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Study of Some Factors Affecting Efficiency of Reproduction In Dairy Cattle Serviced By Artificial Insemination

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This bulletin is a report on Department of Dairy Husbandry research project number 89 entitled "Increasing the Effectiveness of Artificial Insemination as a means of Improving Dairy Cattle."

Study of Some Factors Affecting Efficiency of Reproduction In Dairy Cattle Serviced by Artificial Insemination*

T. E. PATRICK AND H. A. HERMAN

ABSTRACT AND CONCLUSIONS

1. A study was made of the effect of the site of insemination in the reproductive tract on reproductive efficiency of 5,422 dairy cows in Louisiana artificial breeding associations. Sixteen cooperating technicians assisted in the study. Semen from 49 bulls was used. Records compiled by the Louisiana Artificial Breeding Cooperative, Inc., were used in computing breeding efficiencies. Efficiency of reproduction was based on the percentage 60 to 90-day non-returns to first service.

2. The non-returns for the four sites of insemination studied were as follows: combination cervix and body of uterus, 66 percent; middle of cervix, 66 percent; body of uterus, 68 percent; and horns of uterus, 67 percent. These differences were negligible and indicate that no increases in breeding efficiency may be expected by depositing semen beyond the mid-point of the cervix.

3. However, when semen was used the third day after collection, breeding efficiencies for intracervical, intrauterine and intracornual inseminations were 64, 65 and 69 percent, respectively. A significant increase of 5 percentage points in breeding efficiency was observed for cornual as compared to cervical semen depositions when three day old semen was used.

4. A large majority of the cows studied were inseminated during the second and third six-hour periods after estrus was observed. First service non-returns for the first, second, third and fourth six-hour intervals after estrus was observed were 69, 65, 68 and 66 percent, respectively. These differences do not indicate any important relation between time of insemination and breeding efficiency for cows serviced within 24 hours after the beginning of estrus.

*Data for this investigation were secured through cooperation with the Louisiana Artificial Breeding Cooperative, and Louisiana State Experiment Station, Baton Rouge, La.

5. Due to the small number of services made during the first six-hour interval, the average breeding efficiency for cows serviced during the third interval (12 to 18 hours after estrus observed) was considered highest, with those inseminated during the second and fourth intervals only slightly lower.

6. The percentage non-returns for 507 virgin heifers was 68, compared to 67 for 2,070 young cows and 69 for 2,768 mature cows. These small differences in conception rate do not indicate heifers are any more difficult to breed than cows that have had one or more calves.

7. A large percentage of the cattle in this study were in fair and good physical condition with only 3.5 percent being classified as poor and 0.5 percent as overfat. Breeding efficiencies for cows classified as poor, fair, good and overfat were 75, 68, 65, and 66 percent, respectively. These results indicate that physical condition was not a major cause of breeding failure. Though roughage feeding practices were inadequate for efficient production in a large percentage of the cases studied, neither quantity nor quality of roughage fed could be charged as being responsible for lowered breeding efficiency. Lack of supplementary minerals did not appear to be a factor contributing to breeding difficulties in the animals studied.

8. Evidences of vaginitis were observed in 10.2 percent of the cows inseminated. Breeding efficiency for animals exhibiting symptoms of vaginitis was 60 percent, compared to 66 percent for those free from this disease. Data available on a limited number of cows indicated Brucellosis was an important factor affecting breeding efficiency. Animals in Brucellosis free herds required 1.77 services per conception compared to 2.10 for cows in infected herds.

9. Semen showed a steady decline in fertility with advancing age. The percentage daily increases in breeding efficiency ranged from 1.4 to 5.9 percent with a mean of 3.27 percent. It was considered significant that fertility declined only 1.4 percent between the first and second day.

10. A significant upward trend in breeding efficiency was observed where cows were inseminated at increasing intervals up to 135 days after parturition. A gradual decline in conception rate occurred for those serviced at later intervals. Only 57 percent of the cows inseminated less than 37 days after calving conceived from one service, compared to 76 percent for those bred 106 to 135 days postpartum.

11. Breeding efficiency based on 94,935 first services was studied by months and seasons for a year period. The mean conception rate was highest in June and lowest in August and February. When the data were summarized by seasons, the average percentage non-returns was highest in spring with summer, fall and winter showing little difference.

12. The percentage of bulls producing inferior quality semen was lowest during spring and highest during summer months, with fall and winter being intermediate.

IMPORTANCE OF PROBLEM

Artificial insemination of dairy cattle is considered the greatest tool available to the average dairy farmer for mass improvement in the inheritance of dairy cattle. Few, if any, practices designed to increase milk production and improve conformation of cattle have enjoyed as much popularity and general acceptance as has artificial insemination.

The annual average butterfat production for all dairy cows in the United States is only 210 pounds. It is estimated to be less than 175 pounds for the average dairy cow in Louisiana. In comparison, the annual butterfat production level of daughters of proved sires used in artificial insemination is 459 pounds. The influence of such sires on the inherited capacity of their daughters for milk and butterfat production is believed to be of far reaching effect.

First cooperative association in America for artificial insemination of dairy cattle was organized in 1938 at Clinton, N. J., with 102 members and 1,050 cows. During the next few years artificial insemination associations were organized in Missouri, New York, Pennsylvania, Wisconsin, Minnesota and many other dairy states. By January of 1952 artificial insemination was being practiced in every state of the Union with 1,648 associations servicing 3,509,573 cows in 543,397 herds annually.

Delayed breeding and sterility have long been recognized as major problems in the dairy industry. However, records kept in connection with artificial insemination have done much to bring this situation to the attention of dairy farmers and investigators alike. It has been estimated that losses due to sterility in cattle in the dairy industry of this country exceeds \$300,000,000 annually (Perry, 1949).

Some dairy farmers have attributed breeding problems in their herds to artificial insemination, reporting that a large majority of the cows conceived from one service when natural service was used. However, in most instances they had incomplete or no records at all to substantiate their claims. Conception rates in both natural and artificial service average from 1.7 to 2.0 services per calf, one method being equally as efficient as the other (Asdell, 1948). Similar results have been reported by Herman and Ragsdale (1950).

Numerous investigations have been conducted in an effort to determine the factors associated with low reproductive efficiency. Nevertheless, delayed breeding and sterility are still prevalent in dairy herds throughout the United States as is shown by the fact that only slightly more than 50 percent of all artificial inseminations result in conception. The importance of this problem is further emphasized by the fact that the percent of cows removed from herds each year due to breeding troubles remains at a relatively high level (Herman and Madden, 1949; Norton, 1952).

Reproduction in the cow is a complex phenomenon with many ramifications. It is remarkable that the cow can produce an ovum which when fertilized by the spermatozoon from the bull develops from a single cell

into a calf weighing 60 to 100 pounds in 9 months. It is not surprising that reproductive failures occur occasionally. In fact it is phenomenal that there are not more reproductive failures in view of the complex mechanisms involved.

REVIEW OF LITERATURE

Physiological and Anatomical Factors Affecting Breeding Efficiency in Dairy Cattle

Rate of Travel and Survival of Spermatozoa in the Reproductive Tract. The length of time required for spermatozoa to reach the ovarian portion of the Fallopian tube and survival in the reproductive tract are important factors in determining the optimum time and site of insemination.

Sergin *et al.* (1940) reported that the environmental conditions of the genital tract of the cow cause an increase in spermatozoan activity and thus reduce survival time. Environment in the cervix was found to be more favorable for spermatozoa survival than either the vagina or uterus. In a study of 22 cows, Beschlebnov (1940) found live spermatozoa in the cervix 24 to 30 hours after service as compared to 4 hours in the vagina and 10 to 15 hours in the uterus and Fallopian tubes. Andreev (1936) and Kirillov (1937) observed that spermatozoa remained active for 22 to 25 hours in the reproductive tract of the cow.

Beschlebnov (1937) reported that the cervix was filled with sperm in one-half hour and that sperm entered the uterus less than 40 minutes after service. Live sperm were found in the Fallopian tubes four hours after service. Brewster *et al.* (1940) reported that the minimum time required for spermatozoa to reach the Fallopian tubes was 4 hours and 15 minutes in heifers and 5 hours in mature cows. More recently VanDemark and Moeller (1951) reported that motile spermatozoa placed in the cervix by artificial insemination or in the vagina by natural service reached the ovarian portion of the Fallopian tube in 2½ minutes. Non-motile spermatozoa deposited in the cervix were transported to the ovarian portion of the Fallopian tube in 4.3 minutes or less. Spermatozoa are transported *in vivo* at a much faster rate than is indicated as being possible from their own motility *in vitro*.

Age of Semen at the Time of Insemination. Herman and Swanson (1941) observed a gradual decrease in the fertility of both diluted and undiluted semen with advancing age. However, 1 of 3 cows inseminated with semen 120 to 200 hours of age conceived. Salisbury (1942) reported that semen in New York State was being used for at least 4 days with satisfactory results. In a later report Herman and Madden (1949) stated that optimum results were obtained when semen less than 24 hours old was used. Fertility of most semen declines with age and will not result in a satisfactory conception rate if it is used beyond 36-48 hours after collection.

Weeth and Herman (1951) compared intracervical and intrauterine methods of insemination with semen ranging up to 60 hours of age. The conception rates of intracervical inseminations were 52.4, 42.3 and 34.2 for semen less than 12, 24 to 36 and 48 to 60 hours of age, respectively. Conception rates for the intrauterine inseminations were 57.4, 55.4 and 44.6 with semen less than 12, 24 to 36 and 48 to 60 hours of age, respectively. A 10.1 percent drop in fertility was observed between fresh and 1 day old semen for the intracervical method as compared to a 2.0 percent decrease for the intrauterine method. The decrease observed for 1-day-old semen with the intracervical method was highly significant but negligible for the intrauterine method.

Stored semen ranging in age up to 60 hours or over is used extensively by breeding associations throughout the United States. A large percentage of the bull studs make a practice of shipping fresh semen 4 to 7 times a week, thus making relatively fresh semen available at all times. Although adequate data are available for making a comprehensive study of the effect of age of semen on breeding efficiency, the author is not aware of a report of this nature.

Time of Ovulation. Brewster *et al.* (1940, 1941) made 83 rectal examinations on 47 cows to determine the time of ovulation. The mean time of ovulation was found to be 13.57 hours after the end of estrus. On the average, ovulation in heifers occurred 11.4 hours after the end of estrus as compared to 14.48 hours for cows. Eighty-nine percent of the ovulations occurred between 6 and 19 hours after the end of estrus. In a study of 125 cows Gerosimova (1937) found that ovulation occurred between 16 and 38 hours after the onset of estrus with the mean time of ovulation being 27 hours and 50 minutes. Eighty-nine percent of the ovulations occurred between 20 and 32 hours after the onset of estrus. Hammond (1927) likewise found that ovulation in dairy cows occurred 24 to 48 hours after the onset of estrus. In a recent study, Hansel and Trimberger (1952) found that ovulation in dairy heifers occurred 8 to 17 hours after the end of estrus with the mean time of ovulation being 12.3 hours after the end of estrus.

Stage of Estrus Inseminated. Breeding during the optimum stage of estrus was not a problem when the bull ran in the pasture with the cows because the cow was usually serviced several times during the period. However, this problem is of utmost importance today since a large percentage of the dairy cattle in this country are serviced only once during estrus either by natural mating or artificial insemination. Kirillov (1937) conducted a study in which the herd was divided into two groups. Only 26 percent of the cows bred 18 to 24 hours after the onset of estrus had to be rebred while 60 percent of those bred at the beginning of estrus required subsequent service.

Bartlett and Perry reported higher conception rates for cows inseminated 8 to 20 hours after the onset of estrus. Herman (1939) reported maxi-

imum breeding efficiency for cows inseminated during active estrus. Barrett and Casida (1946) obtained the highest rates of conception for cows inseminated 3 to 20 hours after the onset of estrus. Trimberger and Davis (1943) conducted a controlled experiment in which cows were inseminated at various stages of estrus. The percentages of conception from one insemination for the different stages were as follows: start of estrus 44.0, middle of estrus 82.5, middle of estrus and rebred in 24 hours 84.0, end of estrus 75.0, 6 hours after estrus ended 62.5, 12 hours after estrus ended 32.0, 18 hours after estrus ended 28.0, 24 hours after estrus ended 12.0, 36 hours after estrus ended 8.0, and 48 hours after estrus ended 0 percent. In a subsequent study, Trimberger (1944) inseminated cows at various intervals before and after ovulation. The results were as follows: inseminations made 24 hours before ovulation gave 53.3 percent conception; 19 to 24 hours, 73 percent; 13 to 18 hours, 85.7 percent; 7 to 12 hours, 78.6 percent; 6 hours or less, 57.1 percent; 2 hours or less after ovulation, 30 percent; 3 to 6 hours, 40 percent; 7 to 12 hours, 30 percent.

In a study involving 19,000 inseminations, Olds (1948) reported slightly higher conception rates for cows serviced during the middle to latter part of the heat period; however, the difference due to time of insemination was not significant. It should be pointed out that a large majority of the cows in this country were inseminated during the period from the middle to the end of estrus.

Site of Semen Deposition. The three basic techniques of artificial insemination described in the literature are vaginal, shallow cervical and deep cervical or intrauterine. (Lasley and Bogart, 1943; Herman and Ragsdale, 1950.) In the vaginal method semen is usually deposited in the anterior portion just below the cervix, with the aid of an inseminating tube and syringe or by means of a gelatin capsule as reported by Ellenberger (1946). The shallow cervical method is accomplished with the aid of a speculum and a syringe attached to an inseminating tube as described by Herman and Ragsdale (1950). Semen deposition, by the deep cervical or intrauterine technique, is accomplished by working the tube in the uterus by manipulation of the cervix through the rectal wall, Salisbury and VanDemark (1951). Lasley and Bogart (1943) and Holt (1946) reported a much higher rate of conception for cows inseminated by the uterine method as compared to those inseminated into the cervix with the aid of a speculum.

In a study involving 2,712 inseminations, Raps (1948) reported a weighted average difference of 6.7 percent advantage in favor of intrauterine insemination as compared to the speculum method for first service cows. The difference observed for second services was negligible. Weeth and Herman (1951) reported 56.1 percent conception for intrauterine inseminations as compared to 48.1 percent for shallow cervical inseminations on first and second services.

Postpartum Interval to First Service. Fall freshening is an improved practice that has been advocated by dairy leaders for many years as

a means of increasing milk and fat yield and distributing production throughout the year. In an effort to obtain fall freshening some cows are serviced as soon as possible after calving and others are held open for relatively long intervals. The question has arisen as to what effect this practice has upon breeding efficiency. Herman and Ragsdale (1950) stated that cows should not be bred until 60 to 75 days after calving if the best results are to be obtained. A longer sexual rest was recommended for cows that have an unusual amount of trouble at calving time.

According to reports by Asdell (1934, 1948) clean, healthy cows should be serviced at the second heat period after calving. If an unusual discharge is observed, the animal should not be bred until the condition is corrected. Hofstad (1941) found that the reproductive system was more susceptible to infection and that breeding difficulties were more common in cows bred 60 days or less after parturition than in those given a longer sexual rest. The conception rate reported for cows serviced less than 40 days after calving was only 45 percent as compared to 74 percent for those serviced 80 to 90 days postpartum. A decline in conception rate was observed for cows bred at longer intervals after calving.

VanDemark and Salisbury (1950) studied the effect of postpartum interval to first service on the conception rate of 593 cows, including 1,674 pregnancies in the Illinois dairy herd. The conception rate observed for cows serviced 1 to 20 days after calving was only 35.0 percent. A gradual increase in conception rate was observed for subsequent 20-day intervals, with the maximum of 57.8 percent being obtained for cows serviced 101 to 120 days after parturition. The percent of services resulting in conception declined slightly for intervals longer than 120 days, with a conception rate of only 46.3 percent being obtained for cows serviced 201 days or over after calving.

Similar studies by Olds *et al.* (1949) and Norton (1952) indicate that cows serviced less than 40 days after calving had a relatively low conception rate. A gradual increase in breeding efficiency was observed in subsequent intervals up to 90 to 120 days after parturition with a slight decrease for intervals exceeding 150 days. Olds (1948) conducted a study of the Kentucky Artificial breeding records, involving 10,587 inseminations to determine the effect of time bred after calving upon breeding efficiency. The results expressed as percentages 60 to 90-day non-returns to single inseminations were as follows: Less than 35 days, 49.5; 36 to 49 days, 60.0; 50 to 75 days, 66.9; 76 to 105 days, 68.6; 106 days and over, 65.8.

Age of Animal. A preponderance of evidence has been presented in the literature to the effect that breeding efficiency in dairy cattle varies with age. Tanabe and Salisbury (1946) observed a steady increase in conception rate of dairy cattle from 1 to 4 years of age. Between the ages of 5 and 7 years the cows maintained a uniformly high conception rate which gradually declined with advancing age. Seath *et al.* (1943) observed no important differences in the conception rate of dairy cows for their first 3 pregnancies.

Conception rates were slightly higher for the 4 to 10 pregnancies, inclusive, with the greatest number of services per conception being required for pregnancies beyond the tenth. In a recent study at the University of Nebraska, Davis (1951) reported a steady increase in conception rate for dairy cows from the first to the fourth lactation, inclusively. The conception rate remained at a relatively high level for the sixth and seventh lactations but declined for the eighth.

Foot and Ridler (1949), in England, studied the variation in conception rate of dairy cows due to age in both natural and artificial service. The percentages conception for the various age groups serviced by artificial insemination were as follows: maiden heifers, 43.4; first calf, 40.7; second calf, 55.2; third calf, 53.8; fourth calf, 58.8; fifth or later, 47.0. Similar results were obtained for cows serviced by natural mating. Several other investigators have reported that heifers required more services per conception than other age groups of dairy cattle (Morgan and Davis, 1938; Bartlett and Perry, 1939; Hilder *et al.*, 1944).

A study of the breeding records of the university and experiment station herds in Kentucky by Olds *et al.* (1949), revealed that 51.7 percent of the heifers conceived at first service as compared to 47.6 percent conception for cows. When total services were considered, the heifers required 2.57 services per conception and the cows 2.26. Six percent of the heifers and 5.4 percent of the cows were classified as non-breeders. In a recent study of the Louisiana station Holstein breeding records, Norton (1952) found that virgin heifers actually required fewer services per conception than any other age group when the records of non-breeders were omitted.

It is a fairly common practice in some areas for dairymen, who artificially inseminate all of their cows, to use a bull on their heifers. This practice is based on the supposition that natural mating of heifers is more efficient than artificial insemination. Shuart *et al.* (1942) compared natural and artificial service with both groups of heifers being bred to the same sire. Twenty-two heifers artificially inseminated required 24 services, making 1.06 services per conception, with 90.6 percent conceiving on first service. In natural service, 22 heifers required 37 services, making 1.67 services per conception with 63.6 percent conceiving on first service.

Nutritional and Pathological Factors Affecting Breeding Efficiency

Nutrition. The relationship between nutrition and infertility has been studied by several investigators; however, few if any controlled experiments of this nature have been conducted with dairy cattle, Asdell (1949). Eckles (1939) records that heavy-fed heifers reached sexual maturity much earlier than light-fed groups; the difference was 112 days for Holsteins and 76 days for Jerseys. Allen (1943) in England reported that underfed heifers were late

reaching puberty. The condition was usually observed in the latter part of a severe winter and was corrected after the animals were placed on pasture in the spring. Maynard (1947) stated that undernutrition may delay puberty in cattle and it may cause retrogressive changes in the reproductive system of mature animals.

Underfeeding or a poorly balanced ration, according to Turner (1946), may reduce secretion of the gonadotrophic hormone by the anterior pituitary which is likely to result in longer intervals between heat periods or cessation of the estrus cycle. In a study of the relation between feeding practices and conception in dairy cattle Dickensheet and Herman (1949) obtained extremely variable results. Little if any difference in breeding efficiency was observed between satisfactory and good feeding practices. Morgan and Davis (1938) reported that reproductive efficiency was highest during the summer months when the nutritional plane was best and lowest during the winter months when pastures were not available and the level of nutrition was lowest.

Roughage. The digestive system of the cow is especially equipped to utilize large quantities of roughage. A good dairy ration should include silage and legume hay as its foundation (Eckles, 1939). According to Dickensheet and Herman (1949) the more successful dairymen usually produce more dry roughage, pastures and silage of high quality than the less efficient. In a report on breeding failures Erb and Shaw (1948) emphasized the importance of feeding high quality roughage, and suggested that dairymen feed an adequate ration rather than add trace elements and vitamins to poor quality feed. Dickensheet and Herman (1949) investigated the relationship between roughage feeding practices and conception rate in both efficient and inefficient herds. No significant relationship between the breeding efficiency of the two groups was observed where various combinations of silage, dried roughage and pasture were used.

Vitamins and Minerals. The relationship between vitamin and mineral deficiencies and breeding efficiency in dairy cattle is a debatable question. Much advice has been given concerning the use of supplementary vitamins and minerals as a means of overcoming breeding difficulties. There is little, if any, critical work to substantiate these claims.

An excellent review of this subject was presented by Asdell (1949), in which literature was cited to demonstrate that vitamin A, phosphorus and possibly calcium deficiencies seriously affect reproduction under experimental or isolated range conditions. Young animals are more seriously affected by these deficiencies than are mature cows. Remarkable claims have been made for vitamins C and E and trace minerals in the treatment of reproductive failures, but so far their value has not been demonstrated by controlled experiments.

According to Jones *et al.* (1941) a poor quality ration, low in vitamin A and phosphorus, is likely to have an adverse effect upon efficiency of re-

production in dairy cattle. The quality of the ration is usually best during the summer and poorest during the winter months due primarily to the presence and absence of pasture.

Asdell (1948) stated that deficiencies of phosphorus or calcium in the ration are likely to cause some reproductive failures but so far as is known, trace minerals have no effect on reproduction. A good grain ration containing 2 percent bone meal plus a liberal amount of legume hay and pasture should adequately supply the phosphorus and calcium needed for reproduction.

Vitamin A deficiency for a prolonged period causes reproductive troubles, resulting in irregular estrus cycles, frequent abortions and an increase in the monstrosities born. This condition is most likely to occur near the end of winter when poor roughage has been fed for a considerable length of time and the vitamins stored in the cow's body are depleted. This deficiency can be corrected by adding vitamin A to the ration or it can be prevented by including green, leafy hay or pasture in the ration.

The addition of minerals or vitamins is of no value whatever, if the level and quality of feeding are average. If the level or quality of the ration is inadequate, the addition of certain minerals or vitamins that are lacking will certainly be helpful. Under these conditions it is more economical and better for the health of the animals if feeding is made adequate.

Diseases of the Genital Tract. Genital infections are without doubt one of the primary factors associated with delayed breeding and sterility in dairy cattle. Several workers (Asdell, 1948; Herman and Madden, 1949) have reported that Brucellosis, Vaginitis, Trichomonosis and Vibrio Fetus impair reproduction by preventing conception temporarily or permanently and by interrupting pregnancy at various stages from fertilization to parturition.

White *et al.* (1925) reported that 1.82 services per conception were required for negative cows as compared to 2.09 services per conception for cows infected with Brucellosis. Similarly, Dickensheet and Herman (1949) reported conception rates of 1.98 in efficient herds and 3.54 in inefficient herds with more than one Brucellosis reactor as compared to 1.66 and 3.33 respectively, for clean herds with no irregularities in heat periods. Miller (1937) reported that the number of services required per conception for Brucellosis reactors was 2.63 after normal calving as compared to 3.20 after abortion.

Physical Condition of Animal. Few, if any, controlled experiments have been conducted to determine the relationship between physical condition and breeding efficiency in dairy cattle. According to Asdell (1934), the optimum condition for efficient reproduction is a thrifty one, not too fat and not too thin. A semi-starved female does not ripen the ova as she should; the ova either degenerate altogether or are formed irregularly. Insufficient diet may cause permanent damage to the ovaries. If pregnancy

does occur, the drain of nutritions from her body by the lactation period may cause irreparable damage to the constitution. Furthermore, the young may die before birth or both the fetus and the mother may have a greatly reduced resistance to disease.

Frank (1950) reported that breeding animals should be gaining weight throughout the breeding season, since an improving condition is more favorable to the normal functioning of the reproductive system than a stationary declining condition. Similarly, Asdell (1934) found that additional feed given at breeding time to animals that were not already overfat had a stimulating effect on their reproductive system.

Generally speaking, dairymen have the opinion that overfat animals are more difficult to breed than those carrying a normal amount of flesh. This belief has not been substantiated by experimentation. Several workers (Marshall and Peel, 1910; Asdell, 1934; Maynard, 1947) have reported that an extremely fat condition is as dangerous to the ovaries as is semi-starvation, since they are likely to become infiltrated with fat which interferes with the development of follicles. This is manifested by a cessation or marked irregularity in estrus periods resulting in sterility or delayed breeding. In extremely fat animals the reproductive organs may become imbedded in fat which is likely to prevent the fertilized egg from reaching the uterus and becoming properly implanted. In contrast, Eckles (1939) reported that excessive fatness in heifers had little effect on the reproductive function.

In a recent study, Dickensheet and Herman (1949) found that 6.5 percent of the herds classed as inefficient were overfat: whereas none of the efficient herds had fat cows. The average conception rate of the overfat cows was 3.32 services per conception as compared to 1.75 in the efficient herds and 3.27 in all herds classed as inefficient. In 1½ percent of the efficient herds and 6½ percent of the inefficient herds, the cows were in thin or poor condition. Relatively high conception rates were obtained in some herds even though the cows were rather thin.

Climatic Factors Affecting Breeding Efficiency

The seasonal nature of sexual activity in many mammals, including the sheep, is well recognized. But whether or not cattle have a seasonal variation in reproductive activity has not been clearly demonstrated. Bogart and Mayer (1947) reported that reproductive abnormalities associated with "summer sterility" in rams were prevented by placing the animals in a cool room during the summer and were brought about by placing them under the influence of high temperature during the winter months. Furthermore, it was demonstrated that changes in environmental temperatures produced variations in sexual activity in the ram indirectly through the thyroid gland.

Numerous workers (Dawson, 1938; Erb *et al.*, 1940; Seath and Staples, 1941; Seath *et al.*, 1943; Nordick, 1949; Norton, 1952) have demonstrated

seasonal variations in breeding efficiency of dairy cattle but the effects of seasonal components such as heat, light and nutrition have not been definitely established.

Effect of Light. Investigations by Mercier and Salisbury (1947a, 1947b) in New York and Canada indicated that variations in length of daylight among seasons influenced the breeding efficiency of dairy cattle. The average conception rate was lowest during the winter months and highest in the summer. It is interesting to note that the poorest conception rate occurred a few weeks after the shortest days of the year and the highest conception rate was obtained a few weeks after the longest days of the year.

Sweetman (1940) reported that the possible sunlight available on December 21, is five hours and twenty-eight minutes in some parts of Alaska. In an effort to determine the effect of light upon reproduction, two groups of animals were investigated, one of which was exposed to fourteen hours of light per day by artificial means as compared to an average of eight hours of light for the other group. The group of cows receiving the greatest amount of light had a conception rate of 53.6 percent as compared to 48.6 percent for the other group. This 5.0 percent difference was significant.

Environmental Temperature. Several studies conducted in the southern and midwestern states indicate that high ambient temperature has an adverse effect on efficiency of reproduction in dairy cattle (Erb *et al.*, 1940; Seath and Staples, 1941; Seath *et al.*, 1943; Hilder *et al.*, 1944; Kansas Artificial Breeding Service Report, 1952). In a study of breeding results from artificial insemination in the University of Nebraska dairy herd, Trimberger and Davis (1945) found that the summer and late summer months required more services per conception than any other months of the year. August, with 2.24 services per conception, was significantly higher in number of services required than any other month. Herman (1952) likewise observed relatively low percent conception for cows inseminated during the months of August and September. A recent study of the Louisiana State University Holstein herd by Norton (1952) showed breeding efficiencies by seasons as follows: 72.7 for spring, 69.9 for winter, 66.0 for fall and 51.4 for summer.

In a study of dairy cattle breeding records at experiment stations in various parts of the United States, Dawson (1938) reported an average conception rate of 36 percent from the stations located in the southern states as compared to an average of 49 percent for those in the northern states. Semen quality was poorest during July, August, and September and best during April, May, and June. More services per conception were required during the summer months than any other season of the year.

This phase of the study was conducted in an effort to determine the effect of season of the year upon breeding efficiency in dairy cattle serviced by artificial insemination.

Weeth and Herman (1951) compared intracervical and intrauterine methods of insemination with semen ranging up to 60 hours of age. The conception rates of intracervical inseminations were 52.4, 42.3 and 34.2 for semen less than 12, 24 to 36 and 48 to 60 hours of age, respectively. Conception rates for the intrauterine inseminations were 57.4, 55.4 and 44.6 with semen less than 12, 24 to 36 and 48 to 60 hours of age, respectively. A 10.1 percent drop in fertility was observed between fresh and 1 day old semen for the intracervical method as compared to a 2.0 percent decrease for the intrauterine method. The decrease observed for 1-day-old semen with the intracervical method was highly significant but negligible for the intrauterine method.

Stored semen ranging in age up to 60 hours or over is used extensively by breeding associations throughout the United States. A large percentage of the bull studs make a practice of shipping fresh semen 4 to 7 times a week, thus making relatively fresh semen available at all times. Although adequate data are available for making a comprehensive study of the effect of age of semen on breeding efficiency, the author is not aware of a report of this nature.

Time of Ovulation. Brewster *et al.* (1940, 1941) made 83 rectal examinations on 47 cows to determine the time of ovulation. The mean time of ovulation was found to be 13.57 hours after the end of estrus. On the average, ovulation in heifers occurred 11.4 hours after the end of estrus as compared to 14.48 hours for cows. Eighty-nine percent of the ovulations occurred between 6 and 19 hours after the end of estrus. In a study of 125 cows Gerosimova (1937) found that ovulation occurred between 16 and 38 hours after the onset of estrus with the mean time of ovulation being 27 hours and 50 minutes. Eighty-nine percent of the ovulations occurred between 20 and 32 hours after the onset of estrus. Hammond (1927) likewise found that ovulation in dairy cows occurred 24 to 48 hours after the onset of estrus. In a recent study, Hansel and Trimberger (1952) found that ovulation in dairy heifers occurred 8 to 17 hours after the end of estrus with the mean time of ovulation being 12.3 hours after the end of estrus.

Stage of Estrus Inseminated. Breeding during the optimum stage of estrus was not a problem when the bull ran in the pasture with the cows because the cow was usually serviced several times during the period. However, this problem is of utmost importance today since a large percentage of the dairy cattle in this country are serviced only once during estrus either by natural mating or artificial insemination. Kirillov (1937) conducted a study in which the herd was divided into two groups. Only 26 percent of the cows bred 18 to 24 hours after the onset of estrus had to be rebred while 60 percent of those bred at the beginning of estrus required subsequent service.

Bartlett and Perry reported higher conception rates for cows inseminated 8 to 20 hours after the onset of estrus. Herman (1939) reported maxi-

mum breeding efficiency for cows inseminated during active estrus. Barrett and Casida (1946) obtained the highest rates of conception for cows inseminated 3 to 20 hours after the onset of estrus. Trimberger and Davis (1943) conducted a controlled experiment in which cows were inseminated at various stages of estrus. The percentages of conception from one insemination for the different stages were as follows: start of estrus 44.0, middle of estrus 82.5, middle of estrus and rebred in 24 hours 84.0, end of estrus 75.0, 6 hours after estrus ended 62.5, 12 hours after estrus ended 32.0, 18 hours after estrus ended 28.0, 24 hours after estrus ended 12.0, 36 hours after estrus ended 8.0, and 48 hours after estrus ended 0 percent. In a subsequent study, Trimberger (1944) inseminated cows at various intervals before and after ovulation. The results were as follows: inseminations made 24 hours before ovulation gave 53.3 percent conception; 19 to 24 hours, 73 percent; 13 to 18 hours, 85.7 percent; 7 to 12 hours, 78.6 percent; 6 hours or less, 57.1 percent; 2 hours or less after ovulation, 30 percent; 3 to 6 hours, 40 percent; 7 to 12 hours, 30 percent.

In a study involving 19,000 inseminations, Olds (1948) reported slightly higher conception rates for cows serviced during the middle to latter part of the heat period; however, the difference due to time of insemination was not significant. It should be pointed out that a large majority of the cows in this country were inseminated during the period from the middle to the end of estrus.

Site of Semen Deposition. The three basic techniques of artificial insemination described in the literature are vaginal, shallow cervical and deep cervical or intrauterine. (Lasley and Bogart, 1943; Herman and Ragsdale, 1950.) In the vaginal method semen is usually deposited in the anterior portion just below the cervix, with the aid of an inseminating tube and syringe or by means of a gelatin capsule as reported by Ellenberger (1946). The shallow cervical method is accomplished with the aid of a speculum and a syringe attached to an inseminating tube as described by Herman and Ragsdale (1950). Semen deposition, by the deep cervical or intrauterine technique, is accomplished by working the tube in the uterus by manipulation of the cervix through the rectal wall, Salisbury and VanDemark (1951). Lasley and Bogart (1943) and Holt (1946) reported a much higher rate of conception for cows inseminated by the uterine method as compared to those inseminated into the cervix with the aid of a speculum.

In a study involving 2,712 inseminations, Raps (1948) reported a weighted average difference of 6.7 percent advantage in favor of intrauterine insemination as compared to the speculum method for first service cows. The difference observed for second services was negligible. Weeth and Herman (1951) reported 56.1 percent conception for intrauterine inseminations as compared to 48.1 percent for shallow cervical inseminations on first and second services.

Postpartum Interval to First Service. Fall freshening is an improved practice that has been advocated by dairy leaders for many years as

a means of increasing milk and fat yield and distributing production throughout the year. In an effort to obtain fall freshening some cows are serviced as soon as possible after calving and others are held open for relatively long intervals. The question has arisen as to what effect this practice has upon breeding efficiency. Herman and Ragsdale (1950) stated that cows should not be bred until 60 to 75 days after calving if the best results are to be obtained. A longer sexual rest was recommended for cows that have an unusual amount of trouble at calving time.

According to reports by Asdell (1934, 1948) clean, healthy cows should be serviced at the second heat period after calving. If an unusual discharge is observed, the animal should not be bred until the condition is corrected. Hofstad (1941) found that the reproductive system was more susceptible to infection and that breeding difficulties were more common in cows bred 60 days or less after parturition than in those given a longer sexual rest. The conception rate reported for cows serviced less than 40 days after calving was only 45 percent as compared to 74 percent for those serviced 80 to 90 days postpartum. A decline in conception rate was observed for cows bred at longer intervals after calving.

VanDemark and Salisbury (1950) studied the effect of postpartum interval to first service on the conception rate of 593 cows, including 1,674 pregnancies in the Illinois dairy herd. The conception rate observed for cows serviced 1 to 20 days after calving was only 35.0 percent. A gradual increase in conception rate was observed for subsequent 20-day intervals, with the maximum of 57.8 percent being obtained for cows serviced 101 to 120 days after parturition. The percent of services resulting in conception declined slightly for intervals longer than 120 days, with a conception rate of only 46.3 percent being obtained for cows serviced 201 days or over after calving.

Similar studies by Olds *et al.* (1949) and Norton (1952) indicate that cows serviced less than 40 days after calving had a relatively low conception rate. A gradual increase in breeding efficiency was observed in subsequent intervals up to 90 to 120 days after parturition with a slight decrease for intervals exceeding 150 days. Olds (1948) conducted a study of the Kentucky Artificial breeding records, involving 10,587 inseminations to determine the effect of time bred after calving upon breeding efficiency. The results expressed as percentages 60 to 90-day non-returns to single inseminations were as follows: Less than 35 days, 49.5; 36 to 49 days, 60.0; 50 to 75 days, 66.9; 76 to 105 days, 68.6; 106 days and over, 65.8.

Age of Animal. A preponderance of evidence has been presented in the literature to the effect that breeding efficiency in dairy cattle varies with age. Tanabe and Salisbury (1946) observed a steady increase in conception rate of dairy cattle from 1 to 4 years of age. Between the ages of 5 and 7 years the cows maintained a uniformly high conception rate which gradually declined with advancing age. Seath *et al.* (1943) observed no important differences in the conception rate of dairy cows for their first 3 pregnancies.

Conception rates were slightly higher for the 4 to 10 pregnancies, inclusive, with the greatest number of services per conception being required for pregnancies beyond the tenth. In a recent study at the University of Nebraska, Davis (1951) reported a steady increase in conception rate for dairy cows from the first to the fourth lactation, inclusively. The conception rate remained at a relatively high level for the sixth and seventh lactations but declined for the eighth.

Foot and Ridler (1949), in England, studied the variation in conception rate of dairy cows due to age in both natural and artificial service. The percentages conception for the various age groups serviced by artificial insemination were as follows: maiden heifers, 43.4; first calf, 40.7; second calf, 55.2; third calf, 53.8; fourth calf, 58.8; fifth or later, 47.0. Similar results were obtained for cows serviced by natural mating. Several other investigators have reported that heifers required more services per conception than other age groups of dairy cattle (Morgan and Davis, 1938; Bartlett and Perry, 1939; Hilder *et al.*, 1944).

A study of the breeding records of the university and experiment station herds in Kentucky by Olds *et al.* (1949), revealed that 51.7 percent of the heifers conceived at first service as compared to 47.6 percent conception for cows. When total services were considered, the heifers required 2.57 services per conception and the cows 2.26. Six percent of the heifers and 5.4 percent of the cows were classified as non-breeders. In a recent study of the Louisiana station Holstein breeding records, Norton (1952) found that virgin heifers actually required fewer services per conception than any other age group when the records of non-breeders were omitted.

It is a fairly common practice in some areas for dairymen, who artificially inseminate all of their cows, to use a bull on their heifers. This practice is based on the supposition that natural mating of heifers is more efficient than artificial insemination. Shuart *et al.* (1942) compared natural and artificial service with both groups of heifers being bred to the same sire. Twenty-two heifers artificially inseminated required 24 services, making 1.06 services per conception, with 90.6 percent conceiving on first service. In natural service, 22 heifers required 37 services, making 1.67 services per conception with 63.6 percent conceiving on first service.

Nutritional and Pathological Factors Affecting Breeding Efficiency

Nutrition. The relationship between nutrition and infertility has been studied by several investigators; however, few if any controlled experiments of this nature have been conducted with dairy cattle, Asdell (1949). Eckles (1939) records that heavy-fed heifers reached sexual maturity much earlier than light-fed groups; the difference was 112 days for Holsteins and 76 days for Jerseys. Allen (1943) in England reported that underfed heifers were late

reaching puberty. The condition was usually observed in the latter part of a severe winter and was corrected after the animals were placed on pasture in the spring. Maynard (1947) stated that undernutrition may delay puberty in cattle and it may cause retrogressive changes in the reproductive system of mature animals.

Underfeeding or a poorly balanced ration, according to Turner (1946), may reduce secretion of the gonadotrophic hormone by the anterior pituitary which is likely to result in longer intervals between heat periods or cessation of the estrus cycle. In a study of the relation between feeding practices and conception in dairy cattle Dickensheet and Herman (1949) obtained extremely variable results. Little if any difference in breeding efficiency was observed between satisfactory and good feeding practices. Morgan and Davis (1938) reported that reproductive efficiency was highest during the summer months when the nutritional plane was best and lowest during the winter months when pastures were not available and the level of nutrition was lowest.

Roughage. The digestive system of the cow is especially equipped to utilize large quantities of roughage. A good dairy ration should include silage and legume hay as its foundation (Eckles, 1939). According to Dickensheet and Herman (1949) the more successful dairymen usually produce more dry roughage, pastures and silage of high quality than the less efficient. In a report on breeding failures Erb and Shaw (1948) emphasized the importance of feeding high quality roughage, and suggested that dairymen feed an adequate ration rather than add trace elements and vitamins to poor quality feed. Dickensheet and Herman (1949) investigated the relationship between roughage feeding practices and conception rate in both efficient and inefficient herds. No significant relationship between the breeding efficiency of the two groups was observed where various combinations of silage, dried roughage and pasture were used.

Vitamins and Minerals. The relationship between vitamin and mineral deficiencies and breeding efficiency in dairy cattle is a debatable question. Much advice has been given concerning the use of supplementary vitamins and minerals as a means of overcoming breeding difficulties. There is little, if any, critical work to substantiate these claims.

An excellent review of this subject was presented by Asdell (1949), in which literature was cited to demonstrate that vitamin A, phosphorus and possibly calcium deficiencies seriously affect reproduction under experimental or isolated range conditions. Young animals are more seriously affected by these deficiencies than are mature cows. Remarkable claims have been made for vitamins C and E and trace minerals in the treatment of reproductive failures, but so far their value has not been demonstrated by controlled experiments.

According to Jones *et al.* (1941) a poor quality ration, low in vitamin A and phosphorus, is likely to have an adverse effect upon efficiency of re-

production in dairy cattle. The quality of the ration is usually best during the summer and poorest during the winter months due primarily to the presence and absence of pasture.

Asdell (1948) stated that deficiencies of phosphorus or calcium in the ration are likely to cause some reproductive failures but so far as is known, trace minerals have no effect on reproduction. A good grain ration containing 2 percent bone meal plus a liberal amount of legume hay and pasture should adequately supply the phosphorus and calcium needed for reproduction.

Vitamin A deficiency for a prolonged period causes reproductive troubles, resulting in irregular estrus cycles, frequent abortions and an increase in the monstrosities born. This condition is most likely to occur near the end of winter when poor roughage has been fed for a considerable length of time and the vitamins stored in the cow's body are depleted. This deficiency can be corrected by adding vitamin A to the ration or it can be prevented by including green, leafy hay or pasture in the ration.

The addition of minerals or vitamins is of no value whatever, if the level and quality of feeding are average. If the level or quality of the ration is inadequate, the addition of certain minerals or vitamins that are lacking will certainly be helpful. Under these conditions it is more economical and better for the health of the animals if feeding is made adequate.

Diseases of the Genital Tract. Genital infections are without doubt one of the primary factors associated with delayed breeding and sterility in dairy cattle. Several workers (Asdell, 1948; Herman and Madden, 1949) have reported that Brucellosis, Vaginitis, Trichomoniosis and Vibrio Fetus impair reproduction by preventing conception temporarily or permanently and by interrupting pregnancy at various stages from fertilization to parturition.

White *et al.* (1925) reported that 1.82 services per conception were required for negative cows as compared to 2.09 services per conception for cows infected with Brucellosis. Similarly, Dickensheet and Herman (1949) reported conception rates of 1.98 in efficient herds and 3.54 in inefficient herds with more than one Brucellosis reactor as compared to 1.66 and 3.33 respectively, for clean herds with no irregularities in heat periods. Miller (1937) reported that the number of services required per conception for Brucellosis reactors was 2.63 after normal calving as compared to 3.20 after abortion.

Physical Condition of Animal. Few, if any, controlled experiments have been conducted to determine the relationship between physical condition and breeding efficiency in dairy cattle. According to Asdell (1934), the optimum condition for efficient reproduction is a thrifty one, not too fat and not too thin. A semi-starved female does not ripen the ova as she should; the ova either degenerate altogether or are formed irregularly. Insufficient diet may cause permanent damage to the ovaries. If pregnancy

does occur, the drain of nutritions from her body by the lactation period may cause irreparable damage to the constitution. Furthermore, the young may die before birth or both the fetus and the mother may have a greatly reduced resistance to disease.

Frank (1950) reported that breeding animals should be gaining weight throughout the breeding season, since an improving condition is more favorable to the normal functioning of the reproductive system than a stationary declining condition. Similarly, Asdell (1934) found that additional feed given at breeding time to animals that were not already overfat had a stimulating effect on their reproductive system.

Generally speaking, dairymen have the opinion that overfat animals are more difficult to breed than those carrying a normal amount of flesh. This belief has not been substantiated by experimentation. Several workers (Marshall and Peel, 1910; Asdell, 1934; Maynard, 1947) have reported that an extremely fat condition is as dangerous to the ovaries as is semi-starvation, since they are likely to become infiltrated with fat which interferes with the development of follicles. This is manifested by a cessation or marked irregularity in estrus periods resulting in sterility or delayed breeding. In extremely fat animals the reproductive organs may become imbedded in fat which is likely to prevent the fertilized egg from reaching the uterus and becoming properly implanted. In contrast, Eckles (1939) reported that excessive fatness in heifers had little effect on the reproductive function.

In a recent study, Dickensheet and Herman (1949) found that 6.5 percent of the herds classed as inefficient were overfat: whereas none of the efficient herds had fat cows. The average conception rate of the overfat cows was 3.32 services per conception as compared to 1.75 in the efficient herds and 3.27 in all herds classed as inefficient. In 1½ percent of the efficient herds and 6½ percent of the inefficient herds, the cows were in thin or poor condition. Relatively high conception rates were obtained in some herds even though the cows were rather thin.

Climatic Factors Affecting Breeding Efficiency

The seasonal nature of sexual activity in many mammals, including the sheep, is well recognized. But whether or not cattle have a seasonal variation in reproductive activity has not been clearly demonstrated. Bogart and Mayer (1947) reported that reproductive abnormalities associated with "summer sterility" in rams were prevented by placing the animals in a cool room during the summer and were brought about by placing them under the influence of high temperature during the winter months. Furthermore, it was demonstrated that changes in environmental temperatures produced variations in sexual activity in the ram indirectly through the thyroid gland.

Numerous workers (Dawson, 1938; Erb *et al.*, 1940; Seath and Staples, 1941; Seath *et al.*, 1943; Nordick, 1949; Norton, 1952) have demonstrated

seasonal variations in breeding efficiency of dairy cattle but the effects of seasonal components such as heat, light and nutrition have not been definitely established.

Effect of Light. Investigations by Mercier and Salisbury (1947a, 1947b) in New York and Canada indicated that variations in length of daylight among seasons influenced the breeding efficiency of dairy cattle. The average conception rate was lowest during the winter months and highest in the summer. It is interesting to note that the poorest conception rate occurred a few weeks after the shortest days of the year and the highest conception rate was obtained a few weeks after the longest days of the year.

Sweetman (1940) reported that the possible sunlight available on December 21, is five hours and twenty-eight minutes in some parts of Alaska. In an effort to determine the effect of light upon reproduction, two groups of animals were investigated, one of which was exposed to fourteen hours of light per day by artificial means as compared to an average of eight hours of light for the other group. The group of cows receiving the greatest amount of light had a conception rate of 53.6 percent as compared to 48.6 percent for the other group. This 5.0 percent difference was significant.

Environmental Temperature. Several studies conducted in the southern and midwestern states indicate that high ambient temperature has an adverse effect on efficiency of reproduction in dairy cattle (Erb *et al.*, 1940; Seath and Staples, 1941; Seath *et al.*, 1943; Hilder *et al.*, 1944; Kansas Artificial Breeding Service Report, 1952). In a study of breeding results from artificial insemination in the University of Nebraska dairy herd, Trimberger and Davis (1945) found that the summer and late summer months required more services per conception than any other months of the year. August, with 2.24 services per conception, was significantly higher in number of services required than any other month. Herman (1952) likewise observed relatively low percent conception for cows inseminated during the months of August and September. A recent study of the Louisiana State University Holstein herd by Norton (1952) showed breeding efficiencies by seasons as follows: 72.7 for spring, 69.9 for winter, 66.0 for fall and 51.4 for summer.

In a study of dairy cattle breeding records at experiment stations in various parts of the United States, Dawson (1938) reported an average conception rate of 36 percent from the stations located in the southern states as compared to an average of 49 percent for those in the northern states. Semen quality was poorest during July, August, and September and best during April, May, and June. More services per conception were required during the summer months than any other season of the year.

This phase of the study was conducted in an effort to determine the effect of season of the year upon breeding efficiency in dairy cattle serviced by artificial insemination.

TABLE 11 -- EFFECT OF LENGTH OF INTERVAL BETWEEN CALVING AND FIRST SERVICE ON EFFICIENCY OF REPRODUCTION IN DAIRY CATTLE.

Post Partum Interval to 1st Service (Days)	Number of Services	Services per Conception	Percent non>Returns	Percent of Total Services
1-37	434	1.75	57	9.2
38-52	428	1.64	61	9.1
53-75	2395	1.50	67	50.8
76-105	952	1.43	70	20.2
106-135	312	1.32	76	6.6
136-165	90	1.37	73	1.9
165 and Over	102	1.47	68	2.2
Total or Average	4713	1.50	67	100.0

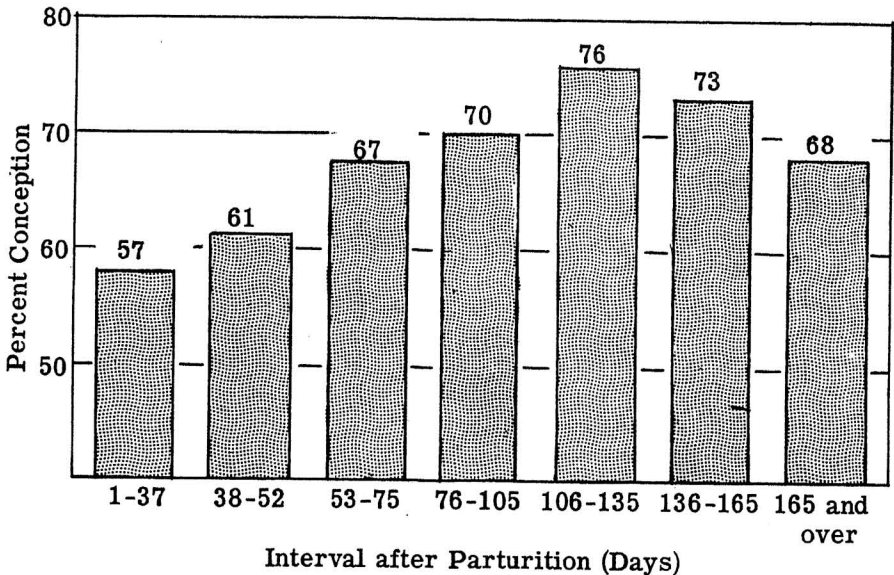


Figure 8--Effect of time serviced after calving on percentage non-returns to first services.

A gradual increase in breeding efficiency was obtained for each subsequent interval up to 106 to 135 days after calving with a slight decline for cows serviced at longer postpartum intervals. Differences between intervals were significant at the 1 percent level when tested by analysis of variance. More than two-thirds of the cows studied were inseminated between 53 and 105 days after calving with only 18.3 percent being serviced less than 53 days after parturition. The fact that a large majority of the cows in this study were inseminated at 60 days or longer after calving indicates that most dairymen participating in the artificial insemination program were following the recommended practices of giving cows a two months postpartum sexual rest.

Climatic Factors

Seasonal fluctuations in the reproductive efficiency of dairy cattle are known to exist, but the variations due to specific climatic factors, such as light, temperature, humidity, and levels of nutrition above maintenance levels, have not been clearly demonstrated.

Mercier and Salisbury (1947a, 1947b) found that variation in the amount of daylight had a slight effect on efficiency of reproduction in dairy cattle. Sweetman (1950) in Alaska reported a 5 percent higher conception rate for cows subjected to 14 hours of light per day as compared to those exposed to 8 hours of light daily. Dawson (1938) reported that semen quality was poorest during the late summer and best during the spring. The number of services required per conception was higher during the summer months than any other season of the year. Similar results were observed by Trimmerger and Davis (1945) in Nebraska, Herman (1952) in Missouri and Norton (1952) in Louisiana.

The purpose of this part of the study was (A) to determine the percentage of cows being bred at each season of the year and (B) to compare the seasonal variations in efficiency of reproduction.

Data on 94,935 first service inseminations extending over all seasons of the year for a period of four years were included in this investigation. Information presented in Tables 12, 13, and 14, and Figures 9 and 10 show the variation in breeding efficiency by months, seasons and years. The mean monthly breeding efficiency as shown in Table 12 varied from 61.5 percent in August to 72.2 percent in June. Breeding efficiency was highest in June for each of the four years and lowest in August three of the four years studied.

The data presented in Table 13 indicates the mean breeding efficiency by seasons for the four-year period of 1948 to 1951, inclusive. The mean

TABLE 12 -- SEASONAL VARIATIONS IN BREEDING EFFICIENCY OF DAIRY CATTLE SERVICED BY ARTIFICIAL BREEDING.

Months	1948		1949		1950		1951		Total	
	S*	%	S	%	S	%	S	%	S	%
January	997	49.5	1,681	59.6	2,461	63.4	3,109	69.0	8,228	63.1
February	1,093	46.2	1,611	59.5	1,838	63.1	2,391	67.8	6,933	61.2
March	1,183	48.4	2,087	62.6	1,967	66.0	2,580	68.6	7,817	63.3
April	1,081	63.7	1,855	68.3	1,579	72.2	2,496	69.5	7,011	68.9
May	1,039	68.3	1,627	68.3	1,510	73.8	2,420	71.4	6,596	70.7
June	935	71.8	1,303	68.7	1,276	75.5	2,080	72.5	5,594	72.2
July	1,027	61.8	1,300	60.7	1,562	70.8	2,555	69.1	6,444	66.7
August	389	56.0	1,006	57.4	1,174	70.1	2,014	59.5	4,583	61.5
September	1,354	60.6	1,508	61.5	1,953	71.0	3,101	66.3	7,916	65.6
October	1,277	59.0	1,825	61.0	2,349	71.2	3,569	68.7	9,020	66.4
November	1,428	56.0	2,649	61.9	3,553	68.8	4,584	64.0	12,214	62.6
December	1,889	59.5	2,609	60.5	3,632	69.3	4,649	63.0	12,579	63.8
Total	13,472	57.1	21,061	62.5	24,854	69.1	35,548	67.1	94,935	65.2

*Number of first services.

**Percent 60-to-90-day non-returns.

TABLE 13 -- SEASONAL VARIATION IN BREEDING EFFICIENCY OF DAIRY CATTLE IN ARTIFICIAL INSEMINATION FOR YEARS 1948 THROUGH 1951.

Seasons	Number of Services	Services per Conception	Percent Conception	Percent of Total cows
Winter	22,978	1.60	63	24.2
Spring	19,201	1.42	70	20.2
Summer	18,943	1.54	65	20.0
Fall	33,813	1.56	64	35.6
Total or Average	94,935	1.53	65	

TABLE 14 -- SEASONAL VARIATION IN BREEDING EFFICIENCY OF DAIRY CATTLE IN ARTIFICIAL INSEMINATION FOR YEARS 1949 AND 1951.

Seasons	Number of Services	Services per Conception	Percent Conception	Percent of Total cows
Winter	13,459	1.53	65	23.8
Spring	11,781	1.43	70	20.8
Summer	11,484	1.56	64	20.3
Fall	19,885	1.57	64	35.1
Total or Average	56,609	1.53	65	

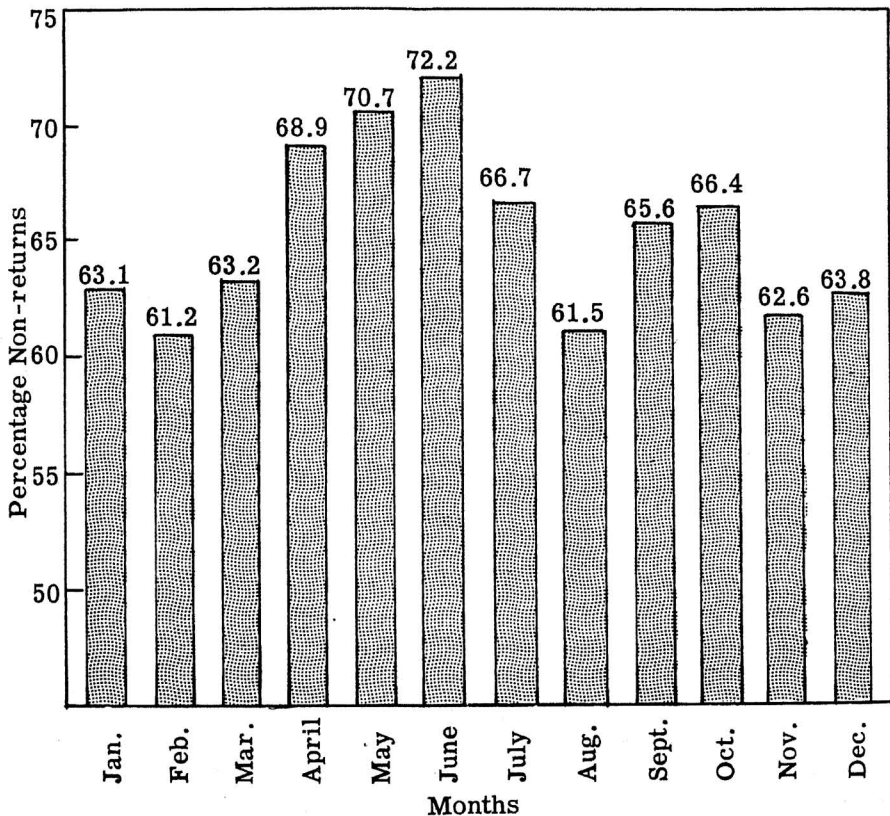


Figure 9--Mean monthly variation in breeding efficiency of dairy cows over four year period.

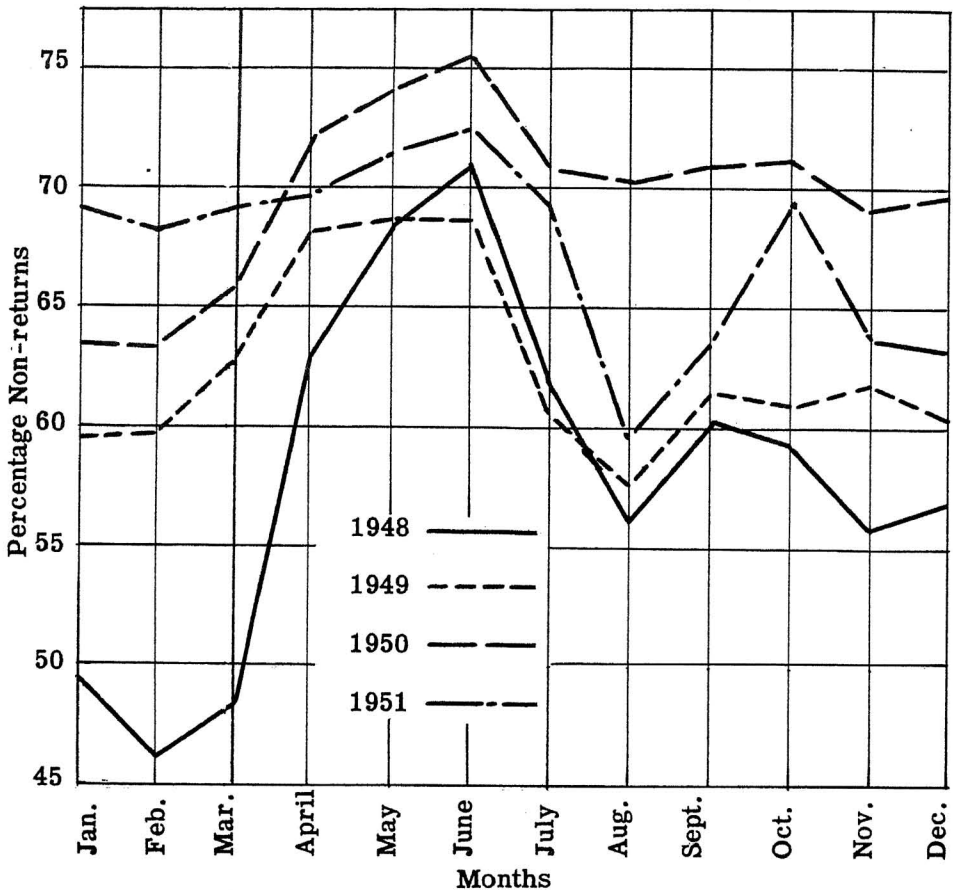


Figure 10--Monthly variation in breeding efficiency of dairy cattle serviced by artificial insemination during a four year period.

seasonal rates of conception for winter, spring, summer and fall were 63, 70, 65, and 64 percent, respectively. Data for the two more nearly normal years of 1949 and 1951 are presented in Table 14. On the average, conception rates for winter, spring, summer and fall were 65, 70, 64, and 64, respectively.

The average percentages of cows inseminated by seasons were as follows: Winter 24.2 percent, spring 20.2 percent, summer 20.0 percent, and fall 35.6 percent. The largest percent of the first service inseminations resulted in conception in the spring with the rate of conception being about equal for summer, fall and winter. Variation in breeding efficiency within seasons was greatest during the summer with August being low three of the four years studied.

Comparatively little decrease in breeding efficiency was observed during the summer and fall of 1950 as shown in Table 12 and Figure 10. The

relatively high breeding efficiency obtained in July, August and September of 1950 is attributed to the fact that the temperature was unusually cool during that period. However, variation in breeding efficiency by months followed the same general pattern as the other years studied. The low breeding efficiency observed in January, February and March of 1948 can be attributed partly to the fact that the program was in its infancy with a large number of inexperienced inseminators being employed during that time.

Data presented in Table 14 show the number of bulls by breeds and the percentage of bulls producing inferior quality semen by months during 1951. Bulls producing poor quality semen, low percent motility and-or high percent abnormal spermatozoa, ranged from zero in April and May to 31 percent in September, with 17 and 27 percent of the bulls producing low quality semen in July and August, respectively. Breed differences in semen quality were quite evident during the summer months. The percentage of bulls producing poor quality semen was highest in the Holstein, intermediate in the Jersey and Guernsey and lowest in the Brahman and Red Sindhi.

TABLE 15 -- VARIATION IN SEMEN PRODUCTION OF DAIRY AND BEEF BULLS BY MONTHS DURING 1951.

Breeds	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Jersey--No. of bulls	12	12	12	12	12	12	12	12	13	16	15	16
Percent of bulls producing poor quality semen	0.0	0.0	0.0	0.0	0.0	8.0	17.0	25.0	31.0	0.0	7.0	12.0
Holstein--No. of bulls	9	8	9	8	9	9	9	9	9	9	10	10
Percent of bulls producing poor quality semen	0	0	11.0	0	0	11.0	22.0	33.0	44.0	11.0	20	0.0
Guernsey--No. of bulls	8	7	7	7	7	7	7	6	7	5	5	8
Percent of bulls producing poor quality semen	12.0	14.0	0.0	0.0	0.0	0.0	0.0	17.0	29.0	20.0	20.0	17.0
Hereford--No. of bulls	2	2	2	2	2	2	2	2	2	2	2	2
Percent of bulls producing poor quality semen	0.0	0.0	50.0	0.0	0.0	0.0	50.0	100	50.0	50.0	0.0	0.0
Angus--No. of bulls	2	2	2	2	2	2	2	2	2	2	2	2
Percent of bulls producing poor quality semen	50	0	0	0	0	0	50	0	0	0	100	0
Brahman--No. of bulls	0	1	2	2	2	2	2	2	2	2	2	2
Percent of bulls producing poor quality semen	0	0	0	0	0	0	0	0	0	0	0	0
Red Sindhi--No. of bulls	1	1	1	1	1	1	1	1	1	1	1	1
Percent of bulls producing poor quality semen	0	0	0	0	0	0	0	0	0	0	0	0
All Breeds--No. of bulls	38	33	35	34	35	35	35	33	35	36	36	38
Percent of bulls producing poor quality semen	5.0	3.0	6.0	0.0	0.0	6.0	17.0	27.0	31.0	8.0	14.0	8.0

DISCUSSION

Purpose of this study was to investigate some of the major factors associated with efficiency of reproduction and to determine their relative importance in dairy cattle serviced by artificial insemination.

A total of 94,935 first service inseminations extending over a four year period beginning January 1, 1948, and ending December 31, 1951, are involved in the several phases of this investigation. Each of the factors studied will be discussed briefly.

The data presented on the four sites of insemination indicated no advantage of depositing semen beyond the middle of the cervix. These results are in agreement with Salisbury and VanDemark (1951), who observed no important difference in conception rate due to site of insemination. It is equally important that the results of this experiment do not indicate that deep uterine insemination will reduce conception rate due to injury or induction of foreign matter into the uterus. Cervical insemination is strongly indicated in cases where there is a possibility of pregnancy due to a previous service since Salisbury and VanDemark (1951) have observed abortions and resorptions following uterine insemination; whereas pregnancy was not affected in cows inseminated in the cervix.

Sergin *et al.* (1941) reported that the physio-chemical environment of the cervix was more favorable for spermatozoan survival than either the vagina or the uterus and that spermatozoa in the cervix served as a source of supply to the uterus. However the combination intracervical-intrauterine insemination technique in which two-thirds of the semen was deposited in the body of the uterus and one-third in the middle of the cervix did not prove to be superior to the other sites of deposition tested.

Preliminary results indicate that cows conceive just as readily when semen is deposited in the non-functional ovary. Data on a very limited number of cows indicate that the fertilized ovum may occasionally migrate and become implanted in what appears to be the non-functional horn of the uterus.

The average conception rate obtained for cows inseminated during four different stages of estrus varied only slightly, indicating no important relation between time of insemination and efficiency of reproduction under the conditions of this experiment. These results are consistent with the findings of Olds (1948), who reported no important differences in conception rate due to the stage of estrus inseminated. Although a large majority of the inseminations in this study were made during the second and third six-hour periods of estrus, the relatively high rate of conception for the limited number of services made during the first hour of estrus is not in agreement with the findings of several workers (Bartlett and Perry, 1939; Trimmerger and Davis, 1943; Asdell, 1948) who reported a relatively low breeding efficiency for inseminations made during the first part of the period. Cows involved in this experiment were handled under routine dairy farm conditions with observations for heat being made only at the morning and afternoon milkings. Thus, it was impossible to establish the exact time for the beginning of estrus. This probably accounts for the relatively high breeding efficiency obtained for insemination made during the first six-hours after estrus was observed.

When these data were summarized for the site of insemination, according to the stage of estrus serviced, the regularly small differences in breeding efficiency were not considered to be significant. Less variation in percentage non-returns was observed for the site of semen deposition made during the third six-hour period than at any other stage of estrus. It has been suggested that optimum reproductive efficiency would be obtained from cervical inseminations during the first stage of estrus and from deep uterine depositions during the latter part of the period. However, this supposition was not confirmed by this investigation. These results are consistent with the observations of VanDemark and Moeller (1951) who reported that motile or non-motile spermatozoa inseminated in the cervix of the estrus cow reached the ovarian portion of the Fallopian tube in 2 to 4 minutes.

The relatively small decrease in conception rate observed between 1 and 2-day-old semen was considered to be of great importance since it is impossible for many technicians to use fresh semen daily due to their distance from the bull stud and transportation facilities available. The 3.8 percent decrease in breeding efficiency between 2 and 3-day-old semen is consistent with the report of Branton *et al.* (1949), who observed a 4.7 percent decrease during this same period. Selected samples of semen used beyond 96 hours after collection resulted in 60.4 percent conception. This is in agreement with the observations of Salisbury (1942) who reported that satisfactory results were obtained with semen up to at least the fourth day.

The 60 to 90-day non-return results obtained for cows in the various age groups do not indicate that heifers are more difficult to settle than older cows (Table 6). Results reported in this study are in agreement with Baker and Quesenberry (1942) and Olds (1948) who found no significant difference in the breeding efficiency of cows at various ages including heifers. When non-breeders were eliminated, Norton (1952) observed that heifers actually required fewer services per conception than any other age group of cows studied. In contrast, numerous investigators have found that heifers require more services per conception than older cows. One such report was of Tanabe and Salisbury (1946).

Although natural and artificial services in heifers were not compared in this study, the relatively high breeding efficiency obtained for heifers compares favorably with reports of natural services in heifers by Norton (1952) and Seath *et al.* (1941, 1943).

Limited data obtained on thin and overfat animals do not indicate that they are any more difficult to breed than cows carrying a normal amount of flesh. The relatively high breeding efficiency obtained for cows in a thin condition is consistent with the findings of Dickensheet and Herman (1949) who reported that conception rates were high in some herds where the cows were rather thin. However, these results are not in agreement with observations of other workers (Marshall and Peel, 1910; Asdell, 1934; Maynard, 1947) who reported that underfed and overfat cattle had more breeding difficulties than those carrying a normal amount

of flesh. A large majority of the animals classified as thin or in poor condition were located in small herds (1 to 3 cows) which have been observed to have a higher breeding efficiency than cows in larger herds. This may account for a portion of the observed variation.

The wide variation in percentage non-returns and the absence of any logical trend for the various combinations of hay and pasture groups do not indicate that roughage feeding practices have any influence upon conception rate in dairy cattle receiving an adequate grain ration. These results are in agreement with the findings of Dickensheet and Herman (1949) who reported no important differences in breeding efficiency due to roughage feeding practices. Results reported in this study are not consistent with the observations of Jones *et al.* (1941) and Morgan and Davis (1938) who reported that cows on pasture usually have a higher rate of conception than those not receiving pasture.

The relatively small differences in percentage non-returns for cows receiving poor, fair and good quality roughage do not indicate any significant relationship between efficiency of reproduction and quality of roughage. This is consistent with the results of Dickensheet and Herman (1949) who found no important relation between conception rate and various combinations of silage, dried roughage and pastures used.

The group of cows receiving salt as the only supplementary mineral had a conception rate of 70 percent as compared to 61 percent for the group of animals receiving a mineral mixture. This difference was significant at the five percent level but it is obviously due to some factor or factors other than minerals or the lack of them.

The relatively low percentage non-returns obtained for the group of cows receiving a supplementary mineral mixture may be due to the fact that many dairymen who were having trouble getting their cows to conceive had been led to believe that additional minerals would solve all of their breeding problems. All authorities agree that dairy cattle need phosphorus, calcium and sodium chloride plus certain other elements for efficient production and reproduction; however, the results obtained in this study indicate that the value of supplementary minerals as a means of increasing efficiency of reproduction has been over-emphasized.

Both Brucellosis and granular vaginitis were found to have an adverse effect on conception rate. These results are in agreement with the reports of Bartlett (1949) and Dickensheet and Herman (1949) who found that both granular vaginitis and Brucellosis lowered breeding efficiency.

The difference in breeding efficiency for cows serviced 1 to 37 days and those serviced 106-135 days after calving was found to be 19 percentage points. This difference is in agreement with Olds (1948) who reported a difference of 19.1 percentage units for cows inseminated less than 35 days and those bred at 76 to 105 days after calving, and VanDemark and Salisbury (1950) who reported a difference of 17.4 percentage units in favor of cows

TABLE 11 -- EFFECT OF LENGTH OF INTERVAL BETWEEN CALVING AND FIRST SERVICE ON EFFICIENCY OF REPRODUCTION IN DAIRY CATTLE.

Post Partum Interval to 1st Service (Days)	Number of Services	Services per Conception	Percent non>Returns	Percent of Total Services
1-37	434	1.75	57	9.2
38-52	428	1.64	61	9.1
53-75	2395	1.50	67	50.8
76-105	952	1.43	70	20.2
106-135	312	1.32	76	6.6
136-165	90	1.37	73	1.9
165 and Over	102	1.47	68	2.2
Total or Average	4713	1.50	67	100.0

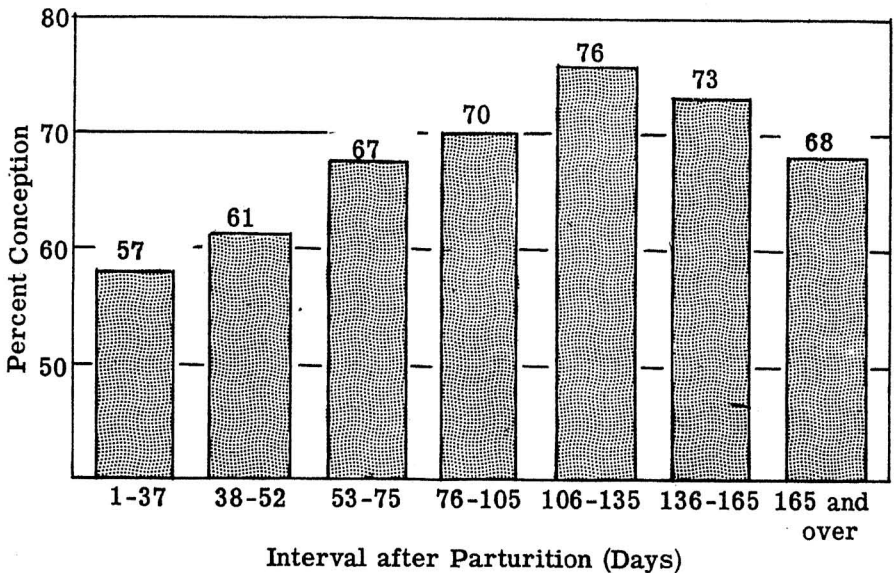


Figure 8--Effect of time serviced after calving on percentage non-returns to first services.

A gradual increase in breeding efficiency was obtained for each subsequent interval up to 106 to 135 days after calving with a slight decline for cows serviced at longer postpartum intervals. Differences between intervals were significant at the 1 percent level when tested by analysis of variance. More than two-thirds of the cows studied were inseminated between 53 and 105 days after calving with only 18.3 percent being serviced less than 53 days after parturition. The fact that a large majority of the cows in this study were inseminated at 60 days or longer after calving indicates that most dairy-men participating in the artificial insemination program were following the recommended practices of giving cows a two months postpartum sexual rest.

Climatic Factors

Seasonal fluctuations in the reproductive efficiency of dairy cattle are known to exist, but the variations due to specific climatic factors, such as light, temperature, humidity, and levels of nutrition above maintenance levels, have not been clearly demonstrated.

Mercier and Salisbury (1947a, 1947b) found that variation in the amount of daylight had a slight effect on efficiency of reproduction in dairy cattle. Sweetman (1950) in Alaska reported a 5 percent higher conception rate for cows subjected to 14 hours of light per day as compared to those exposed to 8 hours of light daily. Dawson (1938) reported that semen quality was poorest during the late summer and best during the spring. The number of services required per conception was higher during the summer months than any other season of the year. Similar results were observed by Trimberger and Davis (1945) in Nebraska, Herman (1952) in Missouri and Norton (1952) in Louisiana.

The purpose of this part of the study was (A) to determine the percentage of cows being bred at each season of the year and (B) to compare the seasonal variations in efficiency of reproduction.

Data on 94,935 first service inseminations extending over all seasons of the year for a period of four years were included in this investigation. Information presented in Tables 12, 13, and 14, and Figures 9 and 10 show the variation in breeding efficiency by months, seasons and years. The mean monthly breeding efficiency as shown in Table 12 varied from 61.5 percent in August to 72.2 percent in June. Breeding efficiency was highest in June for each of the four years and lowest in August three of the four years studied.

The data presented in Table 13 indicates the mean breeding efficiency by seasons for the four-year period of 1948 to 1951, inclusive. The mean

TABLE 12 -- SEASONAL VARIATIONS IN BREEDING EFFICIENCY OF DAIRY CATTLE SERVICED BY ARTIFICIAL BREEDING.

Months	1948		1949		1950		1951		Total	
	S*	%	S	%	S	%	S	%	S	%
January	997	49.5	1,681	59.6	2,461	63.4	3,109	69.0	8,228	63.1
February	1,093	46.2	1,611	59.5	1,838	63.1	2,391	67.8	6,933	61.2
March	1,183	48.4	2,087	62.6	1,967	66.0	2,580	68.6	7,817	63.3
April	1,081	63.7	1,855	68.3	1,579	72.2	2,496	69.5	7,011	68.9
May	1,039	68.3	1,627	68.3	1,510	73.8	2,420	71.4	6,596	70.7
June	935	71.8	1,303	68.7	1,276	75.5	2,080	72.5	5,594	72.2
July	1,027	61.8	1,300	60.7	1,562	70.8	2,555	69.1	6,444	66.7
August	389	56.0	1,006	57.4	1,174	70.1	2,014	59.5	4,583	61.5
September	1,354	60.6	1,508	61.5	1,953	71.0	3,101	66.3	7,916	65.6
October	1,277	59.0	1,825	61.0	2,349	71.2	3,569	68.7	9,020	66.4
November	1,428	56.0	2,649	61.9	3,553	68.8	4,584	64.0	12,214	62.6
December	1,689	59.5	2,609	60.5	3,632	69.3	4,649	63.0	12,579	63.8
Total	13,472	57.1	21,061	62.5	24,854	69.1	35,548	67.1	94,935	65.2

*Number of first services.

**Percent 60-to-90-day non-returns.

TABLE 13 -- SEASONAL VARIATION IN BREEDING EFFICIENCY OF DAIRY CATTLE IN ARTIFICIAL INSEMINATION FOR YEARS 1948 THROUGH 1951.

Seasons	Number of Services	Services per Conception	Percent Conception	Percent of Total cows
Winter	22,978	1.60	63	24.2
Spring	19,201	1.42	70	20.2
Summer	18,943	1.54	65	20.0
Fall	33,813	1.56	64	35.6
Total or Average	94,935	1.53	65	

TABLE 14 -- SEASONAL VARIATION IN BREEDING EFFICIENCY OF DAIRY CATTLE IN ARTIFICIAL INSEMINATION FOR YEARS 1949 AND 1951.

Seasons	Number of Services	Services per Conception	Percent Conception	Percent of Total cows
Winter	13,459	1.53	65	23.8
Spring	11,781	1.43	70	20.8
Summer	11,484	1.56	64	20.3
Fall	19,885	1.57	64	35.1
Total or Average	56,609	1.53	65	

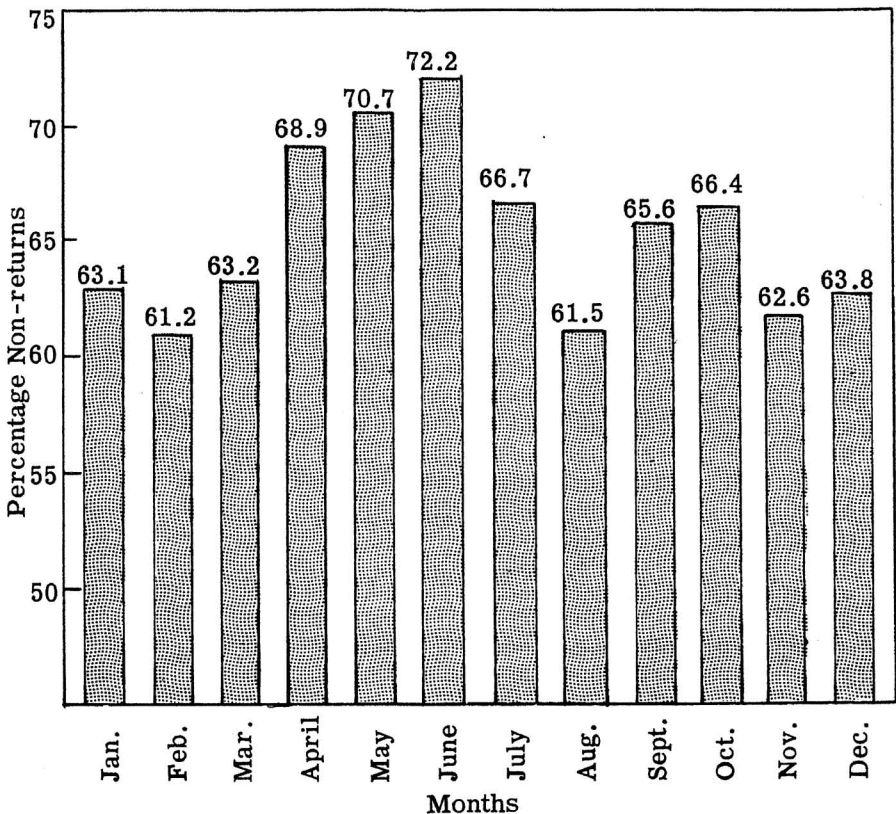


Figure 9--Mean monthly variation in breeding efficiency of dairy cows over four year period.



Figure 10--Monthly variation in breeding efficiency of dairy cattle serviced by artificial insemination during a four year period.

seasonal rates of conception for winter, spring, summer and fall were 63, 70, 65, and 64 percent, respectively. Data for the two more nearly normal years of 1949 and 1951 are presented in Table 14. On the average, conception rates for winter, spring, summer and fall were 65, 70, 64, and 64, respectively.

The average percentages of cows inseminated by seasons were as follows: Winter 24.2 percent, spring 20.2 percent, summer 20.0 percent, and fall 35.6 percent. The largest percent of the first service inseminations resulted in conception in the spring with the rate of conception being about equal for summer, fall and winter. Variation in breeding efficiency within seasons was greatest during the summer with August being low three of the four years studied.

Comparatively little decrease in breeding efficiency was observed during the summer and fall of 1950 as shown in Table 12 and Figure 10. The

relatively high breeding efficiency obtained in July, August and September of 1950 is attributed to the fact that the temperature was unusually cool during that period. However, variation in breeding efficiency by months followed the same general pattern as the other years studied. The low breeding efficiency observed in January, February and March of 1948 can be attributed partly to the fact that the program was in its infancy with a large number of inexperienced inseminators being employed during that time.

Data presented in Table 14 show the number of bulls by breeds and the percentage of bulls producing inferior quality semen by months during 1951. Bulls producing poor quality semen, low percent motility and-or high percent abnormal spermatozoa, ranged from zero in April and May to 31 percent in September, with 17 and 27 percent of the bulls producing low quality semen in July and August, respectively. Breed differences in semen quality were quite evident during the summer months. The percentage of bulls producing poor quality semen was highest in the Holstein, intermediate in the Jersey and Guernsey and lowest in the Brahman and Red Sindhi.

TABLE 15 -- VARIATION IN SEMEN PRODUCTION OF DAIRY AND BEEF BULLS BY MONTHS DURING 1951.

Breeds	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Jersey--No. of bulls	12	12	12	12	12	12	12	12	13	16	15	16
Percent of bulls producing poor quality semen	0.0	0.0	0.0	0.0	0.0	8.0	17.0	25.0	31.0	0.0	7.0	12.0
Holstein--No. of bulls	9	8	9	8	9	9	9	9	9	9	10	10
Percent of bulls producing poor quality semen	0	0	11.0	0	0	11.0	22.0	33.0	44.0	11.0	20	0.0
Guernsey--No. of bulls	8	7	7	7	7	7	7	6	7	5	5	6
Percent of bulls producing poor quality semen	12.0	14.0	0.0	0.0	0.0	0.0	0.0	17.0	29.0	20.0	20.0	17.0
Hereford--No. of bulls	2	2	2	2	2	2	2	2	2	2	2	2
Percent of bulls producing poor quality semen	0.0	0.0	50.0	0.0	0.0	0.0	50.0	100	50.0	50.0	0.0	0.0
Angus--No. of bulls	2	2	2	2	2	2	2	2	2	2	2	2
Percent of bulls producing poor quality semen	50	0	0	0	0	0	50	0	0	0	100	0
Brahman--No. of bulls	0	1	2	2	2	2	2	2	2	2	2	2
Percent of bulls producing poor quality semen	0	0	0	0	0	0	0	0	0	0	0	0
Red Sindhi--No. of bulls	1	1	1	1	1	1	1	1	1	1	1	1
Percent of bulls producing poor quality semen	0	0	0	0	0	0	0	0	0	0	0	0
All Breeds--No. of bulls	38	33	35	34	35	35	35	33	35	36	36	38
Percent of bulls producing poor quality semen	5.0	3.0	6.0	0.0	0.0	6.0	17.0	27.0	31.0	8.0	14.0	8.0

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serviced 101 to 120 days after calving as compared to those bred less than 40 days postpartum.

The question often arises as to whether or not a dairyman is justified in servicing his cows less than 60 days postpartum in an effort to have them freshen at some desired time. If lowered breeding efficiency for the first service was the only factor to be considered it would appear that breeding 30 to 60 days postpartum is advisable under certain conditions. However, data presented by Hofstad (1941) indicate that cows bred less than two months after calving have a much higher incidence of metritis, abortions, Dystocia and Retained Placenta. Thus it would appear that the dairyman who services his cows less than 60 days after calving is inviting breeding troubles and should expect a relatively low breeding efficiency. The large number of second and third services required for cows bred too soon after calving has a tendency to lower the overall conception rate and increase the cost of artificial insemination.

The mean conception rate was highest in the spring with winter, summer and fall being about equal. Seasonal variation in breeding efficiency observed in this study was much less than that reported by Seath *et al.* (1943) and Norton (1952) in natural service. The relatively small variation in breeding efficiency obtained in artificial as compared to natural service can be attributed to at least two factors; first in artificial insemination, each semen sample was evaluated, with only those meeting the minimum quality tests being used; secondly, a large number of herds were included in this study as compared to one in natural service. The comparatively high conception rate obtained during the summer in artificial insemination can also be attributed to the fact that the service of bulls producing poor quality semen was curtailed or discontinued altogether.

Seasonal variations in semen quality observed are in agreement with the report of Dawson (1938) who found that semen quality was poorest during July, August and September and superior during April, May and June.

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