 1975) and sixty days is the usual period that dairymen wait before the initial postpartum insemination. Cows that delivered twins or had a difficult parturition, and cows that had retained placenta, metritis, or pyrometra during the first two weeks postpartum were assigned to an abnormal group (Treatment III) and were to be bred when the dairyman and herd veterinarian considered them ready for breeding.

Report forms (Appendix A) for recording calving, estrus, and insemination dates were exchanged bi-weekly with each dairyman. Treatment assignments were made from information received on the reports. Space was also provided on the forms for results of veterinarian visits, any problems that occurred, and culling reasons and dates. Cows were listed by both a control number and a barn name or number to prevent duplication of a barn name or number for different cows during the study. From data provided in these reports, interval from parturition to first estrus, interval from parturition to first insemination, inter-estrual intervals, intervals between inseminations, inseminations per conception, days open to conception, and days open between first insemination and conception were calculated. Also calving month, abnormal assignment reasons and frequencies, and cull reasons, frequencies, and dates were determined. Information was monitored bi-weekly to determine the study's progress and the dairyman's adherence to the assigned breeding dates.

A computer program was written to calculate and print the minimum date for first insemination, and to print the first three insemination dates. Additional space for other insemination dates were provided. These printouts (Appendix B) were updated every four weeks, a copy sent to the dairyman and a copy kept for our records. An updated report listed assigned minimum insemination dates for cows that had calved recently, as well as recent insemination dates for cows already assigned. Neither calving date nor treatment group was listed on the printout since it was felt these might bias the dairyman's decision as to whether to inseminate a cow at first estrus after the minimum breeding date. Cows were listed either by numerical or alphabetical order depending on the method of identification used in the herd. Each printout listed all cows still in the herd that had calved since the study began. When a cow was determined to be pregnant, PREG was written next to the conception date on the computer printout. Pregnancies were determined by rectal palpation in herds that had herd health programs, and by non-return to estrus in herds without herd health programs.

Four visits were made to the farms during the study to answer questions and discuss the progress of the experiment. A final visit was made to most farms to check for accuracy in the information. In addition to visits, a questionnaire (Appendix C) was sent to the dairymen that completed the study to determine management practices, changes in the dairy operation that occurred within the year, and their reaction to the experiment.

DHIA records were used to obtain days in milk, daily milk yield, and milk yield to date for each cow until the first test date past 150 days postpartum. These data were used to determine the lactation curves for the first 180 days of lactation for cows in the three treatment groups. In addition, 150 day milk yield for each cow, and average daily yield per cow for each group and overall was determined. Age at calving was also obtained from DHIA records.

Statistical analysis techniques were similar to those used for the 1972 data.

Analysis by Interval to First Insemination

Cows were also grouped, ignoring treatments, by twenty day intervals to first insemination. Data from only pregnant cows were used. The range used was from less than forty days to greater than 120 days open. The parameters calculated and analyzed for these groups were the same as those used for the treatment groups. Analysis was similar to previously mentioned methods.

Lactation Curves by Interval to Conception

Lactation curves for the first 180 days of lactation were calculated from DHIA records, and were plotted by twenty day interval to conception periods from twenty to 180 days. All the individual milk weights during successive five day periods, beginning eight to thirteen days postpartum, were averaged to make single points on the lactation curve. This provided for thirty-five 5-day periods for each treatment, interval to conception period, and overall 180 day lactation curve. The cubic regression equations for these 180 day lactation curves were tested to determine if differences existed among interval to conception periods, and treatments. The method used to test for differences between equations was an extension of a technique to test for differences between two linear regressions (Gill, 1975). Average daily yield was also determined for each group.

Least Squares Analysis

Interval to first estrus, interval to first insemination, interval to conception, interval from first insemination to conception, inseminations per conception, and 150 day milk yield were analyzed by least squares techniques on the CDC 6500 computer. For purposes of analysis, herd size, housing, treatments, and season of calving were classified into groups. Herd size was determined to be either small (less than 50 cows), medium (50-70 cows), medium-large (71-90 cows), or large (more than 90 cows) depending principally on the herd size during the year. Housing was considered either as free stall or stanchion. Three treatments have been described previously. Season of calving was divided into quarter periods beginning with January through March. Age at calving, the number of times detected in estrus before initial insemination, the previously mentioned intervals, inseminations per conception, and 150 day milk yield were used as variables where appropriate. The general equation used is as follows:

$$Y_{ijklm} = u + T_i + S_j + H_k + Z_l + TS_{ij} + TH_{ik} + TZ_{il} +$$
$$SH_{jk} + SZ_{jl} + HZ_{kl} + TSH_{ijk} + TSZ_{ijl} + b_iX_i + e_{ijklm}$$

The description of variable symbols are given in Appendix Table 2, parts 1 and 3.

The above model failed to account for herd variation. Therefore, an equation was developed that included a herd within herd size variable, but excluded the housing variable. That equation is given below:

$$Y_{ijlmn} = u + T_i + S_j + Z_l + R_{nl} + TS_{ij}\ TZ_{ik} + SZ_{jk} +$$
$$TSZ_{ijk} + b_iX_i + e_{ijlmn}$$

Variable symbols are described in Appendix Table 2, parts 2 and 3. For each parameter, the equation that resulted in the highest multiple correlation coefficient was used. The actual model used for each parameter of interest is given in the results section for that parameter.

RESULTS

Twelve of the fifteen initial herds completed the field study. A total of 976 cows were assigned during the study period August 1973 to September 1974. Of those, 420 cows were assigned to Treatment I (43.0%), 422 to Treatment II (43.2%), and 134 to Treatment III (13.7%). Data from cows that conceived in less than 250 days were used for most of the analyses. This included 304, 298, and 83 cows, respectively, for the three treatment groups. The remaining cows were open more than 250 days (15 cows), culled non-pregnant (181 cows), or inseminated but not confirmed pregnant when culled or at the end of the study (98 cows), and were therefore considered as open. Of 837 cows that calved in these 12 herds during 1972 (pre-treatment control period), 30 cows were open longer than 250 days and were excluded from the analyses for that period. Of the remaining cows, 591 conceived in less than 250 days, and 213 were culled as non-pregnant.

Herd sizes during 1972 as determined by the number of cows calving within the year are given in Table 1. The four largest herds accounted for 48 percent of the total cows calving in 1972, and for 45 percent of the total cows

Table 1.--Number of cows calving or assigned, percent pregnant, percent abnormal, and percent culled by herds during 1972 and 1973-74.

Herd	Number of Cows		Percent Pregnant[c]	Percent Abnormal[d]	Percent Culled[e]	
	1972[a]	1973-74[b]	1973-74	1973-74	1972	1973-74
1	79	86	78	2.3	35	21
2	56	62	79	14.5	20	16
3	51	60	72	5.0	35	28
4	78	110	72	30.0	27	31
5	36	37	70	8.1	22	30
6	48	58	81	17.2	29	21
7	83	103	74	11.7	23	23
8	98	110	73	4.6	34	41
9	37	54	67	14.8	8	41
10	131	118	55	14.4	35	32
11	83	103	64	20.4	28	33
12	57	60	83	10.0	35	20
Total Ave.	837	961	71	13.4	29	29

[a]Number of cows calving.

[b]Number of cows assigned.

[c]As a percent of cows assigned per herd that were diagnosed or considered pregnant.

[d]Percent assigned to Treatment III.

[e]As a percent of cows calving or assigned.

assigned in 1973-74. Seventy-one percent of the cows were housed in free stalls, 21 percent in stanchions, and 6 percent in loose housing. Other characteristics of the dairy farms are given in tables in Appendix C. These data were prepared from responses to the questionnaire sent to each cooperating dairyman. There were significant differences among herds for age at calving and lactation number ($p < .01$); herd means ranged from 40-58 months, and 2.0-3.0 lactations respectively (overall means were 48 months and 2.0 lactations; Appendix Table 1).

Average age for cows assigned during 1973-74 was 47 months. A simple correlation of .95 between age at calving and lactation number was calculated which agrees with that reported by Everett et al. (1966).

Treatment III Assignments

Retained placenta and uterine infection, defined as infection within the first two weeks postpartum, accounted for 68 percent of the assignments to Treatment III (Table 2). Dystocia, twinning, abortion, and combinations of the abnormalities at parturition accounted for the remainder of the cows assigned to Treatment III (abnormal group). Percent of abnormal cows assigned per herd is shown in Table 1. Herd means ranged from 2 to 30 percent. Herd four had a high incidence of uterine infections within two weeks postpartum which accounted for 72 percent of the cows assigned to Treatment III in that herd. Herd 11 had a high

Table 2.--Reasons and frequencies for assignments to Treatment III (cows abnormal at calving).[a]

Reason	Percent of Total Abnormal Assignments	Percent of Total Assignments
Twins	5	0.6
Retained placenta	28	3.9
Uterine infection[b]	40	5.4
Abortion	7	1.1
Dystocia	10	1.3
Combination[c]	10	1.4
Total	100	13.7

[a]N = 134.

[b]Defined as diagnosed uterine infection within two weeks postpartum

[c]Combination of two or more preceding conditions.

occurrence of retained placenta which accounted for 76 percent of the cows assigned to Treatment III in that herd.

Interval to First Estrus

The average interval to first estrus for all cows was 58 days (Table 3), and was not different among treatments. The number of cows having an observed estrus after partuition was 881 or 92 percent of cows assigned. The other cows were culled before observed and/or recorded in estrus. Within herds, treatment means were only different in Herd 2 where cows in Treatment III had a significantly

Table 3.--Reproductive performance for cows assigned to Treatments I, II, and III during 1973-74.

	Treatment			Ave.
	I	II	III	
Interval to first observed estrus (days)	57[a] (388)[b]	59(383)	59(110)	58(881)
Interval to first insemination (days)	73[e] (376)	82(372)	83(101)	78(849)
Interval to conception (days)[c]	99[f] (304)	105(298)	112(83)	103(685)
Interval from first insemination to conception (days)	28(304)	25(298)	30(83)	30(685)
Inseminations per conception[c]	1.8(304)	1.7(298)	1.7(83)	1.7(685)
Percent pregnant[d]	77(304)	75(298)	65(83)	75(685)

[a]Mean value.

[b]Number of observations.

[c]Cows open longer than 250 days excluded.

[d]As a percent of cows assigned in the study that became pregnant.

[e]Significantly different than Treatments II and III ($p < .05$).

[f]Significantly different than Treatment III ($p < .05$).

longer interval than cows in Treatments I and II ($p < .01$; Appendix Table 3). Herds in which cows averaged 51 days or less to first estrus were not different from each other as determined by Scheffe's interval. Also, herds in which cows averaged 54 days or longer to first estrus were not different from each other. Data analysis by first insemination intervals showed that cows bred at less than 40 days postpartum averaged 36 days to first estrus (Table 4). Cows that had longer intervals to first insemination had associated longer intervals to first estrus, ranging from 42 days for the 40-60 day first insemination period to 100 days for the 120 day or greater period.

The least squares model for interval to first estrus was as follows:

$$Y_{ijlmn} = \mu + T_i + S_j + Z_l + R_{nl} + TS_{ij} + TZ_{il} + SZ_{jl} + TSZ_{ijl} + e_{ijlm}$$

Symbols for variables are described in Appendix Table 2, parts 2 and 3. The treatment X season X herd size interaction was significant ($p < .05$; Appendix Table 4). Herds within herd size was highly significant ($p < .0005$). Least square adjusted means for interval to first estrus are given in Appendix Table 5 for treatments, seasons, herd size, and herds. The multiple correlation coefficient (r^2) was .16.

Table 4.--Reproductive performance for cows first inseminated at various 20 day postpartum intervals.[a]

IFI[b]	Number[c]	IFE[d]	IFI[e]	ITC[f]	IFITC[g]	I/C[h]
<40	10	36[i]	36	92	56	2.4
40-60	180	42	52	86	34	1.9
61-80	254	51	70	97	27	1.7
81-100	129	70	90	115	25	1.6
101-120	72	77	108	126	18	1.6
121+	40	100	140	155	15	1.4
Total-Ave.	685	58	78	103	30	1.7

[a]Cows open longer than 250 days excluded; only cows that conceived are used.

[b]Interval to first insemination periods (days postpartum).

[c]Number of cows first inseminated during that period.

[d]Interval to first observed estrus (days).

[e]Interval to first insemination (days).

[f]Interval to conception (days open).

[g]Interval from first insemination to conception (days).

[h]Inseminations per conception.

[i]Average values per period.

Interval to First Insemination

The average interval to first insemination for cows in Treatment I was 73 days, which was significantly shorter ($p < .05$) than the 82 and 83 days for cows in Treatments II and III (Table 3). The 849 cows (89% of the cows assigned) that had a first insemination were used for the calculations of these unadjusted treatment means.

Herd means for interval to first insemination are in Appendix Table 6. Significant differences ($p < .05$) among treatments existed within Herds 1, 7, and 8 where cows in Treatment I had shorter intervals than cows in Treatments II and III. Herds in which cows averaged 72 to 91 days to first insemination were not different from each other ($p < .05$) and herds in which cows averaged 66 to 79 days to first insemination were similiar as determined by Scheffe's interval.

The interval to first insemination ranged from 72 to 94 (mean 84) days for cows among the 12 herds in 1972 (Appendix Table 6), and herd means were not different. Cows in ten herds had shorter intervals to first insemination in 1973-74 than in 1972.

Analysis of intervals to first insemination (Table 4) showed that cows bred at less than 40 days postpartum averaged 36 days to first insemination. Successive 20 day intervals had mean values of 52, 70, 90, 108, and 140 days to first insemination respectively.

The least squares model for interval to first insemination (Appendix Table 7) is given below:

$$Y_{ijlmn} = \mu + T_i + S_j + Z_l + R_{nl} + TS_{ij} + TZ_{il} + SZ_{jl} +$$
$$TSZ_{ijl} + b_1X_1 + b_2X_1^2 + b_3X_2 + b_4X_2^2 + e_{ijlmn}$$

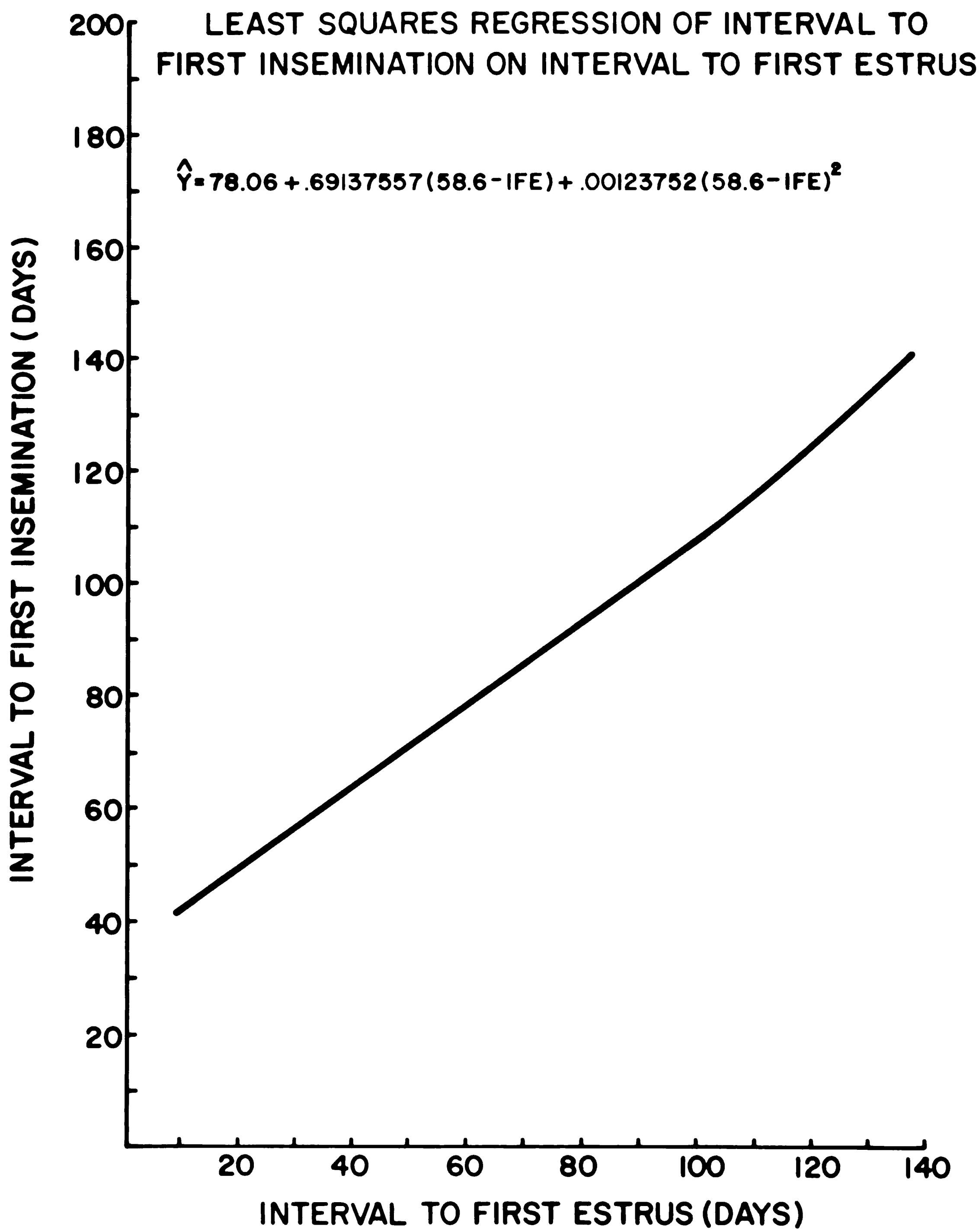
Description of variables are given in Appendix Table 2 parts 2 and 3. Treatments and herds within herd size had significant effects ($p < .05$) on interval to first insemination. The multiple correlation coefficient (r^2) for interval to first insemination was .70 indicating that 70 percent of the variation in interval to first insemination was accounted for by the variables listed. Cows in Treatment I had shorter intervals than cows in Treatments II and III. The linear and quadratic terms of interval to first estrus and number of times detected in estrus before first insemination also had a significant effect ($p < .01$). Regression equations for these are plotted in Figures 1 and 2. Each additional day to first estrus (from 20 to 100 days) resulted in .75 additional days to first insemination (Figure 1). Also as the number of estrous cycles before first insemination increased, the interval to first insemination increased (Figure 2). Least square adjusted means are given in Appendix Table 8.

The percent of cows first inseminated during various 20 day postpartum intervals is shown in Table 5. This table shows how closely treatment assignments were followed.

Figure 1. Least squares regression of interval to first insemination on interval to first estrus.

$$\hat{Y} = 78.06 + .69137557(58.6 - IFE) + .00123752(58.6 - IFE)^2$$

$$r^2 = .70$$



LEAST SQUARES REGRESSION OF INTERVAL TO FIRST INSEMINATION ON INTERVAL TO FIRST ESTRUS
$\hat{Y} = 78.06 + .69137557(58.6 - IFE) + .00123752(58.6 - IFE)^2$
INTERVAL TO FIRST INSEMINATION (DAYS)
200
180
160
140
120
100
80
60
40
20
20
40
60
80
100
120
140
INTERVAL TO FIRST ESTRUS (DAYS)

Figure 2. Least squares regression of interval to first insemination on number of estrous periods before initial insemination.

$$\hat{Y} = 78.06 + 49.1(1.67 - \#\text{Estrous Periods}) - 6.59(1.67 - \#\text{Estrous Periods})^2$$

$$r^2 = .70$$

LEAST SQUARES REGRESSION OF INTERVAL TO FIRST INSEMINATION ON NUMBER OF ESTROUS PERIODS BEFORE INITIAL INSEMINATION

$\hat{Y} = 78.06 + 49.1(1.67 - \#\text{ Estrous Periods}) - 6.59(1.67 - \#\text{ Estrous Periods})^2$

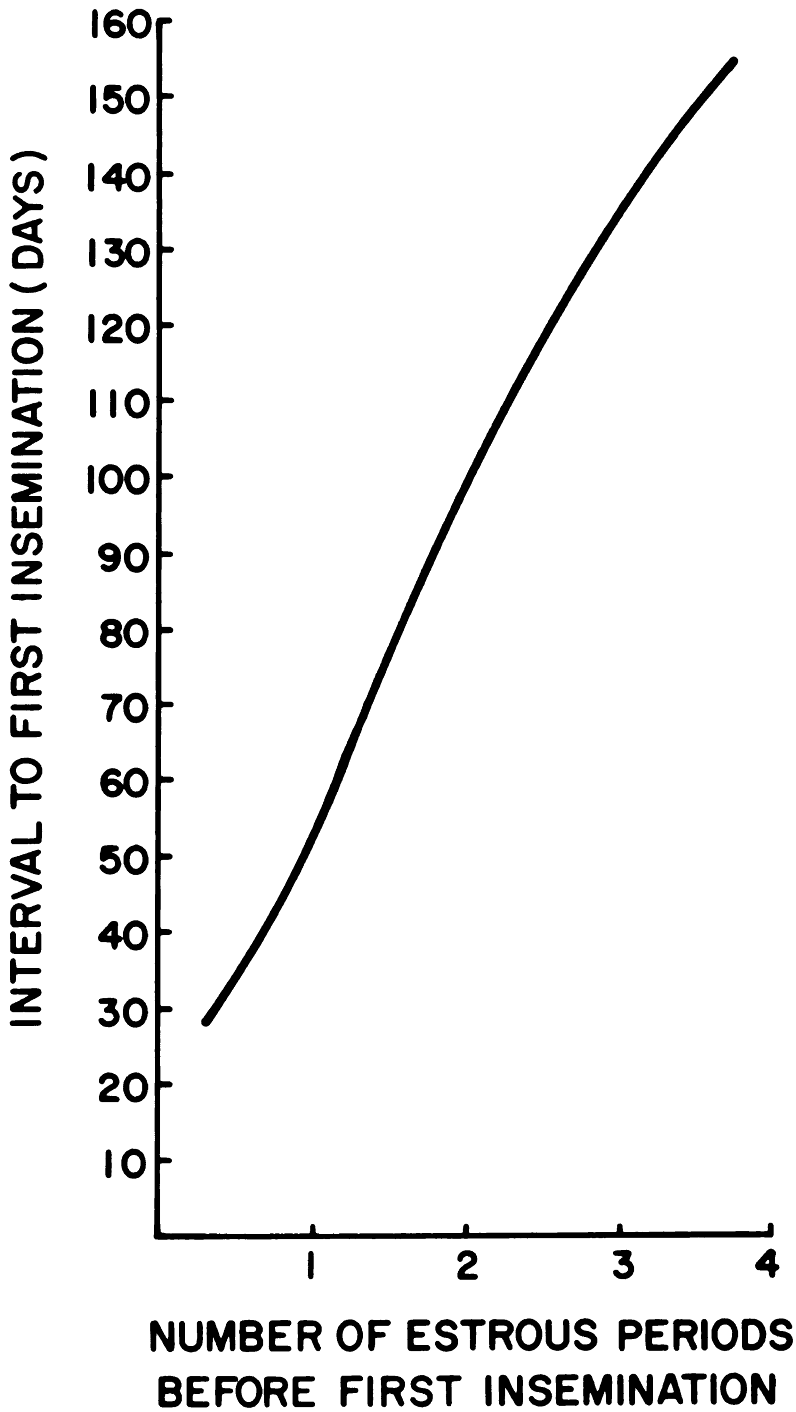


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Table 5.--Percent of cows in Treatments I, II, and III first inseminated at various 20 day postpartum intervals.[a]

IFI[b]	Treatment			Total
	I	II	III	
<40	3[c](10)[d]	---	---	1(10)
40-60	37(113)	17(51)	19(16)	26(180)
61-80	31(95)	42(126)	40(33)	37(254)
81-100	17(51)	21(61)	20(17)	19(129)
101-120	9(26)	12(36)	12(10)	11(72)
121+	3(9)	8(24)	8(7)	6(40)
Total	100(304)	100(298)	100(83)	100(685)

[a]Only cows that eventually conceived are used; cows open longer than 250 days excluded.

[b]Interval to first insemination periods (days postpartum).

[c]Percent of cows in a treatment group that had a first insemination during that postpartum interval.

[d]Number of cows inseminated.

Three percent of the cows in Treatment I were bred before 40 days postpartum. Thirty-seven percent of the cows in Treatment I were bred between 41-60 days after calving while 17 and 19 percent of cows in Treatments II and III were bred during this period. During the 61-80 day period for Treatment II, 42 percent of the cows were inseminated.

Estrous and Insemination Intervals

The interestrual intervals prior to insemination, and insemination intervals are given in Table 6. There were no differences among groups for intervals between estrous periods prior to initial insemination (average 31 days). However, the interval between first and second insemination in the abnormal cows was significantly longer ($p < .05$) than for normal cows (Treatments I and II).

Estrus and insemination intervals among herds are in Appendix Table 9. The interval between first and second estrus (range 29 to 52 days), and the interval between first and second insemination were different for cows among herds ($p < .05$). Other intervals were not different. No data on estrus and insemination intervals were collected for the 1972 period.

The interval from first estrus to first insemination also varied for cows among herds as shown in Appendix Table 10. Herd means ranged from 9 to 38 days, and treatment averages were 17, 23, and 24 days respectively. Longer herd intervals from first estrus to first

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Table 6.--Days between estrus and inseminations for cows in Treatments I, II, and III.[a]

	Estrus Intervals			Insemination Intervals				
Treatment	1-2[b]	2-3	3-4	1-2[c]	2-3	3-4	4-5	5-6
	Days			Days				
I	32	27	26	36	35	39	37	26
II	35	32	28	38	36	31	30	31
III	34	31	39	51[d]	36	39	23	14
Average	33	30	29	39	36	36	33	28

[a]Cows open longer than 250 days excluded.

[b]Interval between first and second estrus periods.

[c]Interval between first and second insemination.

[d]Significantly different than Treatments I and II ($p < .05$).

insemination were usually indicative of early postpartum estrous detection rather than late postpartum inseminations. Treatment means, however, do tend to reflect the first insemination interval. Data analyzed by intervals to first insemination show that cows that had longer intervals to first insemination also had longer intervals from first estrus to first insemination (Table 4).

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Interval to Conception

The interval to conception (days open) for 1973-74 of 99 days for cows in Treatment I was significantly shorter ($p < .05$) than the 112 days for cows in Treatment III but not different than the 105 days for cows in Treatment II as determined by Dunnett's t test (Table 3). Within herds, treatment differences were only observed in Herd 1 where cows in all three treatments were different from each other (Appendix Table 11). The 83 days open for cows in Herd 12 and the 121 days open for cows in Herd 7 were different ($p < .05$) from each other, but not different from cows in all other herds as determined by Scheffe's interval. The interval to conception during 1972 ranged from 90 to 133 (mean 111) days among the 12 herds (Appendix Table 11). No differences were observed as determined by Scheffe's interval. The simple correlation between interval to first insemination and interval to conception was .46 and .42 for 1972 and 1973-74 respectively.

Increasing the interval to first insemination (Table 4) resulted in longer intervals to conception, except for cows bred less than 40 days postpartum. Cows bred between 40-60 days had less days open than did cows bred prior to 40 days postpartum (86 vs 92 days). The range in interval to conception was from 86 to 155 days among 20 day intervals to first insemination.

The least squares analysis of variance (Appendix Table 12) for interval to conception shows that none of

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the main effects significantly ($p < .05$) affected the variable. However, interval to first insemination and its interactions with number of inseminations and interval from first insemination to conception were significant ($p < .05$). The interval from first insemination to conception and its interactions with interval to first estrus and number of estrous periods before first insemination were also significant ($p < .05$). From these the following model was derived.

$$Y_{ijklm} = \mu + T_i + S_j + H_k + Z_l + TS_{ij} + TH_{ik} + TZ_{il} + SH_{jk} + SZ_{jl} + HZ_{kl} + TSH_{ijk} + TSZ_{ijl} + b_1X_3 + b_2X_5 + b_3X_3X_5 + b_4X_3X_3 + b_5X_5X_2 + b_6X_5X_1 + e_{ijklm}$$

Variable symbols are described in Appendix Table 2 parts 1 and 3. The multiple correlation for days open was .99 which indicates most of the variation was accounted for in the model. Adjusted least square means are in Appendix Table 13, but none were different within a variable. The linear regressions of interval to first insemination and interval from first insemination to conception on days open are plotted in Figures 3 and 4. Each additional day to first insemination resulted in an increase of .96 days open as determined by this least squares regression. Each additional day in interval from first insemination to conception resulted in an additional 1.06 days open.

Figure 3. Least squares regression of interval to conception on interval to first insemintion.

$$\hat{Y} = 30.0 + .96189967(IFI)$$

$$r^2 = .99$$

LEAST SQUARES REGRESSION OF INTERVAL TO CONCEPTION ON INTERVAL TO FIRST INSEMINATION

$\hat{Y} = 30.0 + .96189967\,(IFI)$

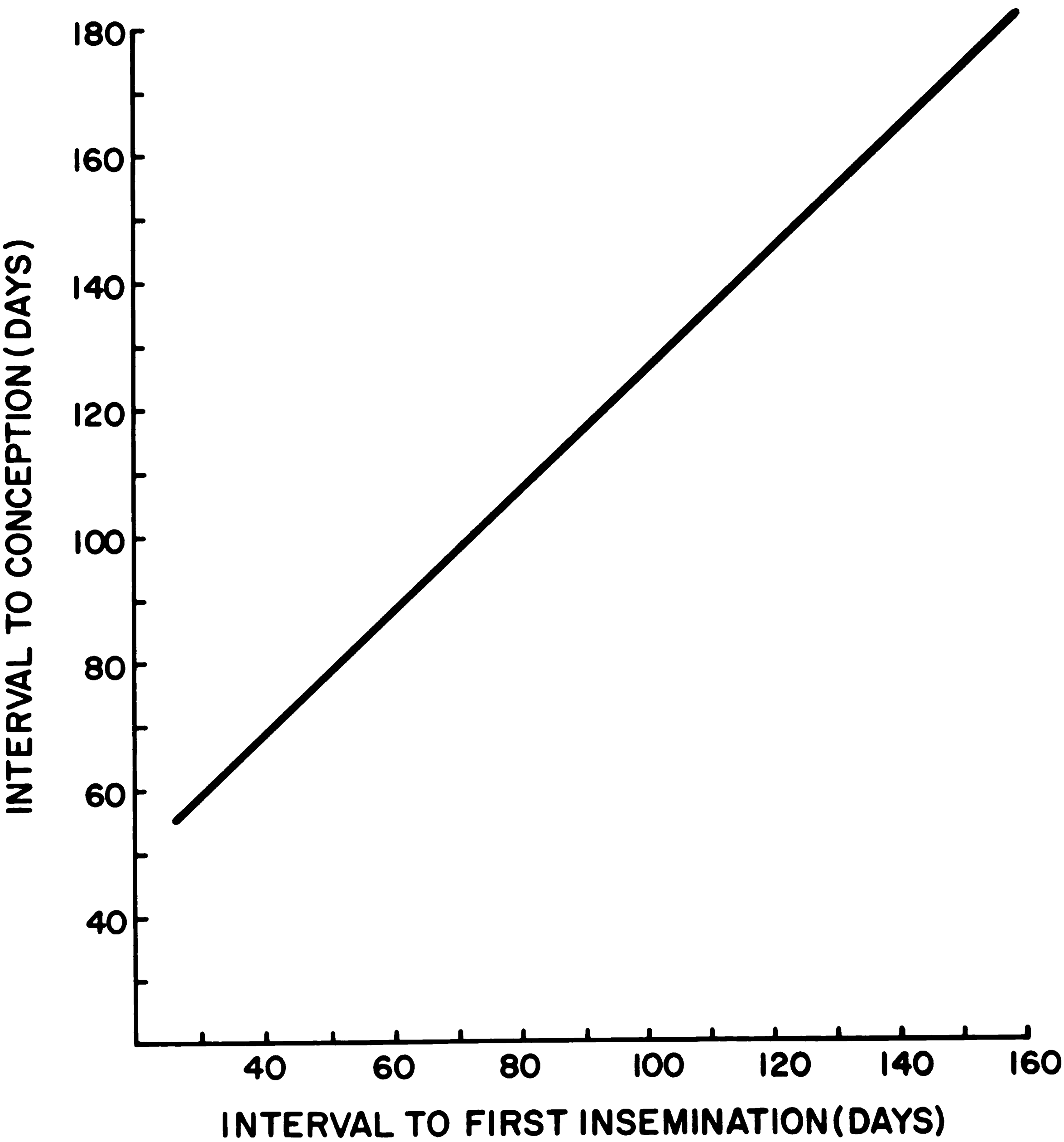


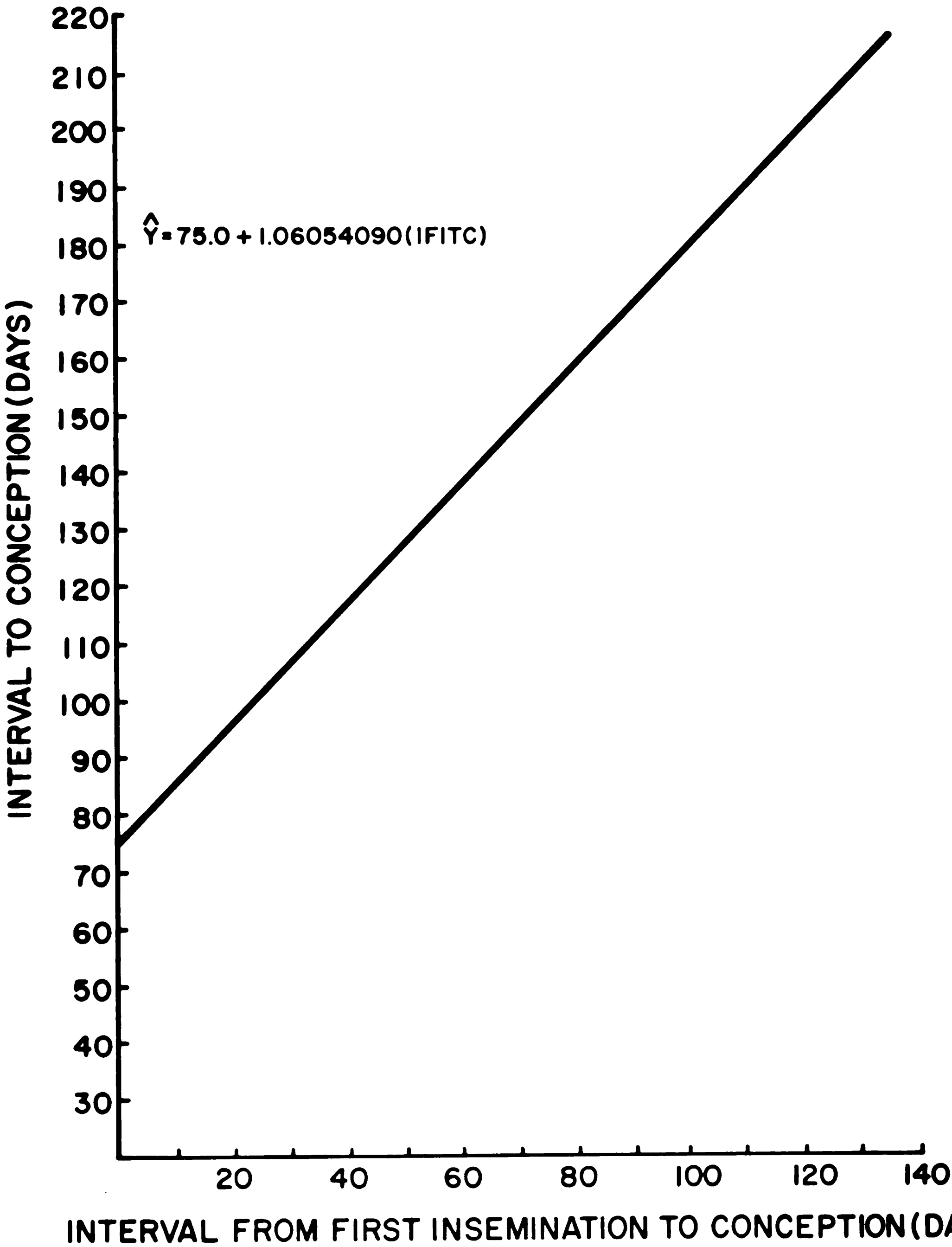
Figure 4. Least squares regression of interval to conception on interval from first insemination to conception.

$$\hat{Y} = 75.0 + 1.06054090(IFITC)$$

$$r^2 = .99$$

INTERVAL TO CONCEPTION (DAYS)

LEAST SQUARES REGRESSION OF INTERVAL TO CONCEPTION
ON INTERVAL FROM FIRST INSEMINATION TO CONCEPTION



Interval From First Insemination to Conception

The interval from first insemination to conception averaged 30 days for all cows that conceived during the 1973-74 study period (Table 3), treatment means were not different. The intervals for cows among herds ranged from 15 to 44 days and were not different (Appendix Table 14). The intervals from first insemination to conception during 1972 ranged from 5 to 47 days for cows among herds (Appendix Table 14).

The number of days from first insemination to conception decreased with longer first insemination intervals from 56 days for cows first bred before 40 days to 15 days for cows first inseminated after 120 days (Table 4).

The least squares table for interval from first insemination to conception is in Appendix Table 15. The following model was used.

$$Y_{ijklm} = \mu + T_i + S_j + H_k + Z_l + TS_{ij} + TH_{ik} + TZ_{il} + SH_{jk} + SZ_{jl} + HZ_{kl} + TSH_{ijk} + TSZ_{ijl} + b_1X_3 + b_2X_3^2 + b_3X_4 + b_4X_2X_6 + b_5X_4X_6 + e_{ijklm}$$

Variable symbols are described in Appendix Table 2 parts 1 and 3. The multiple correlation coefficient was .99 with interval to conception accounting for the major portion of the variation as evidenced by the simple correlation of .82 between the two. Although no main effects were significant, the interval to conception was highly significant ($p < .0005$) and the linear regression is plotted in Figure 5. Each additional day open was associated with an increase of .98 days in interval from first insemination to conception. The linear and quadratic terms of interval to first insemination were also significant ($p < .01$), and the regression equation is plotted in Figure 6. From the range of 35 to 120 days postpartum, each additional day to first insemination results in a linear decline of .98 days from first insemination to conception as determined by least squares regression. Adjusted mean values for housing, treatments, herd size, and season are given in Appendix Table 16.

Percent Conception at Various Inseminations

Percent conception by years and treatments is shown in Table 7, and Appendix Taxles 17 and 18. Table 7 shows the percent conception at the first four inseminations for cows assigned to the three treatment groups. Only 2 percent (15 cows) of the cows that conceived within 250 days postpartum required more than four inseminations, and data from these cows are not shown in this table. Conception rate at first insemination averaged 56 percent and was not different among treatments. Percent conception at second insemination also was not different among groups. Percent conception at third and fourth insemination for cows in Treatment II was significantly higher ($p < .05$) than cows in Treatments I and III.

Figure 5. Least squares regression of interval from first insemination to conception on interval to conception.

$$\hat{Y} = -75.0 + .985885(DO)$$

$$r^2 = .99$$

LEAST SQUARES REGRESSION OF INTERVAL FROM FIRST INSEMINATION TO CONCEPTION ON INTERVAL TO CONCEPTION

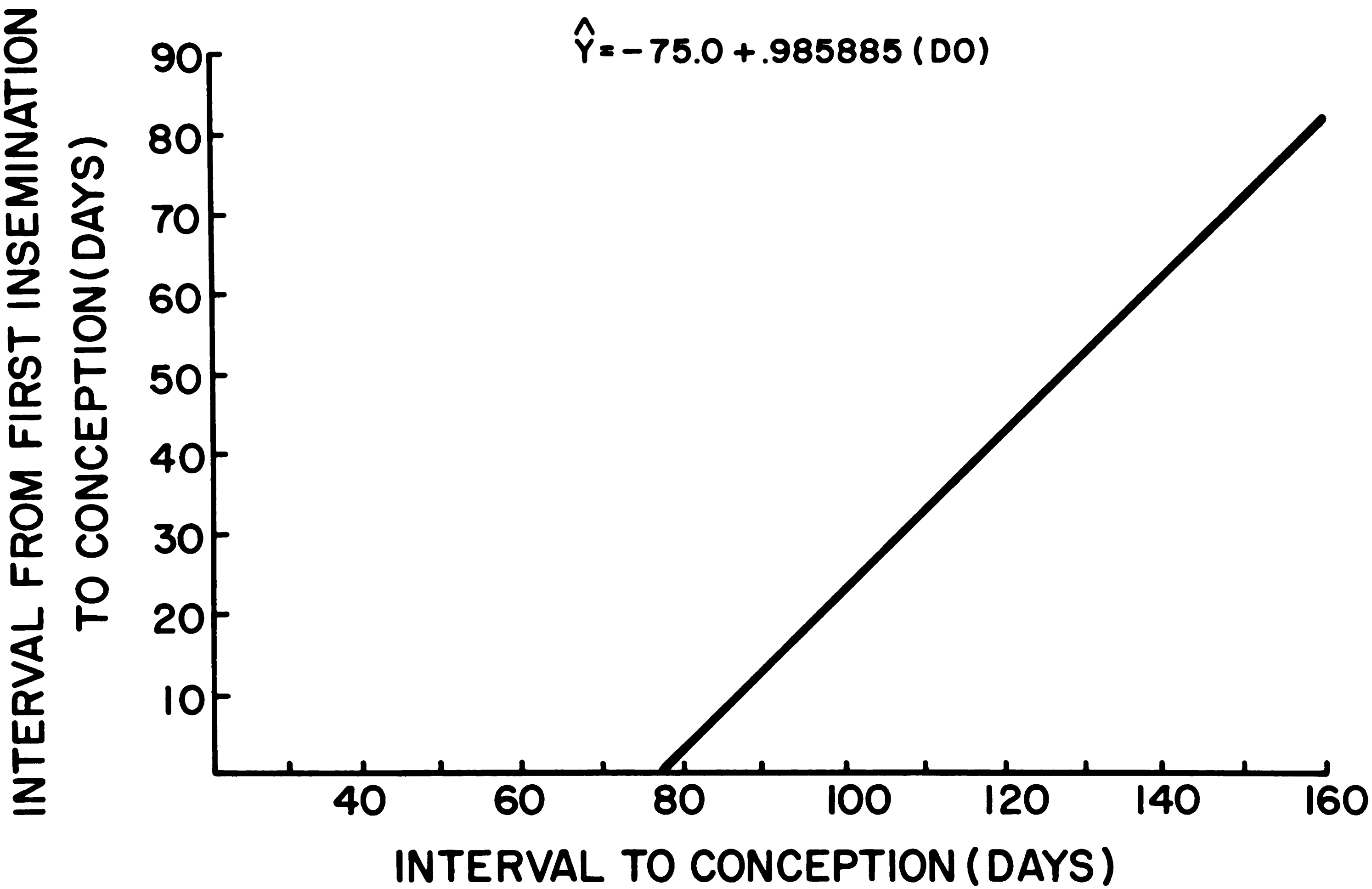


Figure 6. Least squares regression of interval from first insemination to conception on interval to first insemination.

$$\hat{Y} = 27.1 - .9829226(76.6\text{-IFI}) - .00085991(76.6\text{-IFI})^2$$

$$r^2 = .99$$

LEAST SQUARES REGRESSION OF INTERVAL FROM FIRST INSEMINATION TO CONCEPTION ON INTERVAL TO FIRST INSEMINATION

$$\hat{Y} = 27.1 - .9829226(76.6 - IFI) + .00085991(76.6 - IFI)^2$$

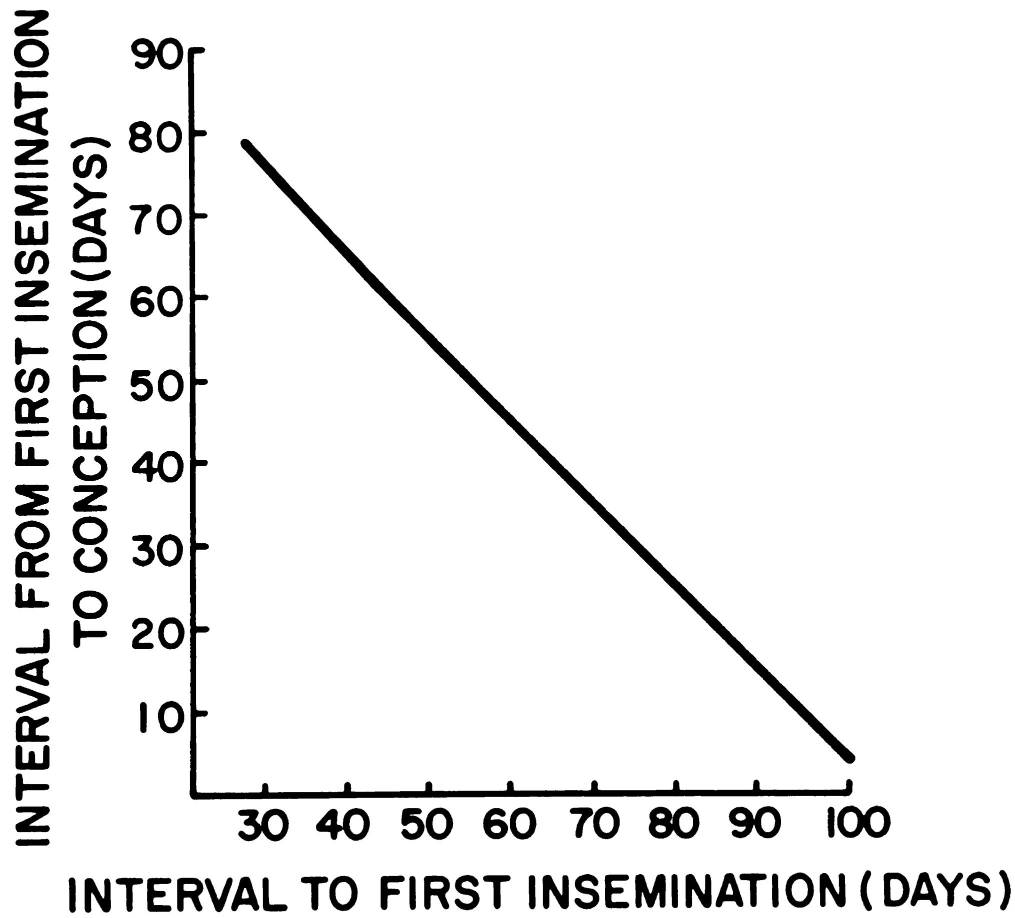


Table 7.--Percent conception at the first through fourth inseminations for all cows and cows in Treatments I, II, and III.

Insemination Number	Treatment			Ave.
	I	II	III	
1	55[a] (168)[b]	56 (166)	58 (48)	56 (382)
2	59 (80)	60 (79)	66 (23)	60 (182)
3	50 (28)	77[c] (41)	58 (7)	63 (76)
4	57 (10)	91[c] (11)	60 (3)	66 (30)

[a]Percent conceiving.

[b]Number conceiving.

[c]Significantly higher than Treatments I and III ($p < .05$).

Percent conception at first insemination was variable among herds for 1972 and 1973-74 (Appendix Tables 17 and 18). Conception rate at first insemination ranged from 39 to 75, and 40 to 73 percent for 1972 and 1973-74, respectively. No differences were observed among treatments within herds during 1973-74. Conception rates at first and succeeding inseminations were similar for 1972 and 1973-74 (Appendix Tables 17 and 18). Percent conception by various 20 day first insemination intervals for normal (Treatments I and II) and abnormal (Treatment III) cows is shown in Tables 8 and 9.

Table 8.--Percent conception at first insemination for normal (Treatments I and II) and abnormal (Treatment III) cows bred at various 20 day postpartum intervals.[a]

IFI[b]	Normal[c]	Abnormal[d]	Total
<40	50[e](10)[f]	---	50(10)
40-60	46(164)	37(16)	45(180)
61-80	60(221)	58(33)	60(254)
81-100	54(112)	71(17)	56(129)
101-120	61(62)	70(10)	63(72)
121+	70(33)	57(7)	67(40)
Average	56(602)	58(83)	56(685)

[a]Only data from cows that eventually conceived were used; cows open longer than 250 days excluded.

[b]Interval to first insemination (days).

[c]Treatments I and II (cows bred at first estrus after 40 or 60 days respectively).

[d]Treatment III (cows clinically abnormal at parturition).

[e]Percent conceiving at first insemination.

[f]Total number of cows inseminated during that period.

Table 9.--Percent conception at the first through fourth inseminations for cows first bred at various 20 day postpartum intervals.[a]

IFI[b]	Insemination Number			
	1	2	3	4
<40	50[c] (5)[d]	40 (2)	---	100 (3)
40-60	45 (81)	58 (57)	60 (25)	71 (12)
61-80	60 (152)	56 (57)	62 (28)	76 (13)
81-100	56 (72)	70 (40)	65 (11)	67 (4)
101-120	63 (45)	63 (17)	80 (8)	---
121+	67 (27)	61 (8)	100 (5)	---

[a]Cows open longer than 250 days are excluded and only data from cows that conceived were used.

[b]Interval to first insemination periods (days postpartum).

[c]Percent conceiving at that insemination.

[d]Number conceiving at that insemination.

Ten normal cows were bred before 40 days postpartum (Table 8), and half of them conceived at first insemination. Abnormal cows bred first at 41-60 days postpartum had a 37 percent conception rate compared with a 46 percent conception for normal cows bred during that period. Percent conception reached 60 percent at the first insemination interval of 61 to 80 days and was above 55 percent for the other periods. Conception rate at first insemination was not different between normal and abnormal cows ($p > .05$). Conception rate at second insemination (Table 9) was above 55 percent for all periods except for five cows first bred at less than 40 days postpartum.

Percent Pregnant

Percent pregnant, defined as percent of cows assigned that were diagnosed or considered pregnant, for treatments and herds during 1973-74 is shown in Tables 1 and 3. In Treatment III, 65 percent of the cows assigned became pregnant which was significantly less ($p < .05$) than the 75 percent pregnant in Treatments I and II (Table 3). The percent of cows pregmant for all treatments among herds ranged from 55 to 83 percent with an average for all herds of 71 percent (Table 1). Percent pregnant was not calculated for the 1972 data. Non-pregnant cows were usually culled.

Inseminations per Conception

Fertility as measured by inseminations per conception averaged 1.7 for cows in all treatments during 1973-74 (Table 3). Treatment means were not different. Within herds, treatment differences occurred in Herds 2 and 10 (Appendix Table 19). Cows in Treatment I required more inseminations in Herd 2, and cows in Treatment III required more in Herd 10. Herds means ranged from 1.4 to 2.0 inseminations per conception but were not different.

Inseminations per conception ranged from 1.3 to 2.4 (mean 1.8) for cows among herds during 1972, but were not different from each other as determined by Scheffe's interval (Appendix Table 19).

Cows in each successive 20 day first insemination interval required fewer inseminations per conception declining from 2.4 for cows bred at less than 40 days to 1.4 for cows bred after 121 days postpartum (Table 4). The simple correlation of inseminations per conception and interval to conception was .67.

Housing was the only main variable that significantly ($p < .05$) affected inseminations per conception (Appendix Table 20). The model was determined to be as follows:

$$Y_{ijklm} = \mu + T_i + S_j + H_k + Z_l + TS_{ij} + TH_{ik} + TZ_{il} + SH_{jk} + SZ_{il} + HZ_{kl} + TSH_{ijk} + TSZ_{ijl} + b_1X_4 + b_2X_4^2 + b_3X_3X_6 + b_4X_5X_6 + b_2X_4X_6 + e_{ijklm}$$

Variable symbols are described in Appendix Table 2 parts 1 and 3. The multiple correlation coefficient was .81 indicating that most of the variation was accounted for. The linear and quadratic terms of interval to conception, and the interactions of 150 day milk yield with interval to first insemination, interval from first insemination to conception, and interval to conception were significant ($p < .05$). Other factors approached significance (Appendix Table 20). Adjusted least square means are given in Appendix Table 21. Cows housed in free stalls averaged 1.85 insemination per conception, and cows in stanchions averaged 1.59 insemination per conception, a significant difference ($p < .05$).

Milk Production

Milk production records were collected and analyzed. The 305 day 2X-ME milk yield ranged from 13,176 to 18,236 (mean 14,914) pounds among herds for cows calving in 1972 and completing more than 250 days of lactation (Appendix Table 1). The actual herd milk production averages from September 1973 to October 1974 ranged from 10,848 to 16,546 pounds (mean 14,040; Appendix Table 1). Significant differences existed among herds ($p < .05$). The overall average milk production per cow for the first 150 days of lactation was 8,174 pounds which projected to an expected 305 day 2X-ME yield of 14,478 (Table 10). Lactation curves for treatments and interval to conception periods for the

Table 10.--Summary of data for 1972 and 1973-74 for herds participating in the early breeding project.

	1972	1973-74	
		All Cows	TRT. II & III
Number of cows[a]	834	976	549
Age at calving (mons.)	48	48	48
Interval to first estrus (days)	--[b]	58	59
Interval to first insemination (days)	84[c]	78	82
Interval to conception (days)[e]	111[d]	103	107
Inseminations per conception[e]	1.8	1.7	1.7
Interval from first insemination to conception (days)[e]	28	30	25
Milk production (pounds)[f]	14,913	14,478	--
Percent culled	30	29	32
Percent pregnant			

[a]Total cows calving in 1972, and number of cows assigned 1973-74.

[b]Data not obtained for 1972.

[c]Significantly longer than all cows 1973-74 ($p < .001$).

[d]Significantly longer than all cows 1973-74 ($p < .01$).

[e]Cows open longer than 250 days excluded.

[f]305 2X-ME.

first 180 days of lactation are plotted in Figures 7-9. Curves were not different among treatments or interval to conception periods. The lactation curve for cows open less than 40 days was omitted due to small numbers. The average milk yield per day per cow for the first 180 days of lactation averaged 52.5 pounds overall and was not different among treatment groups (Table 11). Milk per cow per day by interval to conception periods (Table 12) was also not different.

The least squares table for 150 day milk yield is given in Appendix Table 22. The following model was determined.

$$Y_{ijlmn} = \mu\ T_i + S_j + Z_l + R_{nl} + TS_{ij} + TZ_{il} + SZ_{jl} + TSZ_{ijl} + b_1X_7 + b_2X_7^2 + e_{ijlmn}$$

The variable symbols are described in Appendix Table 2 parts 2 and 3. The multiple correlation coefficient was .53. The simple correlation between age and milk yield was .42. The age effect was highly significant ($p < .0005$) in both the linear and quadratic terms. The regression curve for age is plotted in Figure 11. Treatments, herd size, herds within herd size, and the three-way interaction of treatments, seasons, and herd size all significantly affected 150 day milk yield ($p < .01$). The least squares adjusted means for treatments, seasons, and herds are given in Appendix Table 23.

Figure 7. 180 day lactation curves for cows in Treatments I, II, and III.

$$\hat{Y}_{I} = 53.58 + .2097(DAYS) - .003101(DAYS)^2 + .00000958(DAYS)^3,\ r^2 = .54$$

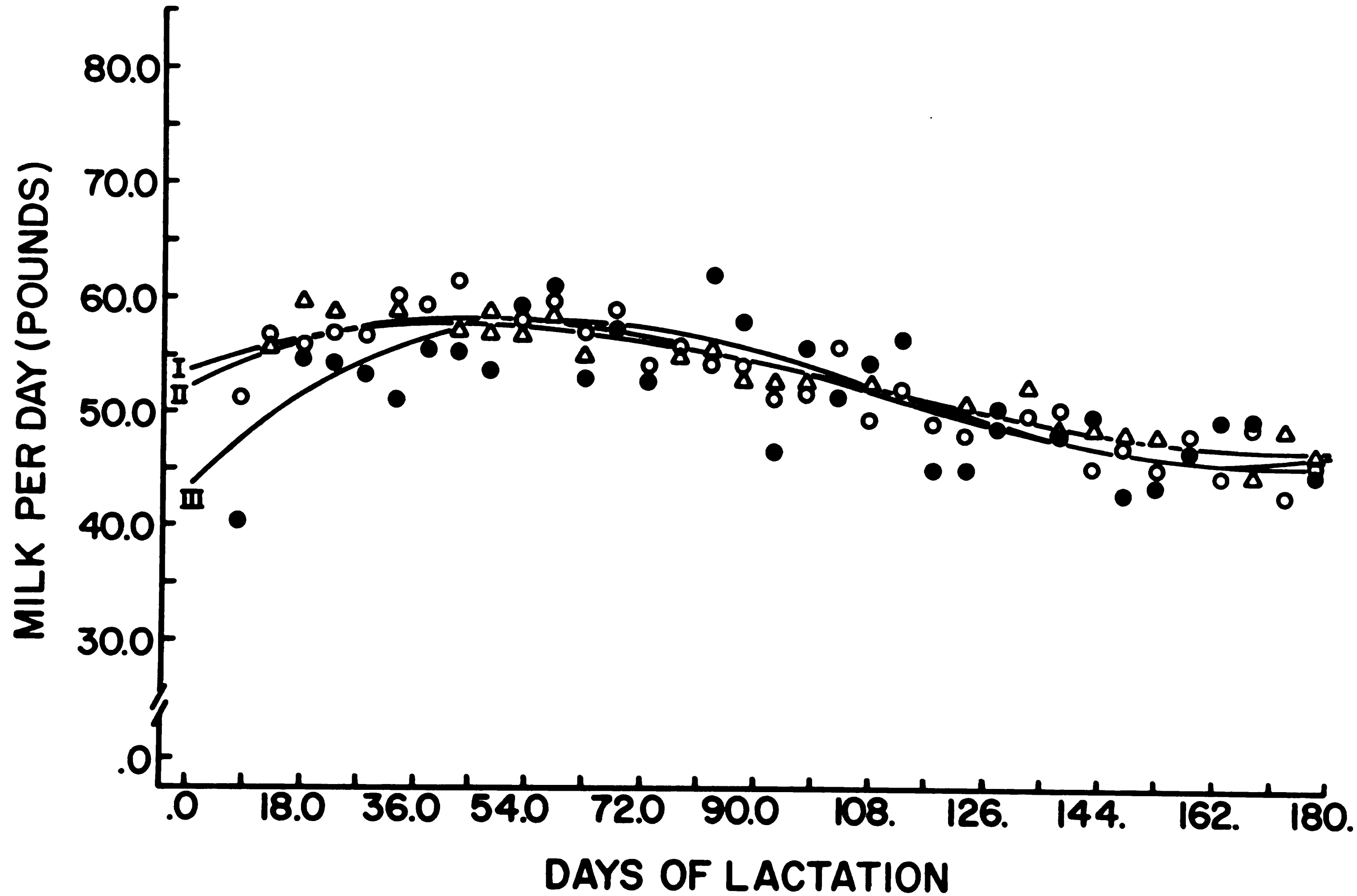
$$\hat{Y}_{II} = 52.10 + .2988(DAYS) - .004223(DAYS)^2 + .00001311(DAYS)^3,\ r^2 = .59$$

$$\hat{Y}_{III} = 43.20 + .5784(DAYS) - .006761(DAYS)^2 + .00002026(DAYS)^3,\ r^2 = .19$$

Δ = Treatment I (Line I)

O = Treatment II (Line II)

● = Treatment III (Line III)



180 DAY LACTATION CURVES FOR COWS
IN TREATMENTS I, II, AND III

Figure 8. 180 day lactation curves for cows that conceived during various 20 day postpartum intervals I.

$\hat{Y}_2 = 55.82 + .07689(\text{DAYS}) - .001908(\text{DAYS})^2 + .00000593(\text{DAYS})^3,\ r^2 = .20$

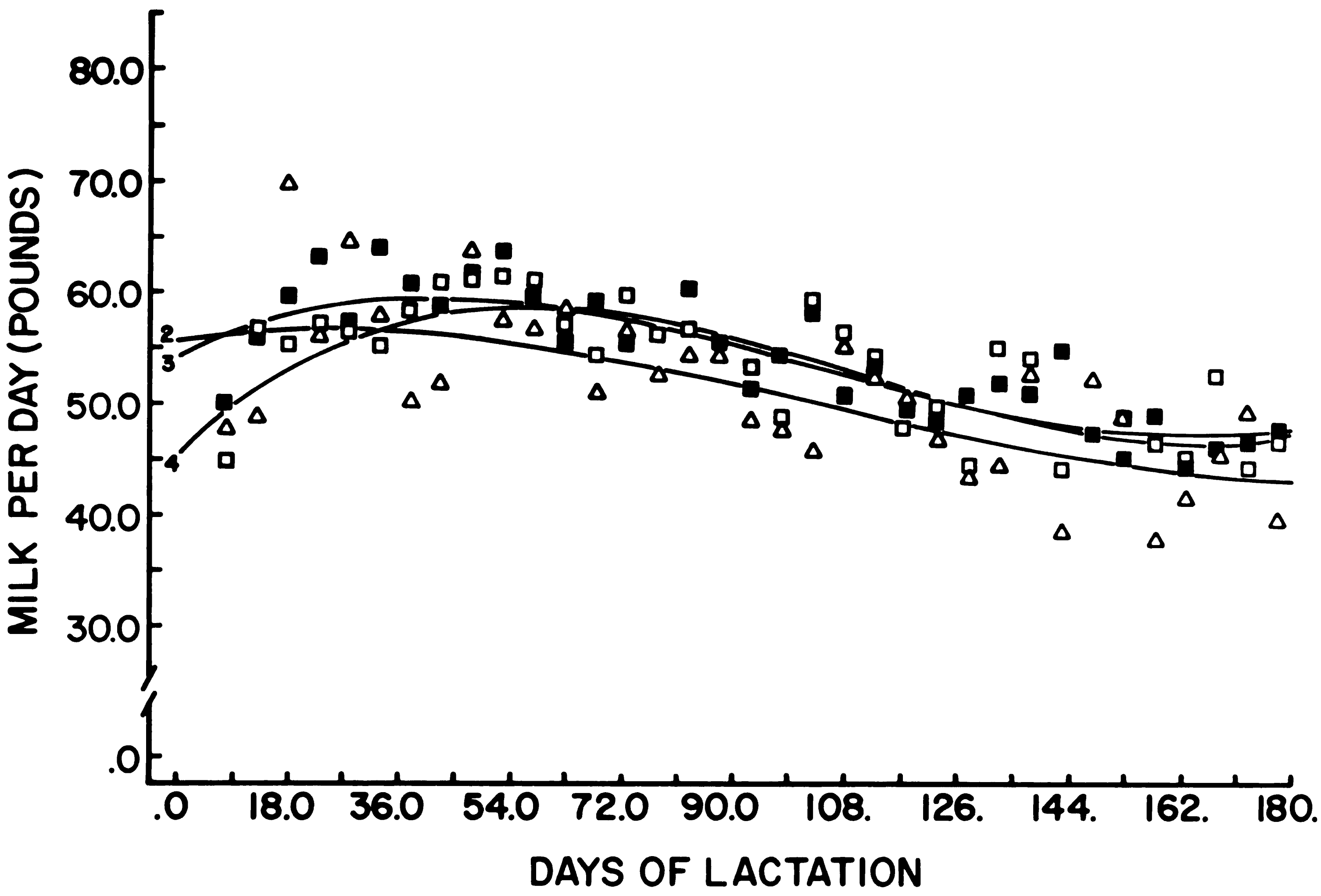
$\hat{Y}_3 = 54.27 + .2717(\text{DAYS}) - .004133(\text{DAYS})^2 + .00001337(\text{DAYS})^3,\ r^2 = .30$

$\hat{Y}_4 = 45.51 + .5263(\text{DAYS}) - .006309(\text{DAYS})^2 + .00001899(\text{DAYS})^3,\ r^2 = .20$

Δ = Interval to Conception 40-59 Days (Line 2)

■ = Interval to Conception 60-79 Days (Line 3)

□ = Interval to Conception 80-99 Days (Line 4)



180 DAY LACTATION CURVES FOR COWS THAT CONCEIVED DURING VARIOUS 20 DAY POSTPARTUM INTERVALS I

Figure 9. 180 day lactation curves for cows that conceived during various 20 day postpartum intervals II.

$$\hat{Y}_5 = 53.02 + .1809(DAYS) - .002344(DAYS)^2 + .00000636(DAYS)^3, r^2 = .15$$

$$\hat{Y}_6 = 51.82 + .1744(DAYS) - .002756(DAYS)^2 + .00000831(DAYS)^3, r^2 = .20$$

$$\hat{Y}_7 = 59.55 + .1999(DAYS) - .003380(DAYS)^2 + .00001035(DAYS)^3, r^2 = .23$$

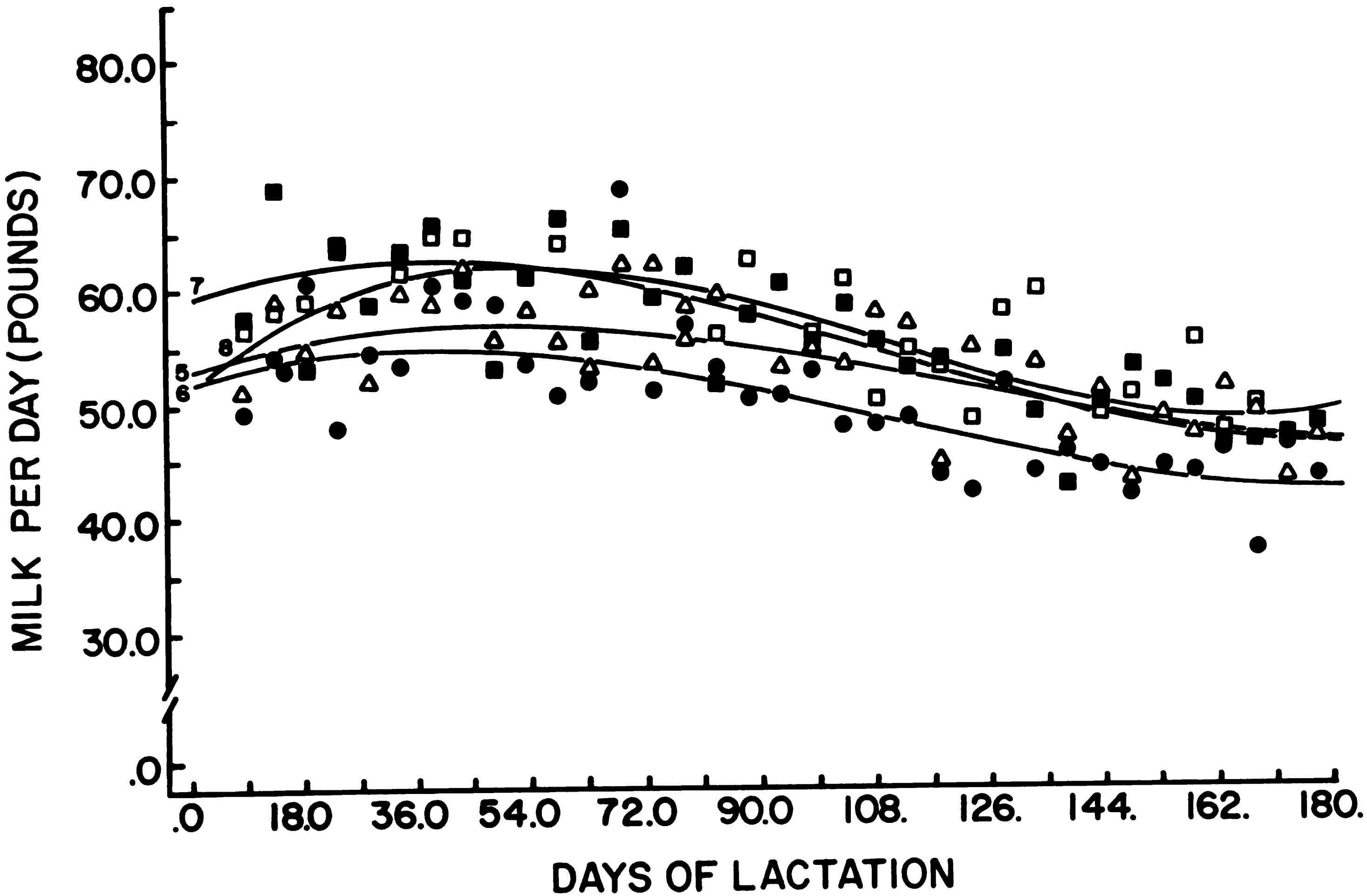
$$\hat{Y}_8 = 51.63 + .4617(DAYS) - .005890(DAYS)^2 + .00001811(DAYS)^3, r^2 = .23$$

Δ = Interval to Conception 100-119 Days (Line 5)

O = Interval to Conception 120-139 Days (Line 6)

■ = Interval to Conception 140-159 Days (Line 7)

□ = Interval to Conception 160+ Days (Line 8)



180 DAY LACTATION CURVES FOR COWS THAT CONCEIVED DURING VARIOUS 20 DAY POSTPARTUM INTERVALS II

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Table 11.--Average milk yield per day during the first 180 days of lactation for cows in Treatments I, II, and III.

Treatment	Milk Yield (lbs.)	Number of Periods	Average Number Observations Per Period
I	52.8±.75[a]	35[b]	58.0[c]
II	52.5±.86	35	58.3
III	51.6±.92	35	15.2
All	52.5±.77	35	131.5

[a]Mean±S.E.

[b]Number of five day periods used to determine mean.

[c]Average number of observations (weights) used per period.

An overall summary of reproductive and lactation data for 1972 and 1973-74 is presented in Table 10. When cows in Treatments II and III were compared with means for 1972, no differences were observed. However, when cows in the early bred group (Treatment I) were included, significantly shorter intervals to first insemination and to conception ($p < .01$) were noted. Means were tested by standard "t" test. Thus the only two variables that we had hoped to change (interval to first insemination and interval to conception) were actually different.

Cull Reasons and Frequencies

Percent of cows culled per herd during 1973-74 ranged from 16 to 41 percent (Table 1), indicating the

Table 12.--Average milk yield per day during the first 180 days of lactation for cows that conceived during various 20 day postpartum intervals.

Days Open Interval	Milk Yield (Pounds)	Number of Periods	Average Number of Observations Per Period
<40	63.7±2.47[a]	24[b]	1.2[c]
40-60	51.0±1.22	35	10.9
61-80	53.8±0.98	35	23.3
81-100	53.0±0.95	35	18.3
101-120	54.0±0.84	35	15.1
121-140	50.5±1.09	35	9.7
141-160	56.1±1.07	35	7.2
161-180	56.1±0.99	35	14.0

[a]Mean±S.E.

[b]Number of five days periods used to determine mean.

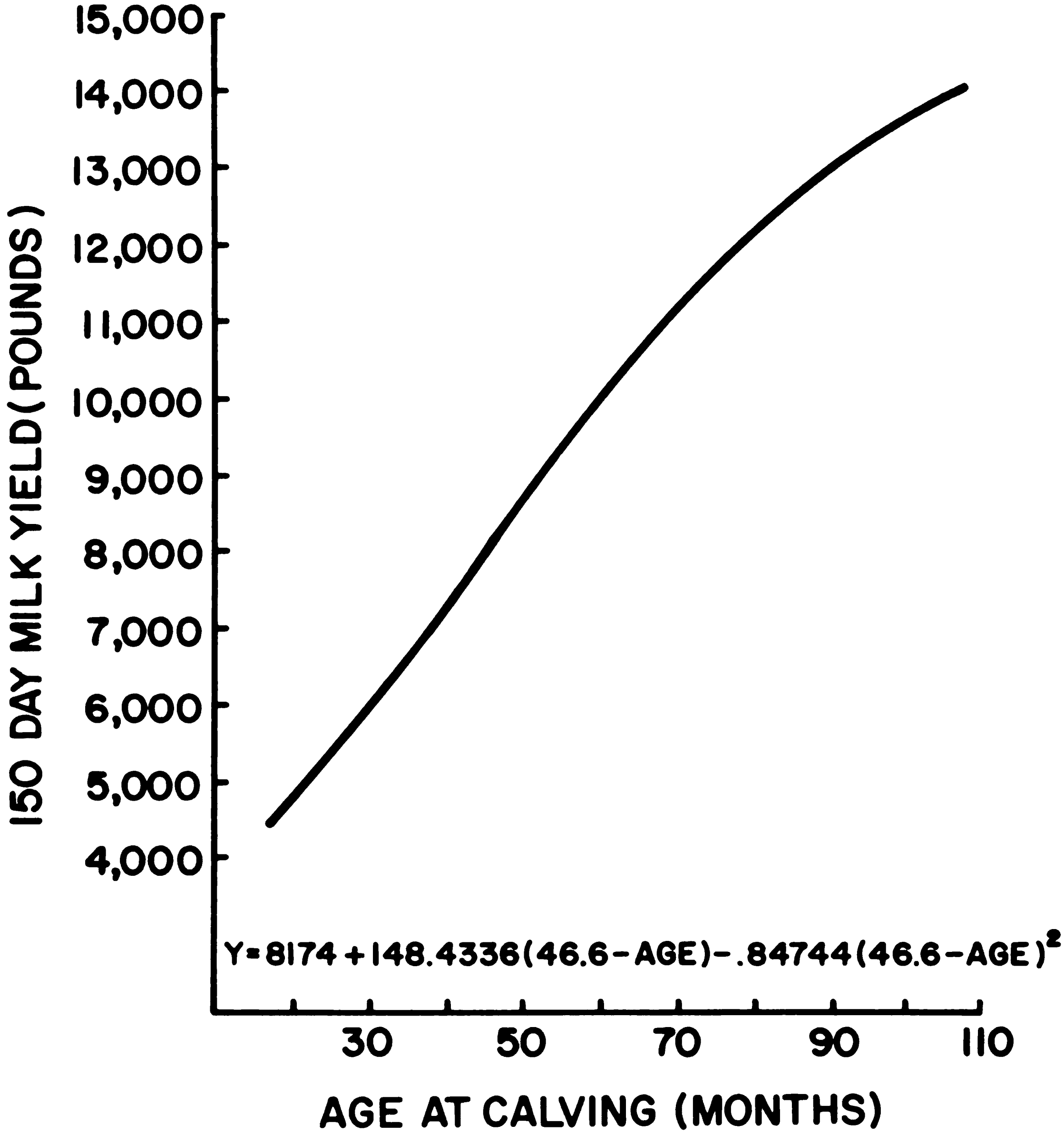
[c]Average number of observations (milk weights) used per period.

Figure 10. Least squares regression of 150 day milk yield on age at calving.

$$\hat{Y} = 8174 + 148.4336(46.6 - AGE) - .84744(46.6 - AGE)^2$$

$$r^2 = .53$$

LEAST SQUARES REGRESSION OF 150 DAY MILK YIELD ON AGE AT CALVING



variation in culling intensity on the various dairy farms. Herd 9 had a high culling rate because grade cows in the herd were sold in order to purchase registered cows. In Herd 8 a large number of cows were sold because the herdsman left, and the owner was unable to manage the larger herd by himself. Culling rate during 1972 varied from 8 to 35 percent among herds with an overall culling rate of 29 percent (Table 1).

Low milk production accounted for the greatest incidence of cows culled for each treatment group, and also for all cows in 1973-74 (Table 13).

Sterility and infertility, and cows sold for dairy purposes accounted for equal number of cows sold (18% or 50 cows). The only cull reasons that were different among treatments were sterility and interfility, and "other" which differed between Treatments I and II ($p < .05$). Cows culled per treatment were 24, 31, 37 percent respectively and percent culled for Treatment I was significantly less than for Treatments II and III ($p < .05$).

Cull reasons and frequencies for cows calving in 1972 are also in Table 13. Dairy purposes and milking problems were not listed as cull reasons in 1972, and are therefore included in "other" reasons. Again, low milk production was the greatest reason for culling (39% of cows culled). Sterility or infertility accounted for 24 percent of the cows culled, and 28 percent were sold due to "other" reasons. Overall culling rate for both years was 29 percent.

Table 13.--Cull reasons and frequencies for all cows during 1972, and for all treatments and cows during 1973-74.

	Treatment and Year				
	1973-74				1972
	I	II	III	Ave.	Ave.
Sterility or infertility	23[a](23)[b,c]	15(19)	17(8)	18(50)	24(58)
Injury, disease, died	12(12)	12(16)	21(10)	14(38)	9(23)
Low production	31(31)	23(30)	27(13)	27(74)	39(94)
Dairy purposes	20(20)	19(25)	15(7)	19(52)	--[d]
Milk problems[e]	6(6)	12(16)	6(3)	9(25)	--[d]
Other	8(8)[c]	18(23)	14(7)	13(38)	28)69)
Total	24[f](100)[g]	31(129)	37(148)	29(270)	29(244)

[a]Percent of the cows culled in a treatment group.

[b]Number culled.

[c]Significantly different than Treatment II ($p < .05$).

[d]No category for this reason in 1972.

[e]Hard milkers, mastitis, udder problems.

[f]Percent of cows culled per treatment.

[g]Number of cows culled per treatment.

DISCUSSION

The 13.7 percent incidence of abnormal cows at or following parturition is close to the 15 percent expected. Morrow *et al*. (1966) reported a 29 percent incidence of abnormal cows, but they included milk fever, acute mastitis, and ketosis (non-reproductive abnormal conditions) in their classification.

Retained placenta and uterine infection were the major reasons for assignment to Treatment III, although there was wide variation among herds. Kjome (1975) reported 14.7 and 17.5 percent incidence of retained placenta and metritis, respectively, for cows in Michigan dairy herds.

The average of 58 days to first estrus for all cows was longer than reported by Morrow *et al*. (1966), and Whitmore *et al*. (1974), but is within the range of 30-72 days reported in Wisconsin Research Bulletin 270 where several studies were summarized. Pelissier (1972) in a study of 24 commercial herds reported that 58 percent of the cows were in estrus by 60 days postpartum. Cows in the three treatment groups had similar intervals to first estrus, however, Morrow *et al*. (1969) and Buch *et al*.

(1955) reported longer intervals to first estrus for "problem" or "abnormal" cows. However, both studies had shorter overall intervals to first estrus than observed in the present study. Variation in estrus detection methods among herds existed (Appendix C, Tables 4a, 4b, and 4c). Herds within herd size, significantly affected interval to first estrus, but season, and herd size did not as determined by least squares analysis. Some investigators have reported an effect of season and herd size on interval to first estrus. The low multiple correlation coefficient indicated that much of the variation was not accounted for in the model.

The average interval to first insemination was longer than expected for Treatments I and II. Ideally, cows bred at first estrus after 40 days postpartum would average 51 days to first insemination (assuming all cows had 21 day estrous cycle, were detected in estrus, and bred). Accordingly, cows bred at first estrus after 60 days would average 71 days to first insemination. However, since cows in both treatments averaged 58 days to first estrus, the interval had to be longer than the ideal, which it was. The actual intervals from first estrus to first insemination was 17 and 23 days for cows in Treatments I and II, respectively. The actual interval to first insemination was 72 and 83 days for cows in Treatments I and II. It was thought that abnormal cows would probably be inseminated later in the postpartum period than Treatment II cows.

However, they were bred just as soon as Treatment II cows, indicating that the abnormal conditions were promptly treated and corrected. Herd differences were evident. Eleven herds actually achieved a shorter interval to first insemination for cows in Treatment I. The herd where cows failed to achieve this had 68 and 63 days to first insemination for cows in Treatment I and II. The 63 days to first insemination for cows in Treatment II in this herd was 12 days shorter than the next shortest herd interval. Least squares regression analysis revealed that treatments and herds had a significant effect, but season of calving and herd size did not.

The estrus and insemination intervals of approximately 31 days indicated that approximately 50 percent of the estrous periods were undetected. Estrous detection did not appear to improve once breeding had started because intervals between inseminations were just as long as intervals between estrus before the first insemination. The 30 days between inseminations is similar to the 45 percent of "delayed returns to insemination" (intervals of 26 days or longer) reported by Olds (1969). Admittedly, early embryonic mortality, and anestrous cows would also tend to lengthen the overall intervals between insemination beyond the expected 21 days. Wide herd variation existed in estrous and insemination intervals.

The interval to conception (days open) and calving interval are considered as the same measurement in the study, i.e., calving interval equals days open + 280 days. The days open for cows in Treatment I, II, and III correspond to 12.5 (Treatment I) to 13 (Treatment III) month calving intervals, all longer than the 12 month calving interval that is considered desirable (Speicher and Meadows, 1967; Louca and Legates, 1968). Cows in one herd achieved a twelve month calving interval, i.e., 85 days open. Cows in seven herds had shorter calving intervals in 1973-74 than in 1972. Cows in three herds had calving intervals of similar length between years and cows in two herds had longer calving intervals. Although cows in Treatments II and III had the same interval to first insemination, cows in Treatment III had a longer period of days open because of longer intervals between inseminations, especially between first and second insemination. Morrow et al. (1969) found an average 126 days open for abnormal cows and 106 days for normal cows. Ten of the dairymen said the overall reproductive performance for 1973-74 was the same or better than previous years. Nine of the herds reported a decrease or no change in abortions compared with previous years. Thus, early breeding did not result in decreased reproductive efficiency.

Least squares regression of days open revealed that season of calving or housing type did not have significant effects. The least squares significant interactions for days open can be observed since longer intervals to first insemination required fewer inseminations per conception and shorter intervals from first insemination to conception. The other interactions of interval from first insemination to conception are probably due to the high correlation between interval from first insemination to conception and days open.

The .42 correlation between interval to first insemination and interval to conception is lower than the .60 correlation reported by Olds and Cooper (1970). The correlation of .82 between interval from first insemination to conception and interval to conception is similar to the .80 correlation reported by the same workers. Also the .96 and 1.06 additional days open for each additional day to first insemination or from first insemination to conception are similar to the .94 and .97 days reported by them.

Least squares analysis of interval from first insemination to conception showed no effect of treatment, season, housing type, or herd size. Increasing the interval to first insemination decreased the interval from first insemination to conception. This may be due to physiological causes, or it may also be because cows that were bred late were given less opportunities to conceive, i.e., only cows that conceived on first few inseminations were kept in the herd, others were sold, thus shorter intervals from first insemination to conception and less inseminations per conception resulted.

Percent conception at first and second insemination was not different among treatments. Fertility at first insemination is usually reported lower for cows bred early. Although this was not evident in Treatment I (perhaps the cows were not bred early enough), it is evident when observed by first insemination intervals. Percent conception was lower in cows bred before 60 days postpartum compared to cows bred after 60 days. This was even more evident in abnormal cows. Pelissier (1972) reported that cows with retained placenta had a 30 percent conception rate at first insemination. Erb and Ehlers (1957) also reported higher percent conception at first insemination for normal cows. Overall conception rate for abnormal cows at first insemination in this study was equivalent to normal cows. The 56 percent conception at first insemination for all cows is similar to that reported by others (Olds and Cooper, 1969; Bozworth et al., 1972; Whitmore et al., 1974; Spalding et al., 1975). Percent conception at first and succeeding inseminations varied for cows within herds.

The overall 1.7 inseminations per conception is consistent with that reported by others (Morrow et al., 1966; Boyd et al., 1954; and Bozworth et al., 1972). It is lower than the 2.4 inseminations per conception reported by Pelissier (1972) in a California field study. Treatment means were not different for inseminations per conception. Morrow et al. (1969) and Pelissier (1972) reported than abnormal cows required more inseminations per conception. It has also been reported that early bred cows require more inseminations. This is observed in the data analyzed by interval to first insemination periods, but is not observed for cows in Treatment I. Interval to conception was correlated with inseminations per conception (r = .67). The interaction of milk and several reproductive parameters on inseminations were significant but undefinable. Likewise no logical explanation of why cows in free stalls required more insemination than cows in stanchions was found, although cows housed in free stalls were in smaller herds (a possible explanation).

The differences in annual milk yield by periods can be attributed to several things. The 1972 production records are selective because only pregnant cows that milked over 250 days are included. Thus all cows that milked less than that are excluded, which included most of the cows sold for low production. The 1973-74 data includes all cows and was taken directly from DHIA forms. Less difference is observed if the 1972 yield is compared with the 1973-74 estimated 305 day yields for pregnant cows.

Average milk yield per day, and the 180 day lactation curves did not show differences for cows among treatments or interval to conception periods. Various studies (Erb *et al.*, 1952; Gaines and Davidson, 1926; Sanders, 1927; Louca and Legates, 1968) indicated that gestation does not affect milk production until after the first five months of pregnancy. If this is the case, one would not expect to see a difference in 180 day yield for cows in treatments or interval to conception periods.

Least squares analysis did show an effect of treatments, but not conception periods, on 150 day milk yields. The treatment effect was probably due to abnormal cows having lower production during the early part of the lactation, and never quite catching up. Age affected yield as would be expected. Herd and herd size differences were observed. Herd yields were variable within herd size categories which probably accounts for herd size variation.

The 29 percent culling rate for both 1972 and 1973-74 is close to the 30 percent annual culling rate often quoted (Foley _et_ _al_., 1972). Low milk production was the major reason for culling with sterility and/or infertility the second major cause which agrees with the culling reasons reported by Erickson (1972). Bozworth _et_ _al_. (1972) reported a 22 percent culling rate in Kansas herds due to sterility or infertility which approximates the 18 and 24 percent found in this study. Although more cows were culled for sterility and infertility in Treatment I, cows in Treatment I had similar pregnancy rates and inseminations per conception as cows in Treatment II. The difference may exist because fewer total cows were culled in Treatment I, although the numbers culled for sterility were similar. The overall lower culling rate for Treatment I tends to refute the once-held belief that early bred cows were more likely to be culled. Although there appeared to be more abnormal cows culled, the difference was not significant. However, there was a lower percent of abnormal cows which subsequently became pregnant.

It is possible that the actual occurrence of abnormal and culling frequencies is different than is reported here. Data were summarized and calculated as reported on the bi-weekly reports from the cooperating dairymen. Therefore, the data are subject to all the biases that affect field study experiments.

SUMMARY

Cows in twelve cooperating dairy herds in south central Michigan were assigned to be bred at either first estrus after 40 days (Treatment I) or 60 days (Treatment II) postpartum. Cows clinically abnormal at parturition (Treatment III) were assigned to be bred when diagnosed as normal by the herd veterinarian. Thirteen percent of the cows were assigned to Treatment III with retained placenta and uterine infection accounting for 68 percent of those assignments. Fewer cows in Treatment I were culled than in Treatments II and III. Low production was the greatest cause for culling in all groups. Sterility and infertility was the second major cause.

Interestrual intervals and intervals between inseminations averaged 31 days for all cows, an indication that approximately 50 percent of the expected estrous periods were not observed. Interval to first estrus was 58 days, and was not affected by treatment.

Cows assigned to Treatment I averaged 73 days to first insemination which was shorter than the 82 and 83 days for Treatments II and III, respectively. In eleven herds, cows assigned to Treatment I had shorter intervals

to first insemination than those assigned to Treatment II. All cows averaged 84 days to first insemination in 1972 which was the pretreatment control period. Treatment and herds within herd size significantly affected interval to first insemination as determined by least squares analysis.

Interval to conception was 99 days for cows in Treatment I which was less than 112 days for cows in Treatment III, but not different than 105 days for cows in Treatment II. These correspond to 12.5 to 13 month calving intervals. Only one herd achieved a 12 month calving interval, but 10 herds had calving intervals shorter or similar to those for 1972. Therefore, breeding some cows earlier reduced overall days open. Interval to conception was affected by interval to first insemination and interval from first insemination to conception and their interactions with other reproductive measurements as determined by least squares analysis.

Intervals from first insemination to conception and inseminations per conception for cows were similar between treatments and years indicating no detrimental effects of early breeding. Least squares analysis revealed that interval to first insemination, interval to conception, and the interactions of 150 day milk yield with interval to first estrus and interval to conception significantly affected the interval from first insemination to conception. Inseminations per conception were affected by housing type, interval to conception, and 150 day milk yields interactions with interval to first insemination, interval from first insemination to conception, and interval to conception. Conception rate for all inseminations was 55 percent or above, and was not affected by treatments.

When the data were grouped by 20 day intervals to first insemination, ignoring treatments, a significant effect was noted for all intervals studied. As the interval to first insemination increased, there was an associated increase in interval to first estrus, and interval to conception, but a decrease in interval from first insemination to conception and inseminations per conception. However, cows first inseminated less than 40 days postpartum had more days open than cows first inseminated from 40-60 days postpartum, indicating that breeding before 40 days was undesirable.

No effects on milk yield per day for the first 180 days of lactation were observed for treatments or intervals to conception. Lactation curves for the first 180 days of lactation were not affected by treatments or intervals to conception. Least squares analysis of 150 day milk yields revealed significant treatment, and herds within herd size effects.

Season affected none of parameters measured. Age at calving affected only 150 day milk production. Herd variation existed for all parameters measured. At the end of the study, 11 of the cooperating dairymen planned to continue breeding some cows early, an indication that their participation in the study convinced them of the benefits of early breeding.

APPENDICES

APPENDIX A

WEEKLY REPORT FORM FOR FIELD STUDY

APPENDIX A

WEEKLY REPORT FORM FOR FIELD STUDY

Herd Name________________________________ Date____________

Instructions:

1. Information should be updated daily
2. When cows have calving or reproductive problems, write the information in the column concerning problem cows. The vet can also use this area for comments when he makes herd visits
3. Forms should be returned to MSU every two weeks when new forms are received.

Day & Date	Cows in Heat Today	Cows Calved Today	Cows Bred Today	Cows with Calving Problems or Reproductive Problems
Sunday				
Monday				
Tuesday				
Wednesday				
Thursday				
Friday				
Saturday				

APPENDIX B

SAMPLE COMPUTER PRINTOUT FOR ASSIGNED MINIMUM INSEMINATION DATES, AND ACTUAL INSEMINATION DATES

APPENDIX B

SAMPLE COMPUTER PRINTOUT FOR ASSIGNED MINIMUM INSEMINATION DATES, AND ACTUAL INSEMINATION DATES

Herd Name
Address

COW NUMBER CONTROL-BARN	BREED AT FIRST HEAT AFTER	FIRST SERVICE DATE	SECOND SERVICE	THIRD SERVICE
-ANGELA	JULY 6, 1975			
-ANITA	JUNE 28, 1974	JULY 28, 1974	AUGUST 28, 1974	DECEMBER 1, 1974
-AUDREY	JANUARY 18, 1975	FEBRUARY 27, 1975		
-BABE	FEBRUARY 9, 1975	APRIL 10, 1975		
-BBKATE	APRIL 7, 1975	MAY 8, 1975		
-BEATRCE	OCTOBER 22, 1974	OCTOBER 12, 1974 Preg		
-BELLE	JUNE 17, 1975			
-BENGIE	APRIL 25, 1975			
-BETH	WHEN NORMAL	MARCH 10, 1975		
-BIRDIE	SEPT. 30, 1974	OCTOBER 6, 1974	OCTOBER 28, 1974	NOVEMBER 23, 1974
-BLANCHE	JANUARY 30, 1975	MARCH 18, 1975 Preg		
-BONITA	JULY 1, 1975			
-BRENDA	JULY 1, 1974	JULY 25, 1974	AUGUST 19, 1974 Preg	
-BUBBLES	JULY 19, 1974	SEPT. 19, 1974	OCTOBER 13, 1974 Preg	
-CHERIE	AUGUST 20, 1974	AUGUST 13, 1974	SEPT. 27, 1974	OCTOBER 19, 1974
-DAISY	WHEN NORMAL	NOVEMBER 29, 1974	JANUARY 11, 1975	FEBRUARY 1, 1975
-DAWN	JUNE 16, 1975			

APPENDIX C

SAMPLE OF QUESTIONNAIRE SENT TO COOPERATING DAIRYMEN, AND THEIR RESPONSES TO QUESTIONS

APPENDIX C

SAMPLE OF QUESTIONNAIRE SENT TO COOPERATING DAIRYMEN, AND THEIR RESPONSES TO QUESTIONS

1. How many cows are in your herd?

2. At what age do you try to have your heifers freshening?

3. What type of housing do you have?

4. Describe the method of heat detection used on your farm:

   Number of times checked per day:
   Who does the heat checking:
   Time spent per observation:
   Place or area where observed:
   Signs looked for:
   Other comments:

5. How good a job do you think you do in heat detection? (Circle one)

   Good Fair Poor

6. How many days after calving do you wait before starting to observe for signs of heat?

7. Do you record heat dates for the herd? (Circle one)

   Yes No

8. How has this study affected your heat detection methods?

9. Before the study, when did you normally try to breed your cows after calving?

10. Who does the insemination on the farm?________________
    Is any natural services used?_________ How much?______

11. Is there a period of time you don't breed your cows so as to miss calving in the summer, and to hit fall freshenings? (Circle one)

    Yes   No

    When do you not breed?

12. Do you plan to continue breeding some cows at first heat after 40 days? (Circle one)

    Yes   No

    If Yes, about what percent do you plan to breed early?__________
    How will you determine which cows to breed at 40 days.

13. How useful was the computer printout in the study?

    Did you follow it fairly closely?

14. How would you say this year's reproductive performance compares with previous years? (Circle one)

    Same   Better   Worse

15. Did you observe any differences in the occurrence of the following conditions? (Check appropriate answer)

	Increased	Decreased	No Change
Metritis			
Abortion			
Calving Problems			
Cystic Cows			

16. Do you have a program of regular veterinary visits for the following: (Check appropriate answer)

	Yes	No
Postpartum Exams		
Pregnancy Diagnosis		
Reproductive Problems		
Examination of Heifers Before Breeding		

    How often do the regular visits occur?

17. Compare this year's nutrition level with last years: (Circle one)

    Same   Higher   Lower

18. What is the average length dry period for cows in your herd?

19. What is your rolling herd average?

20. Have you noticed a change in milk production during the year? (Circle one)

    Increase   Decrease   No Change

21. Estimate the percentage of cows culled from your herd for the following reasons:

	Percent
Low Production	
Sterility or Reproductive Problems	
Dairy Purposes	
Other Reasons	

22. Have there been any major changes in your dairy operation since September 1, 1973? (i.e., new facilities, large number of cows bought or sold, major herd health problems, change of herdsman, etc.) Describe, change, and tell effect, if any.

23. Please give us your evaluation of the study as conducted.

24. Would you be interested in continuing this study for two more years? (Circle one)

    Yes   No

Table	Question Number On Questionnaire
1	1
2	2
3	3
4a	4
4b	5,6,8
4c	4,7
5	9
6	10
7	10
8	11
9	12
10	13
11	14
12	15
13	16
14	17
15	18
16	19
17	20
18	21
19	22

Table 1.--Herd size.

Number of Herds	Size Range
3	40-60
5	61-80
3	81-100
1	101+

Table 2.--Age at first calving (goal).

Number of Herds	Age (Months)
3	24
2	27
1	25-27
6	24+

Table 3.--Types of housing.

Number of Herds	Type
7	Free Stall
3	Stanchion
1	Loose
1	Combination Loose and Stanchion

Table 4a.--Estrus detection methods.

Times Checked per Day		Time Spent per Observation		Signs Observes	
No. of Herds	Times/Day	No. of Herds	Time (Minutes)	No. of Herds	Signs
2	2	4	No Answer	10	Mounting or Standing
2	2-3	1	2-3	5	Fluid Discharge
4	3	1	3-5	4	Roughed Hair
2	3-4	1	5	7	Unusual Behavior (Pairing off, Butting, Nervousness)
1	No Answer			2	Milk Loss
				1	Paint Stick
				1	No Answer

Table 4b.--Estrus detection methods.

Estrus Detection Efficiency (Self-Judgment)		Effect of Study on Estrus Detection Methods		Days Postpartum Before Observing for Estrus	
No. of Herds	Efficiency	No. of Herds	Effect	No. of Herds	Days
6	Good	1	No Answer	5	All Observed
6	Fair	7	No Effect	3	20-30
0	Poor	4	More Aware	3	30
				1	35-40

Table 4c.--Estrus detection methods.

Record Estrus Dates		Number of People Responsible		Area Observed	
No. of Herds	Response	No. of Herds	No. of People	No. of Herds	Place
12	Yes	3	One	2	No Answer
0	No	5	Two	10	Barn Lot
		4	All[a]		

[a]No specific person responsible.

Table 5.--Usual interval to first postpartum insemination.

Number of Herds	Interval (Days)
1	*
1	40,[a] 60-90[b]
1	50-60
7	60
2	60-90

*When veterinarian says ready.

[a]When breeding cows for calving during base period.

[b]Regularly.

Table 6.--Herd insemination responsibility.

Number of Herds	Inseminator
9	One person
2	Two people
1	A.I. Technician

Table 7.--Natural service use.

Used in Herd		Extent Used	
Number of Herds	Response	Number of Herds	Use
10	Yes	1	10%
2	No	4	Heifers
		1	Clean up
		2	After 2nd Service
		1	After 3rd Service
		1	30-50% after 1st Service

Table 8.--Breed year around.

Number of Herds	Response
9	Yes
2	No
1	No Answer

Table 9.--Future plans for early[a] breeding.

Plan to Continue Breeding Early		Percent to Breed Early		How Determine Which Cows to Breed	
No. of Herds	Response	No. of Herds	% of Herd	No. of Herds	Decision Basis
11	Yes	3	Not Stated	4	Low level of Production
1	No	2	10		
		3	25-30	4	Veterinarian says Ready
		1	25-50	2	Time of Year
		1	50	1	Cows with History of Breeding Problems
		1	50-60		
				1	All that Qualify
				2	No Answer

[a]First estrus after 40 days postpartum.

Table 10.--Printout usefulness.

Number of Herds	Degree of Usefulness	Number of Herds	Closely Followed
3	Unknown	7	Yes
2	Little-Some	3	Tried
7	Useful	2	No

Table 11.--Reproductive performance compared with previous years.

Number of Herds	Change
4	Better
6	Same
1	Worse
1	No Answer

Table 12.--Reproductive problems during year.

Problem	Change		
	Increase	Decrease	No Change
	(No. of Herds)		
Metritis	1	2	9
Abortions	3	2	7
Calving Problems[a]	0	3	9
Cystic Cows[b]	4	1	7

[a]Cows having dystocia, retained placenta, milk fever.

[b]Cows having ovarian follicular cysts, and cystic corpora lutea.

Table 13.--Regular[a] veterinary care.[b]

Number of Herds	Response
11	Yes
1	No

[a]Monthly visits.

[b]Consisting of postpartum examinations, pregnancy diagnosis, and treatment of reproductive problems.

Table 14.--Nutrition level compared with last years.

Number of Herds	Change
2	Better
10	Same
0	Worse

Table 15.--Dry period length.

Number of Herds	Days Dry
1	Approx. 35
4	40-50
6	60-65
1	No Answer

Table 16.--Rolling herd average.

Number of Herds	Range (lbs.)
2	10,000 - 11,999
2	12,000 - 13,999
4	14,000 - 15,999
4	16,000 - 17,999

Table 17.--Change in milk during year.

Number of Herds	Change
6	Increase
3	Decrease
3	No Change

Table 18.--Cull reasons and frequencies.[a]

Reason	0-24(%)	25-49(%)	50-74(%)	75-100(%)
	(Number of Herds)			
Low Production	5[b]	5	2	0
Sterility and Infertility	3	4	4	1
Dairy Purposes	8	1	2	0
Other Reasons	7	5	0	0

[a]Percent of total cows culled per herd.

[b]Number of herds that low production accounted for less than 25% of total cows culled.

Table 19.--Effect of changes during year.

Change		Effect[a]	
No. of Herds	Change	No. of Herds	Effect
6	Additional cows purchased	1	Increased breeding problems
		1	Increased calving problems
2	Large number of cows sold		
3	Housing and/or parlor change		
2	Herdsman change		
1	Toxicity problem[b]	1	Increased death loss
1	IBR problem[c]	1	Increased abortions, breeding problems
4	No change		
1	Dairy Herd Monitor purchased	1	Useful

[a] Blank spaced indicate no effect reported.

[b] Nitrates.

[c] Infectious Bovine Rhinotracheitis.

APPENDIX D

TABLES

Table D-1.--Age at calving, lactation number, and herd milk yields for cows in herds participating in the early breeding project.

Herd	Age at Calving[a]	Lactation Number	Milk Yield (lbs.)	
			1972[b]	1974[c]
1	43±2.4[d]	2.3±0.17	14,794	14,885
2	53±3.5	3.0±0.28	17,038	16,053
3	50±3.5	2.5±0.24	18,236	16,367
4	40±2.2	2.0±0.17	13,538	12,758
5	50±3.3	2.9±0.26	16,208	14,577
6	46±3.4	2.7±0.27	16,045	16,340
7	52±2.5	2.9±0.19	14,481	14,096
8	45±2.0	2.2±0.16	13,176	15,331
9	58±4.1	2.9±0.26	15,132	10,848
10	50±2.0	2.7±0.14	13,342	11,206
11	51±2.5	2.8±0.19	16,013	16,546
12	48±2.6	2.9±0.26	15,993	14,116
Ave.	48±0.8	2.6±0.06	14,914[e]	14,040[e]

[a]Age in months for cows calving in 1972.

[b]305 2X-ME (pounds) for cows calving in 1972 that were open less than 250 days and lactated more than 250 days.

[c]Rolling herd average September, 1974 from DHIA records.

[d]Mean ± S.E.

[e]Average milk yield per cow.

Table D-2.--Description of variables used in least squares multiple regression analyses.

1. Main effects for least squares analyses of interval to conception, interval from first insemination to conception, and inseminations per conception

Y_{ijklm} = Parameter of interest

μ = Constant (mean)

T_i = Treatment

S_j = Season

H_k = Housing

Z_l = Herd size

TS_{ij} = Treatment by season interaction

TH_{ik} = Treatment by housing interaction

TZ_{il} = Treatment by herd size interaction

SH_{jk} = Season by housing interaction

SZ_{jl} = Season by herd size interaction

HZ_{kl} = Housing by herd size interaction

TSH_{ijk} = Treatment by season by housing interaction

TSZ_{ijl} = Treatment by season by herd size interaction

2. Main effects for least squares analyses of interval to first estrus, interval to first insemination, and 150 day milk yield

Y_{ijlmn} = Parameter of interest

μ = Constant (mean)

T_i = Treatment

S_j = Season

Z_l = Herd size

R_{nl} = Herds within herd size

Table D-2.--Continued.

TS_{ij}	= Treatment by season interaction
TZ_{il}	= Treatment by herd size interaction
SZ_{jl}	= Season by herd size interaction
TSZ_{ijl}	= Treatment by season by herd size interaction

3. List of other variables for all least squares analyses

X_1	= Number of times detected in estrus before first insemination
X_2	= Interval to first estrus
X_3	= Interval to first insemination
X_4	= Interval to conception
X_5	= Interval from first insemination to conception
X_6	= 150 day milk yield
X_7	= Age in months at calving
X_8	= Number of inseminations
X_iX_j	= Interactions of above variables
X_i^2	= Quadratic term of above variables
e_{ijklm}	= Error term

Table D-3.--Interval to first estrus for cows in Treatments I, II, and III within herd--1973-74.[a]

Herd	Treatment			Total
	I	II	III	
1	65±4.4[b]	76±4.7	60±12.0	70±3.2[a]
2[c]	57±5.2	63±5.5	119±21.6	67±4.8[a]
3	67±4.3	74±5.9	57±[d]	70±3.6[a]
4	54±5.7	47±4.5	53±6.7	51±3.2[b]
5	45±4.8	46±8.7	57±7.6	46±4.1[b]
6	56±4.9	46±5.8	39±5.7	48±3.4[b]
7	62±6.1	70±5.2	67±6.1	66±3.7[a]
8	54±4.1	53±4.1	65±25.2	54±2.9[b]
9	66±4.6	73±4.7	80±9.4	70±3.1[a]
10	71±5.1	69±5.2	71±12.6	70±3.6[a]
11	37±4.4	39±3.9	42±4.5	39±2.5[b]
12	49±5.0	40±2.8	47±4.2	45±2.7[b]
Ave.	57±1.5	59±1.6	59±3.5	58±1.1

[a]Cows open longer than 250 days excluded.

[b]Mean ± S.E.

[c]Significant differences exist among treatments in this herd ($p < .05$).

[d]Insufficient numbers to calculate standard error.

[e]Means with same letter are not different from each other.

Table D-4.--Least squares analysis of variance for interval to first estrus.

Variable	D.F.	M.S.	F.	Sign.
Treatment (TRT)	2	176.8	0.2	.82
Season	3	772.3	0.8	.47
Herd Size	3	1342.4	1.5	.22
TRT X Season	6	1121.4	1.2	.29
TRT X Herd Size	6	865.2	0.9	.46
Season X Herd Size	9	1477.7	1.6	.11
TRT X Season X Herd Size	16	1659.1	1.8	.03*
Herds/Herd Size	8	6712.7	7.3	.0005***
Other	5			
Error	823	915.3		
Total	881			

Table D-5.--Least squares adjusted means for interval to first estrus.

Code[a]	Treatment	Season	Herd Size	Herds/Herd Size[b,c]			
				1	2	3	4
1	57.1	62.6	61.3	47.4	72.7	63.2	60.5
2	58.3	58.5	55.5	69.6	51.7	62.3	59.0
3	60.1	57.3	62.9		51.0	50.0	63.8
4		55.5	54.2				50.7

[a]Code for treatments (TRT) 1=TRT1, 2=TRT2, 3=TRT3.

Code for season of calving 1=January-March, 2=April-June, 3=July-September, 4=October-December.

Code for herd size 1=Small, 2=Medium, 3=Medium-Large, 4=Large.

[b]Code for herds/herd size 1 (small)= herds 5,9; 2 (medium)=herds 2, 6, 12; 3 (medium-large)=herds 1, 3, 8; 4 (large)=herds 4, 7, 10, 11.

[c]Significant differences exist among herds/herd size ($p < .0005$).

Table D-6.--Days to first insemination for cows within herds by years and treatments.[a]

Herd	Year and Treatments				
	1973-74				1972
	I	II	III	Total	Ave.
1[d]	71±3.8[b]	87±4.0	60±12.0	78±3.0[e,c]	85±4.2[d]
2	66±5.1	75±5.8	119±21.6	76±4.6[e,c]	85±6.3[d]
3	74±3.4	85±4.0	82±[c]	79±2.6[e,c]	87±3.5[d]
4	74±4.5	81±4.2	78±5.7	77±2.7[e,c]	86±3.7[d]
5	59±4.6	78±7.4	57±7.6	66±4.0[b,c]	77±6.3[d]
6	68±4.7	77±6.1	77±6.1	73±3.5[e,c]	85±4.3[d]
7[d]	86±5.3	99±4.5	73±8.6	91±3.3[e]	72±3.2
8[d]	65±3.3	77±2.4	100±4.1	72±2.2[e,c]	80±2.2[d]
9	76±4.2	79±4.7	90±5.2	79±2.8[e,c]	73±3.8
10	81±5.0	89±5.2	87±10.5	86±3.4[e]	94±3.7[d]
11	71±4.2	77±3.1	89±6.6	77±2.5[e,c]	93±3.5[d]
12	68±3.4	63±2.8	74±13.3	66±2.4[b,c]	72±3.0[d]
Ave.	73±1.3	82±1.4	83±3.2	78±0.9	84±1.2

[a]Cows open longer than 250 days excluded.

[b]Mean ± S.E.

[c]Insufficient numbers to calculate S.E.

[d]Significant differences exist among treatments within herd ($p < .05$).

[e]Means with same letter are not different from each other within years.

Table D-7.--Least squares analysis of variance for interval to first insemination.

Variable	D.F.	M.S.	F.	Sign.
Treatments (TRT)	2	765.4	3.2	.04*
Season	3	46.1	0.2	.90
Herd Size	3	315.0	1.3	.27
TRT X Season	6	71.2	0.3	.94
TRT X Herd Size	6	256.8	1.1	.38
Season X Herd Size	9	227.2	0.9	.48
TRT X Season X Herd Size	16	253.7	1.1	.39
Herds/Herd Size	8	579.7	2.4	.01**
Interval First Estrus	1	5365.9	22.3	.0005***
Interval First Estrus^2	1	1385.2	5.7	.02*
No. Heats	1	11156.2	46.5	.0005***
No. Heats^2	1	8669.9	36.1	.0005***
Other	10			
Error	768	239.9		
Total	839			

Table D-8.--Least squares adjusted means for interval to first insemination.

Code[a]	Treatment[b]	Season	Herd Size	Herds/Herd Size[c,d]			
				1	2	3	4
1	75.6	78.8	79.4	79.6	79.4	79.6	76.0
2	79.2	78.7	75.7	76.9	78.6	78.1	81.6
3	79.4	77.0	77.9		76.2	76.5	78.1
4		77.8	79.3				76.5

[a]Code for treatments (TRT) 1=TRT1, 2=TRT2, 3=TRT3.

Code for seasons of calving 1=January-March, 2=April-June, 3=July-September, 4=October-December.

Code for herd size 1=Small, 2=Medium, 3=Medium-Large, 4=Large.

[b]Significant differences within treatments ($p < .05$).

[c]Codes for herds/herd size 1 (small)=herds 5, 9; 2 (medium)=herds 2, 6, 12; 3 (medium-large)=herds 1,3,8; 4 (large)=herds 4, 7, 10, 11.

[d]Significant differences exist among herds/herd size ($p < .05$).

Table D-9.--Days between estrus and inseminations for all cows by herds.[a]

Herd	Estrus Intervals			Insemination Intervals				
	1-2[b,d]	2-3	3-4	1-2[c,d]	2-3	3-4	4-5	5-6
	Days			Days				
1	41	20	--	40	47	24	--	--
2	42	--	--	43	35	33	36	23
3	29	20	--	37	40	48	--	--
4	28	35	22	40	37	37	20	--
5	37	59	--	47	42	44	--	--
6	32	24	24	54	36	32	20	22
7	52	34	20	43	38	26	33	35
8	28	29	22	33	33	41	27	22
9	39	24	--	34	33	25	23	24
10	39	37	50	33	30	38	34	30
11	29	28	31	40	42	42	--	--
12	32	31	25	25	29	34	45	22
Ave.	33	30	29	39	36	36	33	28

[a]Cows open less than 250 days excluded.

[b]Interval between first and second estrus (days).

[c]Interval between first and second insemination (days).

[d]Significant differences exist among herds ($p < .05$).

Table D-10.--Days from first estrus to first insemination for cows in Treatments I, II, and III within herds.[a]

Herd	I	II	III	Total
1	6[b]	11	0	8
2	9	12	0	9
3	7	11	25	9
4	20	34	25	26
5	14	32	0	20
6	12	31	38	25
7	26	29	6	25
8	11	24	35	18
9	10	6	10	9
10	10	20	16	16
11	34	38	47	38
12	19	23	27	21
Ave.	17	23	24	20

[a]Cows open longer than 250 days excluded average in days.

[b]Mean.

Table D-11.--Days to conception for cows within herds by years and treatments.[a]

Herd	Year and Treatments				
	1973-74				1972
	I	II	III	Total	Total
1[d]	78±4.9[b]	107±5.7	201±28.0	95±4.9[e,b]	105±5.8
2	126±12.2	106±10.7	130±28.5	118±7.8[e,b]	114±8.2
3	86±7.0	104±8.3	82±[c]	95±5.5[e,b]	101±6.6
4	88±7.0	108±8.0	99±9.7	99±4.7[e,b]	133±8.0
5	100±11.8	101±14.6	87±22.9	99±8.3[e,b]	98±8.9
6	115±15.2	117±9.6	120±16.6	116±7.5[e,b]	90±5.2
7	119±8.0	112±6.7	130±22.8	121±5.2[e]	104±5.0
8	93±6.5	111±8.2	110±23.1	101±5.0[e,b]	112±5.5
9	97±7.5	105±8.2	92±9.5	100±5.1[e,b]	95±8.2
10	117±9.9	101±5.5	129±15.7	111±5.4[e,b]	130±5.3
11	90±9.4	90±6.1	109±10.8	94±4.9[e,b]	112±5.1
12	86±2.7	80±5.3	84±11.7	83±4.7[b]	103±8.8
Ave.	99±2.7	105±2.3	112±5.4	103±1.7	111±1.9

[a]Cows open longer than 250 days excluded.

[b]Mean ± S.E.

[c]Insufficient numbers to calculate S.E.

[d]Significant differences exist among treatments in herd 1 ($p < .05$).

[e]Means with same letter are not different from each other within years ($p < .05$).

Table D-12.--Least squares analysis of variance for interval to conception.

Variable	D.F.	M.S.	F	Sign.
Treatment (TRT)	2	1.68	0.269	.76
Season	3	4.07	0.653	.58
Herd Size	3	2.17	0.348	.79
Housing	1	0.44	0.070	.79
TRT X Herd Size	6	2.66	0.426	.86
TRT X Season	6	2.35	0.376	.89
TRT X Housing	2	3.71	0.594	.55
Season X Herd Size	8	4.24	0.680	.71
Season X Housing	3	6.00	0.961	.41
TRT X Season X Herd Size	16	5.31	0.851	.63
TRT X Season X Housing	6	3.89	0.623	.71
Interval to First Insemination (IFI)	1	2160.45	346.016	.0005***
Interval from First Insemination to Conception (IFITC)	1	3692.00	591.309	.0005***
IFI X Number of Insemi-nations	1	28.19	4.516	.03*
IFI X IFITC	1	64.69	10.361	.001**
IFICT X Interval First Estrus	1	27.49	4.404	.04*
IFITC X Number of Estrus Periods	1	24.45	3.917	.05*
OTHER	29	6.24		
ERROR	588			
TOTAL	679			

Table D-13.--Least squares adjusted means for interval to conception.

Code[a]	Housing	Treatment	Herd Size	Season
1	103.7	103.6	103.3	104.0
2	103.5	103.4	103.6	103.7
3		103.8	104.0	103.3
4			103.5	103.5

[a]Code for housing 1=free stalls, 2=stanchions.

Code for treatments (TRT) 1=TRT1, 2=TRT2, 3=TRT3.

Code for herd size 1=Small, 2=Medium, 3=Medium-Large, 4=Large.

Code for season of calving 1=January-March, 2=April-June, 3=July-September, 4=October-December.

Table D-14.--Days from first insemination to conception for cows within herds by years and treatments.[a]

Herd	Year and Treatments				
	1974-74				1972
	I	II	III	Total	Total
1[c]	8±3.5[b]	18±5.8	140±15.0	17±4.3[e]	21±5.1
2[c]	59±12.2	25±7.8	8±8.4	40±7.2	29±7.5
3	13±6.0	21±6.7	0	16±4.4[e]	14±5.3
4	21±6.7	30±7.9	23±9.7	25±4.6[e]	47±7.5
5	40±13.3	31±12.3	30±30.3	36±8.9[e]	21±8.7
6	49±14.7	41±8.0	45±16.9	44±6.9[e]	5±4.6
7	37±8.1	25±5.6	57±19.8	34±5.0[e]	32±4.8
8	27±6.3	35±7.7	10±9.8	30±4.7[e]	32±5.2
9	18±6.8	22±8.1	6±5.8	19±4.8[e]	22±7.9
10	38±9.9	20±5.5	52±15.7	32±5.4[e]	36±5.3
11	20±7.3	14±5.7	21±11.1	17±4.3[e]	19±5.0
12	18±2.8	16±5.2	4±4.2	15±4.7[e]	31±8.3
Ave.	28±2.5	25±2.0	30±5.0	30±1.6	27±1.6

[a]Cows open longer than 250 days excluded.

[b]Mean ± S.E.

[c]Significant differences exist among treatments within herd ($p < .05$).

[d]Means with same letter are not significantly different within years ($p < .05$).

Table D-15.--Least squares analyses of variance for interval from first insemination to conception.

Variables	D.F.	M.S.	F.	Sign.
Treatment (TRT)	2	.96	.1481	.862
Season	3	1.87	.2901	.833
Herd Size	3	1.01	.1550	.926
Housing	1	.00	.000	.996
TRT X Herd Size	6	1.47	.2268	.968
TRT X Season	6	1.25	.1928	.979
TRT X Housing	2	1.88	.2896	.749
Season X Herd Size	8	3.22	.4950	.860
Season X Housing	3	2.94	.4514	.716
TRT X Season X Herd Size	16	4.82	.7406	.753
TRT X Season X Housing	6	2.83	.4345	.856
Interval to First Insemination (IFI)	1	2745.25	422.1147	.0005***
IFI^2	1	49.47	7.6068	.006**
Interval to Conception	1	14381.96	2211.3949	.0005***
Interval to First Estrus X Milk	1	25.74	3.9584	.047*
Interval to Conception X Milk	1	27.19	4.1800	.041*
OTHER	22			
ERROR	596	6.50		
TOTAL	679			

Table D-16.--Least squares adjusted means for interval from first insemination to conception.

Code[a]	Housing	Treatments	Herd Size	Season
1	27.11	27.1	27.3	26.9
2	27.11	27.2	27.2	27.0
3		27.0	26.8	27.4
4			27.2	27.1

[a]Code for housing 1=Free stall, 2=Stanchion.

Code for treatments (TRT) 1=TRT1, 2=TRT2, 3=TRT3.

Code for herd size 1=Small, 2=Medium, 3=Medium-Large, 4=Large.

Code for season of calving 1=January-March, 2=April-June, 3=July-September, 4=October-December.

Table D-17.--Percent conception at the first through fourth inseminations for cows within herds--1972.[a]

Herd	Insemination Number			
	1	2	3	4
1	56[b](19)[c]	100(14)	--[d]	--
2	50(20)	50(10)	60(6)	75(3)
3	73(27)	60(16)	75(3)	--
4	39(18)	50(14)	14(2)	42(5)
5	60(18)	75(9)	100(3)	--
6	75(25)	89(8)	100(1)	--
7	48(34)	46(17)	50(10)	100(10)
8	45(30)	35(13)	58(14)	50(5)
9	63(20)	58(7)	60(3)	50(1)
10	49(44)	67(30)	80(12)	100(3)
11	66(40)	57(12)	67(6)	100(3)
12	57(21)	56(9)	14(1)	33(2)
Ave.	55(316)	57(149)	54(61)	63(32)

[a]Cows open longer than 250 days excluded (30 cows).

[b]Percent conceiving.

[c]Number conceiving.

[d]Data incomplete due to lost herd records.

Table D-18.--Percent conception at the first through fourth inseminations cows within herds--1973-74.[a]

Herd	Insemination Number			
	1	2	3	4
1	73[b](49)[c]	61(11)	100(7)	--
2	45(22)	59(16)	27(3)	50(4)
3	68(30)	71(10)	75(3)	100(1)
4	61(48)	55(17)	57(8)	100(6)
5	46(12)	57(8)	66(4)	100(2)
6	40(19)	61(17)	55(6)	80(4)
7	47(36)	63(26)	73(11)	25(1)
8	50(39)	49(19)	70(14)	83(5)
9	61(22)	57(8)	83(5)	0(0)
10	42(28)	66(25)	46(6)	42(3)
11	67(45)	68(15)	57(4)	100(3)
12	65(32)	58(10)	7(5)	50(1)
Ave.	56(382)	60(182)	63(76)	66(30)

[a]Cows open longer than 250 days excluded (15 cows).

[b]Percent conceiving.

[c]Number conceiving.

Table D-19.--Inseminations per conception for cows within herds by years and treatments.[a]

Herd	Year and Treatments				
	1973-74				1972
	I	II	III	Total	Total
1	1.2±.08[b]	1.4±.13	3.0±[c]	1.4±.08[e]	1.4±.09[b]
2	2.6±.33	1.6±.19	1.2±.20	2.0±.19[e]	1.9±.17[b]
3	1.3±.14	1.5±.17	1.0±[c]	1.4±.11[e]	1.4±.14[b]
4	1.6±.18	1.8±.18	1.5±.19	1.6±.11[e]	2.4±.22[b]
5	1.8±.22	2.0±.42	1.7±.67	1.8±.19[e]	1.5±.11[b]
6	2.1±.36	2.0±.18	1.7±.29	2.0±.16[e]	1.3±.09[e]
7	2.0±.22	1.6±.11	2.0±.27	1.8±.12[e]	1.9±.13[b]
8	1.9±.17	1.9±.17	1.3±.25	1.8±.12[e]	2.2±.18[b]
9	1.6±.20	1.7±.27	1.3±.25	1.6±.16[e]	1.7±.21[b]
10[d]	2.1±.24	1.6±.15	2.7±.63	2.0±.16[e]	1.7±.09[b]
11	1.5±.17	1.4±.15	1.5±.22	1.5±.10[e]	1.5±.11[b]
12	1.6±.09	1.7±.21	1.2±.20	1.6±.16[e]	2.0±.26[b]
Ave.	1.8±.07	1.7±.05	1.7±.17	1.7±.04	1.8±.05

[a]Cows open longer than 250 days excluded.

[b]Mean ± S.E.

[c]Insufficient numbers to calculate standard error.

[d]Significant differences exist among treatments within herd ($p < .05$).

[e]Means with same letter are not significantly different within years.

Table D-20.--Least squares analysis of variance for inseminations per conception.

Variable	D.F.	M.S.	F.	Sign.
Treatment (TRT)	2	.531	2.36	.09
Season	3	.404	1.79	.15
Herd Size	3	.492	2.19	.09
Housing	1	1.052	4.67	.03*
TRT X Herd Size	6	.443	1.97	.07
TRT X Season	6	.345	1.53	.16
TRT X Housing	2	.529	2.35	.10
Season X Herd Size	8	.270	1.20	.30
Season X Housing	3	.210	0.93	.42
TRT X Season X Herd Size	16	.166	0.74	.75
TRT X Season X Housing	6	.267	0.19	.31
Interval to Conception (ITC) Interval to Conception^2	2	.663	2.95	.05*
Interval to First Insemination (IFI) X Milk	1	.861	3.83	.05*
Interval From First Insemination to Conception (IFITC) X Milk	1	.863	3.84	.05*
ITC X Milk	1	.864	3.84	.05*
IFITC X Age	1	.817	3.63	.06
ITC X Age	1	.817	3.63	.06
IFITC	1	.781	3.47	.06
IFI X Age	1	.786	3.49	.06
IFI X IFITC	1	.751	3.34	.07
No. Heats X Age	1	.720	3.20	.07
IFI	1	.722	3.21	.07
ITC	1	.710	3.16	.08
OTHER	23			
ERROR	588	.2249		
TOTAL	679			

Table D-21.--Least squares adjusted means for inseminations per conception.

Code[a]	Housing[b]	Treatments	Herd Size	Season
1	1.85	1.81	1.57	1.59
2	1.59	1.79	1.72	1.78
3		1.58	1.72	1.76
4			1.89	1.78

[a]Code for housing 1=Free stall, 2=Stanchion.

Code for treatments (TRT) 1=TRT1, 2=TRT2, 3=TRT3.

Code for herd size 1=Small, 2=Medium, 3=Medium-Large, 4=Large.

Code for season of calving 1=January-March, 2=April-June, 3=July-September, 4=October-December.

[b]Significant effect ($p < .05$).

Table D-22.--Least squares analysis of variance for 150 day milk yield.

Variable	D.F.	M.S.	F.	Sign.
Treatment (TRT)	2	8,036,310	4.51	.01**
Season	3	450,871	.25	.86
Herd Size	3	11,339,024	6.36	.0005***
TRT X Season	6	932,910	.52	.52
TRT X Herd Size	6	3,024,745	1.70	.12
Season X Herd Size	8	2,305,886	1.29	.24
TRT X Season X Herds	16	4,387,599	2.46	.001**
Herds/Herd Size	8	26,952,971	15.11	.0005***
Age	1	180,545,401	101.24	.0005***
Age^2	1	179,847,742	100.86	.0005***
OTHER	12			
ERROR	613	1,783,227		
TOTAL	679			

Table D-23.--Least squares adjusted means for 150 day milk yield.

Code[a]	Treatment[b]	Season	Herd Size[c]	Herds/Herd Size[d,e]			
				1	2	3	4
1	8,489[f]	8,243	8,156	8,538	8,510	8,524	7,560
2	8,296	8,169	8,723	7,810	7,910	9,011	7,942
3	7,737	8,066	7,694		8,102	6,987	8,185
4		8,218	8,123				9,009

[a]Code for treatments (TRT) 1=TRT1, 2=TRT2, 3=TRT3.

Code for season of calving 1=January-March, 2=April-June, 3= July-September, 4=October-December.

Code for herd size 1=Small, 2=Medium, 3=Medium-Large, 4=Large.

[b]Significant differences among treatments ($p < .01$).

[c]Significant differences among herd size ($p < .0005$).

[d]Code for herds/herd size 1 (small)=herds 5,9; 2 (medium)= herds 2,6, 12; 3 (medium-large)=herds 1,3,8; 4 (large)=herds 4,7, 10, 11.

[e]Significant differences among herds/herd size ($p < .0005$).

[f]Pounds.

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