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To the Graduate Council:

I am submitting herewith a thesis written by John H. G. Rankin entitled "The Effect of Induced Estrus on Conception Rate in Dairy Cattle." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Dairying.

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THE EFFECT OF INDUCED ESTRUS ON CONCEPTION RATE IN DAIRY CATTLE

A Thesis

Presented to

The Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

John H. G. Rankin

August 1963

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CHAPTER I

INTRODUCTION

During the first few weeks of a dairy cows' lactation the milk production rises to a maximum then gradually declines as the lactation progresses. Lactations showing a slow decline are said to have higher persistency than lactations showing a rapid decline in production. Although lactations vary in persistency the production of all cows declines as the lactation progresses.

This decline in production combined with the physiological necessity of a dry period makes it necessary for the cow to be bred at regular intervals thus re-establishing the high post-calving level of production. It can be shown that the calving interval which offers the most economic benefit is one which balances the loss of production during the dry periods with the gain in production due to the post-calving peak. Obviously cows with lactations of low persistence need a shorter calving interval than cows with lactation intervals of high persistence, but for the sake of convenience of management and standardization of records, a calving interval of twelve months is usually adopted.

One of the problems facing the dairy farmer in his attempt to keep his cows to the most economical calving interval is getting the cows to conceive at the right time. For this reason any method of improving the conception rate would find great practical application.

To maintain a twelve-month calving interval the cows must be bred as soon as possible after sixty days postpartum. It is entirely possible that the uterus is not in a suitable condition to provide optimum conditions for sustaining a pregnancy at this time. This experiment was designed to examine the possibility of improving the conception rate in dairy cattle by inducing an early postpartum estrus with hormone injections. The relationship between the rate of uterine involution and conception rate was also studied.

CHAPTER II

REVIEW OF LITERATURE

I. VARIABILITY OF REPRODUCTIVE PHENOMENA IN THE COW

Length of estrous cycle. Erb et al. (19) observed 9994 estrous cycles in 2607 cows and found that the modal length was 20 days in heifers, 21 days in cows up to 13 years of age and 22 days in cows over 13 years of age. They found that breeding had a pronounced effect on the cycle length. The average length of non-service cycles was 20.8 days and the average length of repeat service cycles was 22.0 days. Fletcher (20), in Louisiana, concluded from observations of 1276 estrous cycles in 154 cows that the average cycle length before a fertile service was greater than the average cycle length before a non-fertile service. He reported the mean length of all normal cycles was 20.4 days. Mares et al. (44) found the length of the estrous cycle in Holstein Freisian heifers to be 22.3 days and that return intervals averaged 25.3 days. They also found that the cycle length in heifers was affected by the season of birth. Summer and spring born heifers had average cycle lengths of 25.0 and 25.2 days, respectively. Fall and winter born heifers had average cycle lengths of 22.2 days and 20.9 days, respectively.

Time from parturition to first estrus. Trimberger (59) worked with 400 dairy cows and found that the apparent time from calving to first estrus averaged 50.9 days but that the true time to first estrus averaged 43.7 days. The difference was due to the fact that 35 cows

had 49 silent heats. He also observed that at 90 days, 93 per cent of all cows had shown signs of estrus and that 97 per cent had ovulated. Olds and Seath (47) found that the time from calving to first estrus to be 32.1 ± 18.6 days after 472 normal parturitions. They estimated the heritability of the time to first estrus as 27 per cent. In 1962 Menge et al. (45) found the average time to first estrus to be 32.4 days after observing 426 calving of 229 Holstein cows. Buch et al. (8) found that the time to first estrus was 33 days for both primiparous and pluriparous cows but it was affected by season. They reported that the service periods in the winter, spring, summer and fall were 38 days, 32 days, 28 days and 32 days, respectively. Casida and Venzke (10) showed that observations of the time to first estrus were dependant upon the watchfulness of the observer. They found that when cows were bred at three months postpartum the average time to first estrus appeared to be 60 days, but when the cows were bred two months postpartum the reported average time to first estrus was shorter by the length of one estrous cycle. Further evidence of the variability of the time to first estrus are observations by Lasley and Bogart (41) that the average time to first estrus in range cattle is 80.2 days. Chapman and Casida (14) made 244 observations of the time to first estrus and found that 20.1 per cent of the observations were between 21 and 40 days postpartum, 25.0 per cent were between 41 and 60 days postpartum and 19.3 per cent were between 61 and 80 days postpartum. Buch et al. (9) found that postpartum anestrus was only responsible for an average of 0.3 day delay in the calving interval.

Postpartum uterine involution. Foote et al. (22) worked with identical and fraternal Hereford twins and their findings agreed with those of Buch et al. (8) in that there was a significantly shorter time to uterine involution in the first service period than in the second. Foote et al. (22) also stated that the uterine involution rate was not significantly correlated with the time from calving to first estrus but that the conception rate at first service was significantly affected by the time to first estrus ($r = 0.4$). Trimberger (58) during research on conception rates from services at various intervals after calving observed that very frequently a cow conceived and carried the fetus to term even though the uterus was not fully involuted and pronounced ready for service at the time of breeding. Perkins and Kedder (49) agreed with this and stated that their observations of 255 service periods of Hereford and Angus cows indicated that conception rate was not affected by the state of involution of the uterus at the time of breeding. They concluded that the time to first breeding was more important than the involution of the uterus for conception in beef cattle. They found no breed differences in time from calving to uterine involution. Chapman and Casida (13) studied the relationship between the time from calving to conception and milk production. They concluded that the primary reason for long periods from calving to conception was low reproductive tone and that the rate of involution of the uterus was a major factor in determining conception rates at the first service after calving.

Conception rates. The effect of the time between calving and breeding on conception rates was studied by Edwards (18). He observed

11,685 cows and found that conception rate varied directly with the time between calving and breeding up to 90 days. He reported conception rates of 48.3 per cent for 0-30 days, 62.5 per cent for 30-60 days and 73.1 per cent for 60-90 days. Further increases in time to 180 days did not increase conception rates. Trimberger (58) quoted a conception rate of 48 per cent for breedings less than 60 days postpartum and 70 per cent for 61-90 days postpartum which is in close agreement with the work of Edwards. Van Demark and Salisbury (65) observed 1674 pregnancies in 593 cows and found the average number of services per conception to be 1.97 and the average interval between calving and first service to be 117 days. They observed that fertility increased with the length of the postpartum interval up to 100 days but did not find a significant correlation between postpartum interval and reproductive efficiency. Shannon et al. (56) studied the fertility of 7071 cows inseminated at various intervals after calving. The results indicated that a minimum interval of 50 days from calving to first insemination was required for satisfactory fertility.

The effect of season on the conception rate of Holstein and Jersey cows was studied by Heller and Rupel (35). They used 642 heifers and 1656 conceptions in 593 herds and found that fewer services per conception were required in the cooler months of the year and that Holsteins were more sensitive in this respect than Jerseys. Generally Holstein cows needed more services per conception than Jerseys. There were no differences due to age of heifers in Holstein cows but Jersey cows eight years of age or older needed more services per conception

than all other cows. In another study of seasonal fluctuations in the reproductive efficiency of dairy cows Poston et al. (50) made a ten-year summary of the breeding records in six herds. They found that the failure of first services ranged from 38 per cent in January to 56 per cent in August. Cows freshening in May had an average calving interval of 422 days whereas cows freshening in October had an average calving interval of 397 days. The interval from calving to conception ranged from 184 days for April calvings to 79 days for June calvings.

Pounden and Firebaugh (51) studied the effect of temperament of the cow on conception rate in 1445 cows and 2009 services. The results indicated that nervous or unusually quiet reactions at the time of service may be less desirable than the more usually observed responses. The effect of temperament on conception rate may be related to the amount of oxytocin or epinephrin released during breeding. However, Hays et al. (34) injected epinephrin or oxytocin after natural mating and artificial breeding of cows and could not demonstrate a significant effect of either. Tjupic (62) found that massaging the reproductive organs of 38 cows for 1.5 minutes before breeding resulted in a conception rate at first service of 84 per cent compared to a 59 per cent for 80 control cows. Inskeep (38) examined the records of 1406 cows in 41 artificially inseminated herds and calculated the heritability of conception rate in Holsteins as 8.5 per cent.

II. HORMONAL CONTROL OF REPRODUCTIVE PHENOMENA

Injected progesterone. In 1948 Christian and Casida (15) gave four heifers 14 daily injections of 50 or 25 milligrams of progesterone

in corn oil starting on the fourteenth day of the cycle. They found that 25 milligrams suppressed the manifestation of heat but did not stop all ovulations. The injection of 50 milligrams suppressed both heat and ovulation and the heifers came into heat five to six days after the injections ceased. All subsequent estrous cycles were normal.

Trimberger and Hansel (61) used 50, 70 and 100 milligrams of progesterone daily in dairy cows and commenced injections at any time in the estrous cycle. They found that the cows came into heat between four and six days after the injections were stopped. They also found that breeding to the first estrus after the injection resulted in a conception rate of 12.5 per cent. The second service resulted in a normal conception rate.

Fosgate et al. (26, 27) investigated the effect of injected progesterone on postpartum activity in the dairy cow more fully. They gave 22 injections of 100 milligrams of 17-alpha-hydroxyprogesterone-n-caproate (Delalutin) on alternate days beginning with the day of calving. They used 25 Holsteins and 14 Jersey cows and found that the injections increased the average time to uterine involution from 27.5 days to 42.0 days and the time to first estrus from 47.9 days to 70.0 days. They report that conception rates were not affected by the treatment and that there were no significant differences between the breeds.

Foote et al. (23) found that a single injection of one milligram of progesterone per pound of body weight given to Angus and Shorthorn cattle on the fourteenth day of the cycle did not affect the time to

first estrus. No effect was observed on conception rate. They concluded that if the ovaries do affect the uterine involution rate, they don't do it through the action of progesterone.

Willett (69) studied the effect of 100 milligram injections of progesterone starting on the fourteenth day of the cycle on the fertility of heifers. He found that the treatment had no effect on conception rate.

Oral progesterone. Several workers (16, 36, 37, 52, 57) have successfully synchronized estrus in sheep by feeding from 50 to 100 milligrams of 6-methyl-17-acetoxyprogesterone (Provera) per day, and conception rates were not affected. Nelms and Combs (46) made three trials of the use of Provera on estrual control in beef cattle. In the first trial nine out of ten cows which had been fed 0.8 milligram per pound of body weight for 15 days came into heat on the third, fourth and fifth day after withdrawal of the hormone. Of these nine, six conceived and calved. In the second trial, 33 cows with calves were fed 220 milligrams of the hormone each day for 50 days. The cows all showed signs of heat in the second or third day after feeding was stopped, and a 66 per cent conception rate was obtained from breeding to the synchronized estrus. In the third trial 60 heifers were fed 250 milligrams of the hormone per day for 14 days and then bred on the third, fourth, and fifth day after withdrawal of the hormone regardless of whether they showed signs of estrus or not. The overall conception rate was 40 per cent which was not different from the conception rate obtained from breeding control heifers during normal estrus.

Estrogen. Casida and Wisnicky (11) used 50 Holsteins to examine the effect of diethylstilbestrol on postpartum changes in the cow. They injected 20 milligrams of the hormone nine hours after calving and found that the treatment did not affect the time from calving to uterine involution, nor the time from calving to first ovulation or first estrus.

Hammond and Day (30) observed that corpora lutea existed for prolonged periods in heifers implanted with stilbestrol but this is in direct opposition to the findings of Greenstein et al. (29) who reported that estradiol administration on day two through day twelve of the estrous cycle caused early regression of the corpus luteum. Wiltbank et al. (71) substantiated the work of Greenstein et al. (29) and found that the injection of 50 milligrams of estradiol valerate or 25 milligrams of estrone or 25 milligrams of a natural estrogen would all cause early regression of the corpus luteum. Rahlmann and Cupps (53) found that 200-300 milligrams of injected estradiol per day decreased the length of the estrous cycle and delayed ovulation. Loy et al. (42) reported that the injection of estradiol-17-B from day one through day thirteen of the estrous cycle caused a decrease in weight of the corpus luteum and a decrease in the percentage of functional luteal cells but did not alter the progesterone concentration.

When examining the differences between different forms of estrogen in their mode of action, Beyer (4) found that a single injection of estradiol-cyclopentypropionate (ECP) was equally as effective as several divided doses but that this was not the case with estrone and estradiol. Victor (67) confirmed the fact that ECP had a longer lasting effect than other forms of estrogen.

Estrogen is not effective when administered at low levels orally. Krawczyk (39) fed 10 milligrams of stilbestrol per day to Holstein and Guernsey heifers for six months. There were no differences in the length of cycle or number of services required for conception between the estrogen fed group and the control group. The stilbestrol fed heifers had a higher rate of gain of body weight than the control heifers.

Douglas et al. (17) injected breeding ewes with one or two milligrams of ECP. He found that the injections were effective in producing estrus. Only three control ewes showed estrus in the first five days as compared to 14 injected ewes. The ewes injected with ECP had a very low conception rate and it appeared that the injection interferred with the hormonal relationships involved in fecundation. Waite and Foote (68) found that it required three to four milligrams of injected estradiol to induce estrus in ewes but that ovulation was induced by an injection of two milligrams or less. This led them to believe that estrus and ovulation are separable phenomena induced at different hormone levels. Venzke (66) using ECP in ewes found that there were no differences between the responses to two milligrams or eight milligrams and that for both levels estrus was induced in 91 per cent of the ewes. No ewes conceived when bred to the induced estrus.

Foote and Walker (24) investigated the influence of exogenous estrogen in ovarian activity in postpartum dairy cows. They used 22 cows and divided them into primiparous and pluriparous groups. Each group was injected with 10 milligrams of estradiol in corn oil nine to

twelve days after calving. They found that all cows of both groups came into heat and ovulated in one day except one primiparous cow which showed estrus in three days and one primiparous cow which did not ovulate. The treatment decreased the time from calving to ovulation from 30.9 to 14.9 days. The time from calving to ovulation of the primiparous group decreased from 39.2 ± 23.5 to 17.0 ± 13.3 days and in the pluriparous group it decreased from 21.0 ± 6.6 to 12.4 ± 0.9 days.

The release of luteinizing hormone (LH) from the anterior pituitary gland when under the influence of estrogen was demonstrated by Lane (40) and indicates that estrogen causes the corpus luteum to regress by acting on the anterior pituitary. Loy et al. (42) postulated that estrogen released the LH stored in the anterior pituitary which resulted in an inadequate supply of LH after the initial release. It would appear than that the regression of the corpus luteum following treatment with estrogen was induced by a lack of LH. The fact that Wiltbank (71) observed no early regression of the corpus luteum when the estrogen injection was followed by an injection of follicle stimulating hormone (FSH) and LH tends to substantiate this theory.

Estrogen with progesterone. The effect of injected progesterone and estrogen was studied by Ulberg and Lindley (64). In ten trials involving 458 estrous cycles over a four-year period they found that 14 daily injections of 12.5 milligrams of progesterone followed by five to ten milligrams of estradiol benzoate three days after the withdrawal of progesterone induced estrus and ovulation with subsequent conception

rates equal to those obtained with progesterone alone. The estrogen treatment removed most of the variability of the onset of estrus.

Foote (21) found that when one injection of 10 milligrams of estradiol-17-B was given two days after eleven daily 50-milligram injections of progesterone in postpartum cows, the time to uterine involution was 36 ± 8.8 days as compared to 39 ± 13.2 days for a group treated only with progesterone and 47 ± 11.4 days for the control group. The times to first estrus and conception followed a similar pattern but the progesterone and estrogen treated cows needed more services per conception than the other cows when all cows were bred at the first estrus after calving. Armstrong et al. (3) also found that cows treated with progesterone followed by estrogen needed more services per conception. Anderson et al. (1) used 80 yearling Hereford heifers and found that serial progesterone injections followed by one injection of estradiol in five to seven days caused a lower conception rate in a group fed oral progesterone than in a control group. Foote et al. (25) worked with Hereford cows and found that while a subcutaneous injection of 10 milligrams estradiol 20 days after a single progesterone injection gave better synchronization of estrus, it produced conception rates much lower than from a progesterone treated group or a control group. Wiltbank (70) used 200 cycling Hereford heifers and found that when 40 milligrams of progesterone and 80 milligrams of estradiol were given daily for 24 days, 98 per cent of the heifers came into heat within four days after the injections ceased. The conception rate when bred at the induced estrus was 56 per cent as compared to the conception rate of 60 per cent in the control group.

Oxytocin. In 1959 Armstrong and Hansel (2) found that daily injections of 20 units of oxytocin in the first week of the estrous cycle of postpubertal non-lactating dairy heifers, would induce the next heat at days eight to twelve of the cycle instead of day 21 and that ovulation was normal. They deduced that oxytocin inhibited the functioning of the corpus luteum by interfering with the secretion of LH from the anterior pituitary gland.

Oxytocin was first used to regulate the estrous cycle without decreasing the conception rate by Hansel and Wagner (32) in 1960. Hansel et al. (31) supported this finding in 1961. They found that of 27 Hereford heifers recycled with oxytocin, 26 came into heat within eight days of oxytocin withdrawal and that the conception rate when bred at the induced estrus was 50 per cent. This result was compared with the results of a trial using 32 Hereford cows fed on oral progesterone for 20 days. In this trial 16 cows came into heat in three to four days and 13 ovulated but showed no signs of estrus. The conception rate when the cows were bred at the induced estrus was only 25 per cent.

Ovarian hormones and uterine infection. Chambers (12) as a result of observations made during his veterinary practice believed that cows which are apparently normal and came into heat regularly but do not conceive after several breedings will settle in 90 per cent or more of the cases following infusion of the uterus with penicillin.

Ulberg et al. (63) infused the uteri of 37 Holstein and 20 Guernsey cows with aureomycin and streptomycin at the beginning of heat or 17 days after the manifestation of heat. They found that the

antibiotics introduced in the luteal phase of the cycle produced some inflammation and that antibiotic infusion of the uterus decreased conception rates in both trials.

The effect of ovarian hormones on the inflammatory response of the ovine uterus was studied by Brinsfield et al. (7). They found that an injection of bacteria into the uterine lumen of sheep produced a rapid inflammatory response in ovariectomised sheep, a moderately fast response in sheep in the estrual phase of the cycle and a delayed response in sheep in the luteal phase of the cycle. They postulated that progesterone and estrogen both inhibit the inflammatory response of the uterus and that progesterone was more effective than estrogen in this respect. They believed that this endocrine action was effected through the control of factors influencing the rate of leucocytic diapedesis.

Mares et al. (45) found that the progesterone content of the bovine ovary increased from day seven to day fifteen of the estrous cycle, then gradually declined. The period of maximum uterine susceptability to infection in the bovine can therefore be expected to center about day fifteen of the estrous cycle.

Rawson et al. (55) worked on the effect of exogenous progesterone on ovariectomised cows and concluded that progesterone promoted conditions in the uterus suitable for the growth of certain bacteria and that the infection could be controlled by removing the source of progesterone or injecting penicillin or injecting estrogen.

Roy et al. (54) found that exogenous progesterone interferred with the formation and/or maintenance of the corpus luteum. They

observed that the cells of the glandular ephithelium of the uterine endometrium tended to be higher in control uteri. The inference was that the endometrium of the progesterone treated group was possibly subfunctional. They concluded that the lowered fertility observed after progesterone administration could at least be partly explained on this basis.

Black et al. (5) found that the action of the uterus under the influence of estrogen was bactericidal rather than bacteristatic and that the uteri of repeat breeding cows had more bactericidal activity in the luteal phase than normal cows. They postulated that the loss of uterine resistance to infection in the luteal phase of the cycle is allied with a changing uterine environment necessary for nutrition and implantation of the embryo. This hypothesis is supported by the work of Black et al. (6) who found that diluted semen injected into the uterus of cycling dairy heifers during the luteal phase of the cycle induced pus formation whereas it did not induce pus formation when injected in the estrual phase.

Hawk et al. (33) investigated the effect of ovarian hormones on capillary permeability of the uterus of the rabbit. They found that the injection of estrogen caused a great increase in the capillary permeability of the uterus and that injected progesterone caused a very slight increase. They stated that progesterone apparently inhibited the ability of the endometrial capillaries or stroma to change in response to infection and that this effect may be related to the known property of progesterone of retarding leukocytic response to induced uterine infection.

III. SUMMARY OF REVIEW OF LITERATURE

The length of the estrous cycle in dairy cattle is reported to be approximately 21 days and is affected by age of the cow or heifer and season of birth. There is a relationship between the ability to conceive and the length of the previous cycle. The time from calving to first estrus was reported to be widely variable but most observers gave 30-40 days as an average figure. Much of the variation in reports of the time from calving to first estrus may be due to inadequate observation.

The average interval from calving to involution of the uterus is reported as being between 40 and 50 days. Pluriparous cows take longer than primiparous cows. Cows calving in the winter have a longer interval between calving and uterine involution than cows calving in the summer. No breed differences were reported and no evidence has been presented to prove a positive relationship between the time from calving to uterine involution and conception rate; but some authors believe that uterine involution is a major factor determining conception rate at first service.

Conception rates are lower when cows are bred less than 60 days postpartum but do not improve if the time from calving to breeding is increased above 90 days. Seasonal variations in conception rate have been reported. Breedings in the warmer months of the year have a lower conception rate than breedings in the cooler months. Nervous or unusually quiet cows may have a lower conception rate than normal.

Serial progesterone injections are effective in synchronizing estrus in dairy cattle though the synchronization is improved if estrogen is injected after withdrawal of the progesterone. Conception rates are slightly lower than normal when cows are bred at the induced estrus. Some forms of progesterone are effective when given in the feed but oral estrogens have not been found to be effective in controlling reproductive phenomena in cattle.

Injected oxytocin may be used to synchronize estrus to some extent and conception rates are better than those obtained with progesterone synchronized estrus. Serial injections of estrogen and progesterone may be used to synchronize estrus and the indications are that the conception rates when bred to the induced estrus are not depressed below normal.

Ovarian hormones affect the resistance of the uterus to infection. A uterus under the influence of progesterone has very little bactericidal activity whereas a uterus under the influence of estrogen has considerable bactericidal activity. The luteal or infection sensitive phase of the estrous cycle appears to be necessary to condition the uterus to provide for the nutrition and implantation of the embryo.

CHAPTER III

EXPERIMENTAL PROCEDURE

An experiment to determine the effect of induced estrus on conception rate in dairy cows was conducted in 1962-63 in the University of Tennessee dairy herd at Knoxville.

Selection of cows. The milking herd at the Knoxville farm consists of purebred Holstein and Jersey cows. All cows and heifers due to calve between July 1, 1962 and December 10, 1962 were used in this experiment. Breeding records showed that 138 cows and heifers were due to calve in this time. These cows were separated into two groups. The groups were balanced with respect to breed, number of parturitions, including the prevailing pregnancy, and predicted calving date. A further consideration in balancing the groups was the average number of services per conception previously required for each cow from the daily herd report made by the farm manager. The two groups were allocated as treatment and control. This decision was arbitrary, there being no reason to select either groups for one label or the other.

During the course of the experiment it was necessary to exclude certain cows for various reasons. The balance of the groups was maintained where necessary by reassigning cows which had not yet calved. A total of thirty-eight cows were dropped from the experiment leaving 110 cows on which data were collected. No data were collected on the thirty-eight cows not used in the experiment most of which were

excluded because they were being used in other studies or were scheduled for show grooming and training. Several cows were dropped because they were under veterinary care during the immediate postpartum interval and it was considered inadvisable to administer the injection. Table I shows the number of cows in each group by breeds and the final balance that was attained.

Treatment. Prior to the experiment all of the cows were subject to the same management procedures as the rest of the herd. The two groups were not separated from each other or the herd at any time during the experiment.

The experimental treatment consisted of an intramuscular injection of five milligrams estradiol-cyclopentylpropionate (ECP) in five milliliters of cottonseed oil. The injection was placed at a depth of 1.5 inches in the Biceps femoris or outside round muscle four days after calving. The control treatment was an injection of five milliliters of cottonseed oil given at the same depth, site and time after calving as the treatment injection.

Uterine size and tone. All treated and control cows were palpated per rectum at the time of the injection. Subsequent uterine palpations were performed at weekly intervals for eight weeks. The ovaries were also palpated when possible. Uterine size was graded as large, medium, normal or small and uterine tone was graded as hard, medium, normal or flaccid. The grading system is explained in Table II.

TABLE I

BREED, NUMBER OF COWS, NUMBER OF CALVES PER COW, CALVING DATES AND NUMBER OF SERVICES PER CONCEPTION OF THE TWO BALANCED GROUPS AFTER READJUSTING FOR UNAVAILABLE COWS

	Final Balance			
	Holstein		Jersey	
	Control	Treated	Control	Treated
Number	38	38	17	17
Average Number Calves	2.4	2.3	2.7	2.1
Average Difference in Numbers Calving Per Month	2.5		1.2	
Average Services Per Conception	2.3	1.8	2.0	1.7

TABLE II

GRADING SYSTEM FOR UTERINE PALPATIONS

Uterine Size	Description
Large (L)	Extends deep into the abdominal cavity. Often heavy and thick. Tone may be Hard or Medium, rarely Flaccid. Extremities cannot be found without a very extensive palpation.
Medium (M)	Extends into abdominal recess, and cannot be totally palpated. Diameter of the horns can be determined. Tone may be Medium, Normal, Flaccid or Hard.
Normal (N)	Extends only slightly beyond the pelvis. The two horns can be held in the hand. The tone can be Normal, Flaccid or Medium.
Small (S)	The whole reproductive tract is coiled just anterior to the vulva. Palpation is difficult. The tone is often Flaccid.

Frequent use was made of intermediate grades both of size and tone. For example, a uterus could grade N-S in size and normal to flaccid in tone. It was relatively easy to determine which grade of size and tone to assign a uterus by using this system.

The number of parturitions was considered in grading the uterus for size. Absolute size was less important than size and position relative to the pelvis. For this reason, a uterus which would be graded as normal in a cow after her second calf would be large enough to grade medium or medium to large in a cow after her first calf.

To avoid any bias in the grading of uterine size and tone, the list of cows which had received an injection of ECP was not consulted during the time that they were subject to weekly rectal palpations. For this reason it was generally not known whether the cow being palpated was in the treated or control group. All palpations were performed by the same person.

Post calving estrus. Close attention was given to all cows on the experiment during the sixty-day postcalving period. All cows observed in heat were noted in the daily herd report by the farm manager. The majority of the observations of postcalving estrus were made by the milking staff and farm manager. The herd was routinely inspected twice daily for cows showing signs of heat.

These signs were unusual restlessness, standing while being mounted by other cows in the herd, attempting to mount other cows, a swelling of the labia majora, and a flow of mucus from the vulva.

Individual cows varied in their manifestation of heat and all of the symptoms were not always seen.

Breeding. It was planned to have all cows in the experiment bred as soon as possible after sixty days postpartum. A record was kept of the date and bull used for each breeding. The rectovaginal technique of artificial insemination was used in all cases.

Whenever possible, individual bulls were used with equal frequency in breeding the treated and control cows. Most of the semen was taken from frozen storage where it was kept under dry ice. A few inseminations were made by a technician who used fresh diluted semen.

Temperament. At the conclusion of the experiment all of the cows were rated as to temperament. The rating was either nervous or non-nervous. Two persons were chosen for their familiarity with the herd, the milker and the herd manager. Each was asked to give an opinion on each cow in the experiment as to whether they thought the cow was generally nervous or non-nervous. The interviews were conducted separately. Only one opinion was obtained on first calving cows.

A rating of nervous by one or both persons gave the cow an overall rating of nervous rather than non-nervous because it was felt that each of the two men knew the cows under slightly different conditions, the milker in the milking parlor and the manager outside the milking parlor. A rating of nervous in either set of conditions was sufficient to consider the cow as nervous in this experiment.

Analysis. Uterine size and tone estimates were coded to a numerical system so that additive summaries and comparisons of the data could be made. The t test was used to test the statistical significance of differences between means and the X^2 test was used where it was necessary to find the probability of two items of data being from the same population (48).

CHAPTER IV

RESULTS

Uterine involution rate. Uterine involution rate was estimated from records of the uterine size and tone made at the weekly rectal palpations. Involution rate was assumed to be represented by the changes in size and tone that were observed. The estimates of size and tone were coded to a numerical system before the analysis was made, as shown in Table III.

The change in uterine size of the control and treated groups over the six-week postpartum period is shown in Figure 1. The indices of uterine size of the control group deviate very little from the straight line, $Y = 6-0.425X$, where Y is the index of uterine size and X is the time in weeks after calving. The standard deviation of the size index of the control group from the regression line is 0.0012. The treated group showed more variation in uterine size than the control group and had smaller uteri for the second to eighth weekly period after calving. The differences in uterine size between the treated and control groups are shown in Table IV. The difference is greatest at three weeks postpartum. The t test shows that this difference of 0.65 is significant at the five per cent level of probability.

The change in uterine tone of the treated and control group is shown in Figure 2. It can be seen that the changes in uterine tone are not directly proportional to time as were changes in uterine

TABLE III

CODING SYSTEM OF UTERINE SIZE AND TONE

Size	Code	Tone	Code
Large	6	Hard	6
Large-Medium	5	Hard-Medium	5
Medium	4	Medium	4
Medium-Normal	3	Medium-Normal	3
Normal	2	Normal	2
Normal-Small	1	Normal-Flaccid	1
Small	0	Flaccid	0

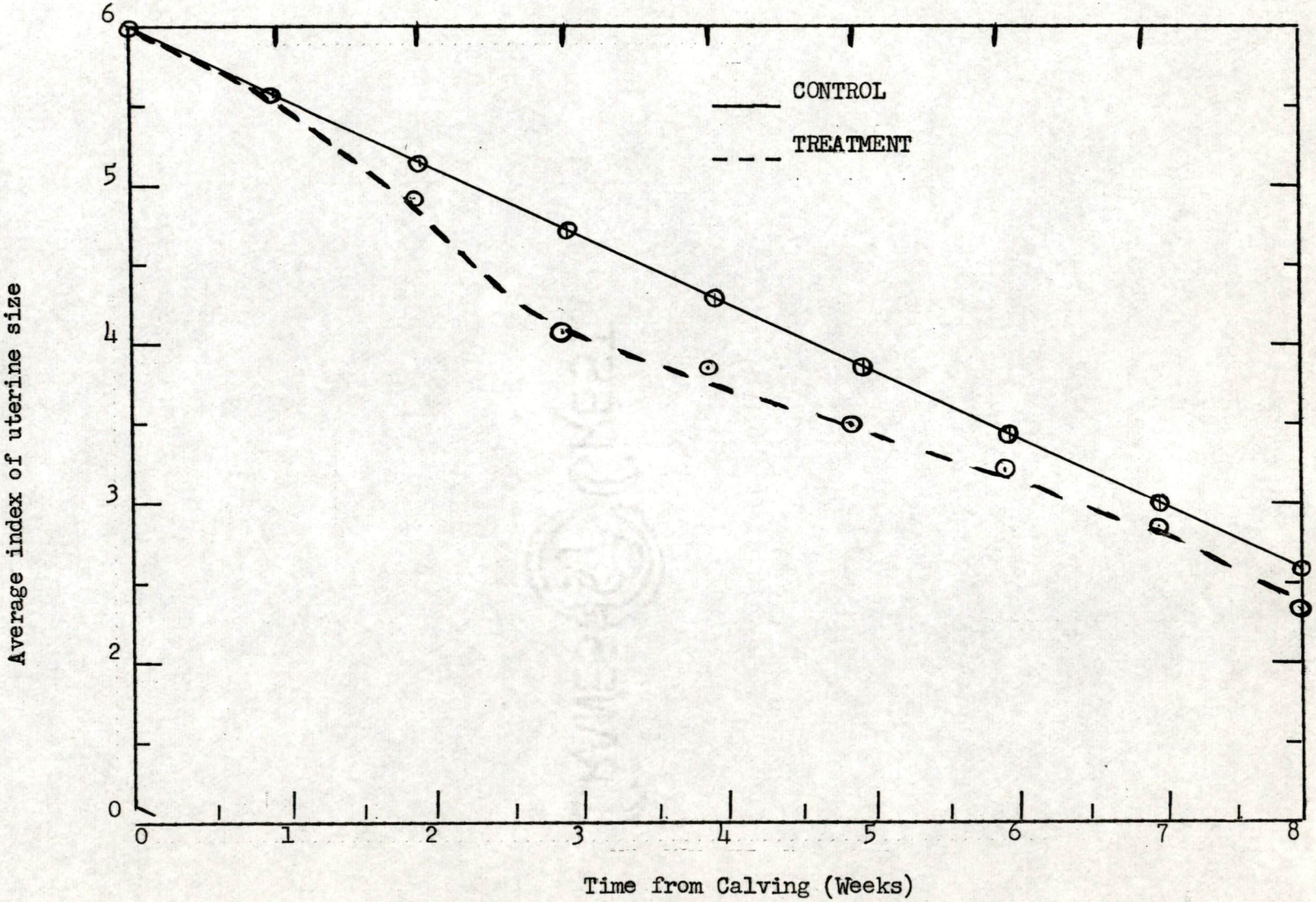


Figure 1. Average uterus size with time from calving of 110 cows comparing the cows injected with estrogen four days after calving and the control cows.

TABLE IV

AVERAGE INDEX OF UTERINE SIZE OF FIFTY-FIVE COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM AND FIFTY-FIVE CONTROL COWS FOR EACH WEEK OF THE SIXTY-DAY POSTPARTUM PERIOD

Time From Calving	Control Group	ECP Group	Difference
(wk)	----------	(index)	----------
0	6.00	5.87	0.13
1	5.60	5.69	0.09
2	5.16	4.77	0.29
3	4.71	4.06	0.65*
4	4.33	3.85	0.48
5	3.82	3.36	0.46
6	3.44	3.04	0.40
7	2.95	2.87	0.08
8	2.71	2.33	0.38

* t test significant P=.05

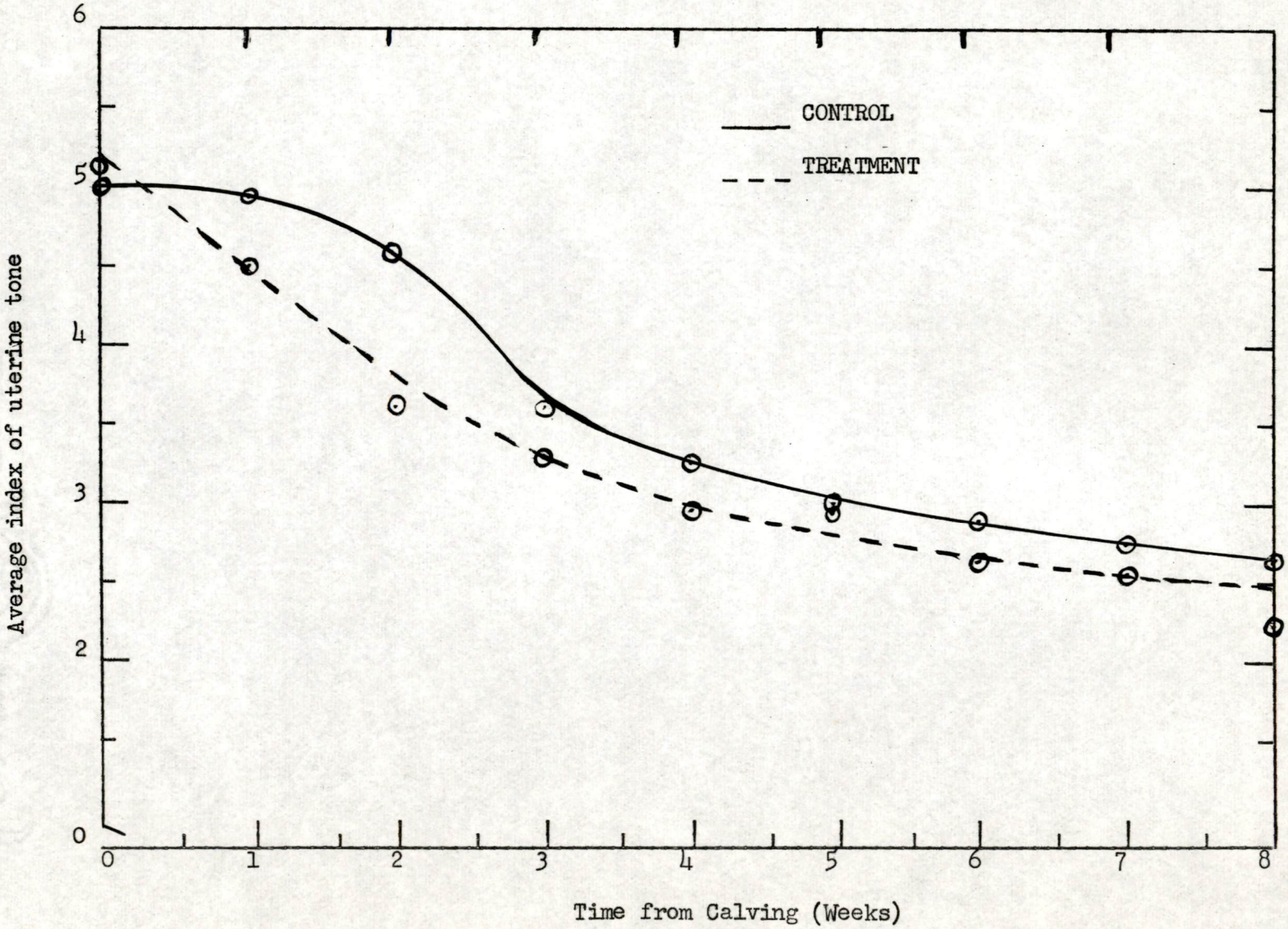


Figure 2. Average index of uterine tone at various time from calving of 110 cows comparing the cows injected with estrogen four days after calving and the control cows.

size. The indices of uterine tone of the control group follow and fit very closely to a sigmoid curve. The curve dips most rapidly in the one to four-week postpartum period with a maximum rate of decrease in the third week. The points fit the curve very well and it is reasonable to expect that they are a true indication of uterine tone. The differences in uterine tone between the treated and control groups are shown in Table V. The maximum difference of 1.08 occurs two weeks after calving. The t test shows that the treated uteri at this time were significantly softer than the control uteri at the five per cent level of probability. Further considerations of factors affecting or related to the response of the uterus to the treatment will be based on the index of uterine size at three weeks and tone at two weeks after calving.

The effect of breed, number of calves, temperament and season of calving on the response of the uterus is shown in Table VI. Holsteins had larger uteri than Jerseys. The uterine tone of the control Holsteins was the same as that of the control Jerseys and the uteri of the treated Holsteins were softer than those of the treated Jerseys. None of these differences was significant. This is to be expected because although the Holstein uterus may be larger than the Jersey uterus, the size estimates made in this study were based on size and position relative to the pelvis and were not intended to be absolute measurements. There were no significant differences in uterine size or tone between the treated Jerseys and the control Jerseys but the treated Holsteins had significantly smaller and softer uteri than the control Holsteins.

TABLE V

AVERAGE INDEX OF UTERINE TONE OF FIFTY-FIVE COWS INJECTED WITH ESTROGEN FOUR DAYS AFTER CALVING AND FIFTY-FIVE CONTROL COWS FOR EACH WEEK OF THE SIXTY-DAY POSTPARTUM PERIOD

Time From Calving	Control Group	ECP Group	Difference
(wk)	----------	(index)	----------
0	5.00	5.16	0.16
1	4.95	4.56	0.39
2	4.53	3.45	1.08*
3	3.66	3.36	0.30
4	3.26	2.98	0.28
5	3.09	3.09	0.00
6	2.84	2.60	0.24
7	2.71	2.60	0.11
8	2.66	2.00	0.56

* t test significant. P = .05

TABLE VI

AVERAGE INDEX OF UTERINE SIZE AT THE THIRD WEEK AND TONE AT THE SECOND WEEK POSTPARTUM OF 110 COWS USED TO EXAMINE THE EFFECT OF BREED, NUMBER OF CALVES, TEMPERAMENT AND SEASON OF CALVING ON RESPONSE TO AN INJECTION OF ESTROGEN FOUR DAYS AFTER CALVING

	Control			Injected with ECP			Difference	
	Size	Tone		Size	Tone		Size	Tone
	--(index)--		(no)	--(index)--		(no)	--(index)--	
All Cows	4.71	4.53	55	4.06	3.45	55	0.65*	1.08*
Holstein	4.84	4.53	38	4.10	3.34	38	0.74*	1.19*
Jersey	4.41	4.53	17	3.94	3.71	17	0.47	0.82
Difference	0.43	0.00		0.16	0.37			
Primiparous	4.46	4.27	22	3.44	2.80	25	1.02*	1.47*
Pluriparous	4.88	4.70	33	4.57	4.00	30	0.31	0.70
Difference	0.42	0.42		1.13*	1.20*			
Non-Nervous	4.72	4.34	29	3.62	2.71	34	1.10*	1.63*
Nervous	4.69	4.73	26	4.76	4.29	21	0.07	0.44
Difference	0.03	0.39		1.14*	1.48*			
Fall Calving	4.18	4.59	22	3.77	3.16	31	0.41	1.43**
Winter Calving	5.06	4.58	33	4.42	3.83	24	0.62	0.75
Difference	0.88*	0.01		0.65	0.67			

* t test significant P = .05

** t test significant P = .01

Primiparous cows had smaller and softer uteri than pluriparous cows but these differences were significant in the treated group only. There were no significant differences in uterine size or tone between the treated and control pluriparous cows but primiparous control cows had significantly longer, harder uteri than primiparous treated cows.

Nervous control cows were very similar to non-nervous control cows and nervous treated cows had significantly longer and harder uteri than non-nervous treated cows.

Fall calving control cows had significantly smaller uteri than winter calving control cows but there was no difference in tone. Fall calving treated cows had smaller and softer uteri than winter calving cows but the differences were not significant. Fall calving control cows had significantly harder uteri than fall calving treated cows. No other differences were significant at the five per cent level.

Postpartum estrus. The average time from parturition to first estrus was 48.5 days for control Holsteins, 35.8 days for treated Holsteins, 37.3 days for control Jerseys and 21.7 days for treated Jerseys. The differences between breeds and the treated and control groups was significant, ($P = .05$).

The incidence of estrus between calving and breeding in the treated and control groups is shown in Table VII. In the treated group 103 heats were observed and in the control group seventy-six heats were observed. This difference is significant at the five per cent level of probability. Most of the difference was due to the

TABLE VII

NUMBER OF ESTROUS PERIODS OBSERVED IN COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM COMPARED WITH CONTROL COWS BY TEN-DAY INTERVALS THROUGH SIXTY DAYS

Time After Calving	Cows Injected With ECP	Control Cows	Difference
(days)	----------(no of estrous periods)----------		
0 - 10	19	5	14**
11 - 20	17	9	8
21 - 30	12	15	3
31 - 40	18	16	2
41 - 50	12	17	5
51 - 60	17	10	7
61 +	8	4	4
Total	103	76	27*

** X^2 test significant P = .01

* X^2 test significant P = .05

high incidence of estrus observed in the treated group in the first ten days where the difference between the treated and control groups was highly significant (P = .01).

The number of estrous cycles between calving and breeding did not influence the size or tone of the uterus. Table VIII shows that there were no significant differences in uterine size and tone between cows having none, one, two or more than two estrous cycles in this time. The treated group was more variable than the control group and treated cows which had had two estrous cycles had longer, harder uteri than the other cows. There were no differences in uterine size or tone between the treated and control cows which had two estrous cycles.

The effect of breed on postpartum estrus of the treated and control groups is shown in Table IX. Jerseys had significantly more postpartum estrous cycles than did Holsteins. This was mostly due to the fact that the seventeen treated Jerseys exhibited ten heats in the first ten days as compared to nine heats observed in thirty-eight Holsteins in the same period. The control Jerseys showed more postpartum estrous periods per cow than the control Holsteins but this difference was not significant.

There were no differences between primiparous and pluriparous cows with respect to the frequency of postpartum estrus. These comparisons are presented in Table X.

The effect of temperament on the incidence of postpartum estrus is shown in Table XI. The nervous group showed no response to the treatment but the non-nervous group showed a significant response with

TABLE VIII

AVERAGE INDEX OF UTERINE SIZE AT THIRD WEEK AND TONE AT SECOND WEEK POSTPARTUM OF 110 COWS ACCORDING TO THE NUMBER OF POSTPARTUM ESTROUS CYCLES COMPARING COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM AND CONTROL COWS

Postpartum Estrous Cycles	Treated			Controls			Difference	
	Cows	Size	Tone	Cows	Size	Tone	Size	Tone
(no)	(no)	---(index)---		(no)	---(index)---		---(index)---	
0	9	4.00	3.78	14	4.93	4.71	0.93*	0.93*
1	17	3.94	2.71	22	4.82	4.32	0.88*	1.61*
2	15	4.53	4.13	11	4.27	4.64	0.26	0.51
More than 2	14	3.64	3.00	8	4.75	5.00	1.11*	2.00*
0 and 1	26	3.96	3.08	36	4.86	4.47	0.90*	1.39**
2 and more than 2	29	4.10	3.58	19	4.47	4.79	0.37	1.21*

** X^2 test significant P = .01

* X^2 test significant P = .05

TABLE IX

POSTPARTUM ESTROUS PERIODS OF 110 COWS OBSERVED IN SEVEN TEN-DAY INTERVALS USED TO COMPARE HOLSTEIN AND JERSEY COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM AND HOLSTEIN AND JERSEY CONTROL COWS

Time Postpartum	Holstein Cows			Jersey Cows		
	Injected With ECP	Controls	Total	Injected With ECP	Controls	Total
(days)	(no of estrous periods)					
0 - 10	9	2	11	10	3	13
11 - 20	13	6	19	4	3	7
21 - 30	6	8	14	6	7	13
31 - 40	13	12	25	5	4	9
41 - 50	8	12	20	4	5	9
51 - 60	11	6	17	6	4	10
61 +	3	2	5	5	2	7
Total	63	48	111*	40	28	68*
Ave. Per Cow	1.7	1.3	1.5	2.2	1.8	2.0

* X^2 test significant P = .05

TABLE X

POSTPARTUM ESTROUS PERIODS OF 110 COWS OBSERVED IN SEVEN TEN-DAY INTERVALS USED TO COMPARE PRIMIPAROUS AND PLURIPAROUS COWS AND COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM AND CONTROL COWS

Time Postpartum	Primiparous Cows			Pluriparous Cows		
	Injected With ECP	Controls	Total	Injected With ECP	Controls	Total
(days)	(no of estrous periods)					
0 - 10	12	2	14	7	3	10
11 - 20	6	3	9	11	6	17
21 - 30	4	5	9	8	10	18
31 - 40	10	6	16	8	10	18
41 - 50	4	7	11	8	10	18
51 - 60	7	3	10	10	7	17
61 +	5	2	7	3	2	5
Ave. Per Cow	1.9	1.3	1.6	1.8	1.3	1.7

TABLE XI

POSTPARTUM ESTROUS PERIODS OF 110 COWS OBSERVED IN SEVEN TEN-DAY INTERVALS USED TO COMPARE NERVOUS AND NON-NERVOUS COWS AND COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM AND CONTROL COWS

Time Postpartum	Non-Nervous Cows			Nervous Cows		
	Injected With ECP	Controls	Total	Injected With ECP	Controls	Total
(days)	(no of estrous periods)					
0 - 10	13	3	16	6	2	8
11 - 20	12	0	12	5	9	14
21 - 30	7	9	16	5	6	11
31 - 40	14	6	20	4	11	15
41 - 50	6	11	17	6	6	12
51 - 60	12	4	16	5	6	11
61 +	6	3	9	2	1	2
Total	70*	36*	106	33	40	73
Ave. Per Cow	2.1	1.2	1.7	1.5	1.5	1.5

* X^2 test significant P = .05

an average of 2.1 postpartum heats per cow in the treated group and 1.2 heats per cow in the control group. The non-nervous control cows show fewer postpartum heats than the nervous control cows but the difference was not significant.

The season of calving affected the number of postpartum heats observed. Table XII shows that cows calving in the fall had significantly more postpartum heats than cows calving in the winter. This was especially prominent in the comparison between fall calving controls and winter calving controls, the difference being significant at the 0.1 per cent level of probability. There were no significant differences between the treated and control groups.

Conception rates. The number of cows conceiving at the first through the fifth services is shown in Table XIII. There was no difference between the treated and control groups. The overall conception rate of the treated group was slightly higher than that of the control group. Both groups showed an improvement in conception rate from the first to the fourth service.

The conception rates of the various bulls used in breeding are shown in Table XIV. The Holstein bulls differed very little in their ability to settle the cows, except for Dean with a conception rate of 7.1 per cent. The Jersey bulls were more variable with Beacon and Design giving conception rates of 50 and 60 per cent, respectively, and Confident with a conception rate of 18 per cent. These differences were significant at the 5 per cent level. The conception rate of the

TABLE XII

POSTPARTUM ESTROUS PERIODS OF 110 COWS OBSERVED IN SEVEN TEN-DAY INTERVALS USED TO COMPARE FALL AND WINTER CALVING AND COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM AND CONTROL COWS

Time Postpartum	Fall Calving Cows			Winter Calving Cows		
	Injected With ECP	Controls	Total	Injected With ECP	Controls	Total
(days)	(no of estrous periods)					
0 - 10	12	3	15	7	2	9
11 - 20	12	6	18	5	3	8
21 - 30	8	9	17	4	6	10
31 - 40	14	7	21	4	9	13
41 - 50	8	9	17	4	8	12
51 - 60	11	6	17	6	4	10
61 +	4	4	8	3	0	3
Total	69*	44**	113	33*	32**	65
Ave. Per Cow	22	20	21	14	10	11

* X^2 test significant P = .025

** X^2 test significant P = .001

TABLE XIII

CONCEPTION RATES FOR FIVE SERVICES OF 105 COWS USED TO COMPARE COWS INJECTED WITH ESTROGEN FOUR DAYS AFTER CALVING AND THE CONTROL COWS

Service Number	Cows Injected with ECP			Control Cows			All Cows		
	Bred	Conceived	Conceived	Bred	Conceived	Conceived	Bred	Conceived	Conceived
	-----(no)------		(%)	-----(no)------		(%)	-----(no)------		(%)
First	53	16	30.2	52	18	34.6	105	34	32.4
Second	36	18	50.0	34	11	32.4	70	29	41.4
Third	18	7	38.9	23	12	52.2	41	19	46.3
Fourth	11	8	72.7	11	7	63.6	22	15	68.2
Fifth	3	2	66.6	4	1	25.0	7	3	42.9
Totals	121	51	42.2	124	49	39.6	240	100	41.7

TABLE XIV

NUMBERS OF COWS BRED AND CONCEIVED TO NINE HOLSTEIN AND ELEVEN JERSEY BULLS
COMPARING THE COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM AND THE CONTROL COWS

Name and Breed	Cows Injected with ECP			Control Cows			All Cows		
	Bred	Conceived	NR*	Bred	Conceived	NR*	Bred	Conceived	NR*
Holstein	------(no)------		(%)	------(no)------		(%)	------(no)------		(%)
Reflector	21	7	33.8	26	12	46.2	47	19	40.1
Jo Jo	23	9	39.1	20	9	45.0	43	18	41.9
Sunny	14	6	42.9	11	4	36.4	25	10	40.0
Sensation	12	5	41.7	7	2	28.6	19	7	36.8
Texal	11	3	27.3	5	4	80.0	16	7	43.8
Dean	5	0	0.0	9	1	11.1	14	1	7.1
Fobes	5	4	80.0	3	1	33.3	8	5	62.5
Democrat	2	2	100.0	3	2	66.7	5	4	80.0
Magician	1	1	100.0	1	0	0.0	2	1	50.0
Total Holstein	94	37	39.4	85	35	41.2	179	72	40.2

TABLE XIV (continued)

Name and Breed	Cows Injected with ECP			Control Cows			All Cows		
	Bred	Conceived	NR*	Bred	Conceived	NR*	Bred	Conceived	NR*
Jersey	------(no)------		(%)	------(no)------		(%)	------(no)------		(%)
Beacon	5	3	60.0	11	5	45.4	16	8	60.0
Confident	6	2	33.3	10	1	10.0	16	3	18.8
Design	4	4	100.0	11	5	45.5	15	9	60.0
Pab	5	1	20.0	1	0	0.0	6	1	16.7
JB	1	1	100.0	3	0	0.0	4	1	25.0
Hero	2	2	100.0	1	1	100.0	3	3	100.0
Jewel	3	0	0.0				3	0	0.0
Lad				3	2	66.7	3	2	66.7
Tristram	2	1	50.0				2	1	50.0
Faultless				2	2	100.0	2	2	100.0
Owl				1	0	0.0	1	0	0.0
Total Jersey	28	14	50.0	43	16	37.2	71	30	42.2

* NR = per cent non-return, i.e. per cent conception

Holstein bulls was 40.2 per cent and that of the Jersey bulls was 42.2 per cent. This difference was not significant.

The group with a previous average conception rate of two had a higher non-return rate at first service than the groups with a previous average conception rate of one or more than two as is shown in Table XV. Previous conception rates had no effect on the response to the treatment with respect to the number of services required per conception.

The effect of breed on the comparison between the treated and control groups is shown in Table XVI. None of the differences seen in the table are significant, but treated Jerseys tended to have a better conception rate than treated Holsteins and control Holsteins had a higher conception rate than control Jerseys.

This suggestion of an interaction is seen more clearly in Table XV and XVI. Table XVII shows the effect of dividing the treated and control groups into primiparous and pluriparous groups. The conception rate of the primiparous control group of 36.7 per cent and that for the pluriparous treated group is 37.5 per cent. These are both lower than the conception rate of the primiparous treated group, 49.0 per cent, and the pluriparous control group, 41.8 per cent. This is more obvious in the conception rates at first service where the X^2 of the comparison for the interaction is 3.56 and is significant at the six per cent level of probability.

The same situation prevails when nervous cows are compared to non-nervous cows as is shown in Table XVIII. The interaction is not so pronounced in this instance but at the first service the non-nervous

TABLE XV

NUMBER OF SERVICES REQUIRED FOR CONCEPTION IN 100 COWS USED TO COMPARE THE EFFECT OF PREVIOUS CONCEPTION RATES AND THE COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM AND THE CONTROL COWS

Number of Services Per Conception	Previous Conception Rate								
	One Service			Two Services			More than Two Services		
	Treated	Controls	NR*	Treated	Controls	NR*	Treated	Controls	NR*
	--(no conceived)--		(%)	--(no conceived)--		(%)	--(no conceived)--		(%)
1	6	4	24	1	8	48	3	6	22
2	6	3	37	8	3	46	4	5	28
3	2	6	53	4	2	46	1	4	39
4	4	2		2	3		2	2	
5	1				1		1		
Total	19	15		21	17		11	17	

* NR = per cent non-return, i.e. per cent conception

TABLE XVI

NUMBER OF SERVICES REQUIRED TO SETTLE 100 COWS USED TO COMPARE HOLSTEINS AND JERSEYS AND THE COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM AND THE CONTROL COWS

Service Number	Holstein Cows						Jersey Cows					
	Cows Injected with ECP			Controls			Cows Injected with ECP			Controls		
	Bred	Conceived	NR*	Bred	Conceived	NR*	Bred	Conceived	NR*	Bred	Conceived	NR*
	------(no)-----		(%)	------(no)-----		(%)	------(no)-----		(%)	------(no)-----		(%)
First	38	10	26.3	36	13	36.1	15	6	40.0	16	5	31.2
Second	28	13	46.4	23	9	39.1	8	5	62.5	11	2	18.2
Third	15	6	40.0	14	8	57.1	3	1	33.3	9	4	44.4
Fourth	9	6	66.7	6	3	50.0	2	1	50.0	5	4	80.0
Fifth	2	1	50.0	3	1	33.3	1	1	100.0	1	1	100.0
Total	92	36	39.1	82	34	41.5	29	14	46.2	42	16	38.1

* NR = per cent non-return, i.e. per cent conception

TABLE XVII

NUMBER OF SERVICES REQUIRED TO SETTLE 100 COWS COMPARING PRIMIPAROUS AND PLURIPAROUS COWS AND COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM AND CONTROL COWS

Service Number	Primiparous Cows						Pluriparous Cows					
	Cows Injected with ECP			Controls			Cows Injected with ECP			Controls		
	Bred	Conceived	NR*	Bred	Conceived	NR*	Bred	Conceived	NR*	Bred	Conceived	NR*
	------(no)-----		(%)	------(no)-----		(%)	------(no)-----		(%)	------(no)-----		(%)
First	24	10	41.7	22	5	22.7	29	6	20.7	30	13	43.3
Second	14	8	57.1	17	5	29.4	22	10	45.4	17	6	35.3
Third	6	2	33.3	12	7	58.3	12	5	41.7	11	5	45.5
Fourth	4	3	75.0	5	4	80.0	7	5	71.4	6	3	50.0
Fifth	1	1	100.0	1	0	0.0	2	1	50.0	3	1	33.3
Total	49	24	49.0	57	21	36.7	72	27	37.5	67	28	41.8

* NR = per cent non-return, i.e. per cent conception

TABLE XVIII

NUMBER OF SERVICES REQUIRED TO SETTLE 100 COWS COMPARING NERVOUS AND NON-NERVOUS COWS AND COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM AND CONTROL COWS

Service Number	Non-Nervous Cows						Nervous Cows					
	Cows Injected with ECP			Controls			Cows Injected with ECP			Controls		
	Bred	Conceived	NR*	Bred	Conceived	NR*	Bred	Conceived	NR*	Bred	Conceived	NR*
	------(no)-----		(%)	------(no)-----		(%)	------(no)-----		(%)	------(no)-----		(%)
First	33	12	36.3	29	8	27.6	20	4	20.0	23	10	43.5
Second	20	10	50.0	21	8	38.1	16	8	50.0	13	3	23.1
Third	10	4	40.0	13	7	53.8	8	3	37.5	10	5	50.0
Fourth	6	6	100.0	6	4	66.7	5	2	40.0	5	3	60.0
Fifth	0	0	0.0	2	1	50.0	3	2	66.7	2	0	0.0
Total	69	32	46.4	71	28	39.4	52	19	36.5	53	21	39.6

* NR = per cent non-return, i.e. per cent conception

control group and the nervous treated group have conception rates of 27.6 per cent and 20.0 per cent, respectively, and can be compared with the conception rates of 36.3 per cent for the non-nervous treated group and 43.5 per cent for the nervous control group.

The season of calving had no significant effect on conception rates as can be seen in Table XIX. The conception rates of the fall calving cows were slightly higher than the conception rates of the winter calving cows but the difference was only 1.9 per cent.

The effect of number of postpartum estrous cycles on conception rate is shown in Table XX. The groups having one postpartum estrus had higher conception rates than the other three groups. The difference is significant at the 6 per cent level when non-return rate at first service is considered. This significance disappears when the second service is included in the comparison. There were no differences between the control and treated groups within any division based on the number of postpartum heats.

The average index of uterine size at the third week and tone at the second week postpartum of the treated and control groups are broken down into subgroups which conceived at services one through six in Table XXI. There are no significant differences but the differences in uterine size between the treated and control groups are greater in cows which conceived at the first and second services than in cows which conceived at later services. Within the treated group, comparisons of size and tone between different services show that uterine size tends to increase when the index of uterine tone decreases, and vice versa,

TABLE XIX

NUMBER OF SERVICES REQUIRED TO SETTLE 100 COWS COMPARING FALL CALVING COWS AND WINTER CALVING COWS AND COWS INJECTED WITH ESTROGEN FOUR DAYS AFTER CALVING AND CONTROL COWS

Service Number	Fall Calving Cows						Winter Calving Cows					
	Cows Injected with ECP			Controls			Cows Injected with ECP			Controls		
	Bred	Conceived	NR*	Bred	Conceived	NR*	Bred	Conceived	NR*	Bred	Conceived	NR*
	------(no)-----		(%)	------(no)-----		(%)	------(no)-----		(%)	------(no)-----		(%)
First	29	9	31.0	22	9	40.9	24	7	29.2	30	9	30.0
Second	19	8	42.1	13	2	15.4	17	10	58.8	21	9	42.9
Third	11	6	54.5	11	7	63.6	7	1	14.3	12	5	41.7
Fourth	5	4	80.0	4	2	50.0	6	4	66.7	7	5	71.4
Fifth	1	1	100.0	2	1	50.0	2	1	50.0	2	0	0.0
Total	65	28	43.1	52	21	40.4	56	23	41.1	72	28	38.9

* NR = per cent non-return, i.e. per cent conception

TABLE XX

NUMBER OF CONCEPTIONS AND CONCEPTION RATES OF 100 COWS HAVING NONE, ONE, TWO AND MORE THAN TWO POSTPARTUM ESTROUS CYCLES BEFORE FIRST SERVICE

Service Number	Number of Postpartum Estrous Cycles							
	None		One		Two		More Than Two	
	Conceived	Conceived	Conceived	Conceived	Conceived	Conceived	Conceived	Conceived
	(no)	(%)	(no)	(%)	(no)	(%)	(no)	(%)
1	6	27.3	17	43.6	7	21.2	4	21.1
2	6	22.2	11	50.0	8	30.8	6	40.0
3	3	25.0	7	63.6	5	27.8	4	44.4
4	5	55.6	4	100.0	2	66.7	4	80.0
5	2	50.0	-	-	1	100.0	0	0.0
Total	20		39		33		18	

TABLE XXI

AVERAGE INDEX OF UTERINE SIZE AT THE THIRD WEEK POSTPARTUM AND TONE AT THE SECOND WEEK POSTPARTUM OF 104 COWS REQUIRING ONE THROUGH SIX SERVICES PER CONCEPTION COMPARING COWS INJECTED WITH ESTROGEN FOUR DAYS POSTPARTUM AND CONTROL COWS

Services Per Conception	Cows Injected with ECP			Control Cows		
	Average Size	Average Tone	Cows	Average Size	Average Tone	Cows
	-----(index)-----		(no)	-----(index)-----		(no)
1	4.06	3.00	16	4.61	4.11	18
2	4.00	3.61	18	5.09	4.91	11
3	4.57	3.00	7	4.92	4.50	12
4	4.00	4.00	8	4.29	4.86	7
5	4.50	5.00	2	4.00	4.00	1
6	5.00	6.00	1	5.00	4.67	3

whereas in the control group an increase in uterine size is accompanied by an increase in the index of uterine tone.

CHAPTER V

DISCUSSION

Several workers (8, 13, 22, 43, 49, 58) have attempted to link uterine involution rate with conception rate but their results have not been consistent. No author has presented concrete evidence to prove that the rate of involution of the postpartum uterus affects the conception rate, but most authors believe that such a relationship must exist. Menge et al. (43) found a significant correlation between the time from calving to first estrus and the time from calving to uterine involution, and Foote et al. (22) found a significant correlation between the time from calving to first estrus and conception rate.

The uncertainty about the role of uterine involution in determining conception rate may be partially explained by the experimental procedure of previous workers in this field. In all cases the postpartum reproductive tract was palpated at weekly intervals until the uterus reached a size and tone which the worker considered to represent the involuted state. This should correspond to the classification of normal as used in this work. No attempt was made by previous workers to assign a size and tone estimate to the week by week observations, nor was there any attempt to code estimates of size and tone to a numerical system and represent the changing uterine size and tone graphically.

It is shown in Figures 1 and 2 (pages 28 and 30) that the treated and control groups were very similar in size and tone by the seventh week

postpartum. Most authors (8, 43) gave forty to fifty days as the average time from calving to involution of the uterus and Figures 1 and 2 show that there is very little difference between the treated and control groups at this time. The figures also show that at two to three weeks postpartum there is a significant difference between the treated and control groups both as to uterine size and uterine tone. Therefore, an estimate of the time it took for the uterus to involute would appear to be of limited value in relating uterine size or tone to any other factor because it is apparent from Figures 1 and 2 that the time to complete involution may not be very different between uteri but that some uteri can be significantly smaller and softer for a longer time. The treated uteri in Figures 1 and 2 were significantly smaller and softer than the control uteri, yet took about the same time to involute completely. It would seem then that the cause of much of the confusion in the literature on this subject may be due to the fact that the established technique of referring to uterine involution by time would not be as discriminating as a method which would also consider rate of change. A better comparison of uterine involution rates could be made at two to three weeks postpartum or by considering the areas under the graphs in Figures 1 and 2.

This point would not be obvious when considered from a theoretical point of view but examination of the control curves of Figure 1 and 2 shows that an average of fifty-five estimates of size and tone is a surprisingly repeatable figure. The standard deviation of the differences between the average index of uterine size of the control

group and the regression line is 0.0012. This is much smaller than had been expected. The standard deviation of the average index of uterine tone from the curve were not calculated but it can be seen in Figure 2 that they fit a sigmoid curve very closely. This means that the averaging of coded estimates of uterine size and tone is a promising approach to problems concerning reproductive phenomena in the cow and may help to resolve some of the existing uncertainty as to the relationship between uterine involution rate and other reproductive phenomena.

The shape of the control groups for uterine size is fundamentally different than the shape of the control graph of uterine tone. The uterine tone can be seen in Figure 2 to decrease in a manner similar to a reversed growth curve. This may be expected, but the significant fact is that the time of maximum change of uterine tone is from one to three weeks postpartum. This then is the interval in which the experimenter should be most interested and the interval in which any factor affecting the uterine tone would be most readily observed. It can be seen that the injection of five milligrams of ECP four days postpartum produced its maximum effect on uterine tone in this interval.

The relationship between uterine size and time postpartum as shown in Figure 1 can be represented by a straight line up to eight weeks postpartum. Obviously this line must curve to become assymptotic with some value of uterine size but this occurs after eight weeks postpartum. The fact that the treated uteri are smaller than the control uteri is due primarily to the decrease in size of the treated uteri in the third week postpartum. This would not be expected from a

consideration of Figure 1 but when Figure 2 is considered and the rapid change in uterine tone in the second and third weeks postpartum, it would be expected that anything which was going to influence the rate of involution of the uterus might do so at this time. It is therefore apparent that uterine tone is a more important factor in the consideration of uterine involution rate than has been previously believed and that the uterus is most sensitive to factors affecting changes in size and tone in the second and third weeks postpartum. The injection of five milligrams of ECP four days after calving made the uterus significantly smaller and softer at two to three weeks postpartum.

It is shown in Table VI that the estrogen treated cows had more estrous periods in the first two weeks than the control cows, which means that the uteri of the estrogen injected cows were subject to more estrual phases than the control group. Several workers (5, 7, 33, 55) have found that a uterus under the influence of estrogen is more resistant to infection than a uterus under the influence of progesterone. The uterus soon after calving is subject to minor bacterial infections (28) and a postpartum uterus under the influence of exogenous estrogen from the injection and endogenous estrogen from the cycling ovaries would be more resistant to infection, would suppress incidental infections more rapidly and would involute more quickly than a uterus which was not under the influence of exogenous estrogen. The relatively low resistance to infection of the control uteri would result in a greater inflammatory response to the normal postpartum bacterial infections than the treated uteri with a correspondingly larger size and harder tone.

The definition of an involuted uterus in the literature is one which is of normal size and tone and suffers no further reduction in size. By this definition Figure 1 shows that the uterus may not be completely involuted at eight weeks postpartum and Figure 2 indicates that the tone would not change much after six weeks postpartum. The time from calving to uterine involution of forty to fifty days as is generally reported in the literature would correspond to a uterus a little larger than medium and a little harder than normal when based on the criteria of size and tone used in Figures 1 and 2.

Jerseys showed no significant difference in uterine size or tone between the treated and control groups but this may have been due to the small numbers involved. There were no differences between breeds, which agrees with the work of Perkins and Kidder (49). There was a significant difference between the primiparous and pluriparous groups, the primiparous group having smaller, softer uteri. This is supported by the observation of Buch et al. (9) and the observed difference would have been larger had it not been for the fact that some allowance was made for the cow's age when the palpation was performed. There are no reports in the literature of other factors affecting uterine involution rate. The uteri of non-nervous cows were smaller and softer than the uteri of nervous cows in the treated group. This effect of temperament on uterine involution rate may have been caused by the large number of primiparous Holsteins which were classed as non-nervous. The season of calving has been found to affect some of the factors known to be associated with uterine involution rate,

such as time from calving to first estrus (8). Table VI shows that the uteri of fall calving cows involuted faster than uteri of winter calving cows.

The injection of five milligrams of ECP four days after calving was effective in inducing postpartum estrus in both the Holstein and the Jerseys. The work of Foote and Walker (24) indicates that giving the injection twelve days postpartum would have been more effective. The observed time from calving to first estrus in the control group was 48.5 days in the Holsteins and 37.5 days in the Jerseys, these figures being higher than those given in the literature (43, 47, 59). As Casida and Venzke (13) have pointed out, reports of the time to first estrus are dependent on the skill of the observer and it could be seen in the data of this experiment that many cows showed apparent cycle lengths of forty to sixty days and that this occurred more frequently than would be expected if temporary anestrus were the cause (9). These long cycles could have been due to silent or unreported heats. Any unrecorded first heats would cause the average time to first estrus to be greater than normal. There were no differences in the number of postpartum estrous cycles between the primiparous and pluriparous cows and this is confirmed by Buch (8) was was the large difference in the incidence of postpartum estrus between fall calving and winter calving cows. Temperament was not related to the number of postpartum estrous cycles and the attempt to find a significant relationship between uterine involution rate and the number of postpartum estrous cycles was unsuccessful.

Treatment significantly decreased the time to first estrus and made the uterus significantly smaller and softer. This means that the phenomena of postpartum estrus and uterine involution are related. It cannot be determined if this relationship is due to cause and effect although the theoretical approach as previously explained would strongly suggest that the uterus of the treated cows involuted more quickly because of the higher incidence of postpartum estrus in these cows.

The conception rates were uniformly low. It is obvious that a factor or factors not under the control of the experiment were depressing the conception rates. The injection of ECP, breed, previous conception rate, number of calves, temperament, number of postpartum estrous cycles and uterine involution rate did not significantly affect the conception rate. There is a suggestion of an interaction between the control and treated primiparous non-nervous Holsteins but the reason for this is obscure. The data on conception rate does not prove that there is no relation between the factors studied and conception rate. The difference, if any, between the treated and control groups were undoubtedly masked by the presence of an unknown factor or factors which depressed conception rates to a level at which the factors under observation in the experiment did not have any significant effect.

CHAPTER VI

SUMMARY AND CONCLUSIONS

An experiment was conducted to examine the effect of induced estrus on conception rates in dairy cows.

An injection of five milligrams of ECP to dairy cows four days postpartum was effective in decreasing the time to first estrus and increasing the number of postpartum estrous cycles in Holstein and Jersey cows. The average time from calving to first estrus for Holsteins was 48.5 days and 35.8 days in the control and treated groups, respectively. It was 37.3 days and 21.7 days in the Jersey control and treated groups, respectively.

The injection of ECP caused a significantly smaller and softer uterus at 2.5 weeks postpartum. The uteri of the injected groups were always smaller and softer than the uteri of the control group, although the difference became less and was not significant five weeks after calving.

The average of fifty-five cow observations of uterine size and tone was found to be a repeatable estimate, the standard deviation of the average index of uterine size from the regression line being 0.0012.

The results indicated that the uterus was more likely to reflect differences in uterine involution rate at the second and third weeks postpartum than at other times and that the size and tone of the involuting uterus bear different relationships to time, the graph

of uterine size against time after calving being a straight line and the graph of uterine tone against time after calving following a reversed sigmoid growth curve.

There appeared to be a significant relationship between uterine involution rate and the time from calving to first estrus but neither of these factors affected the conception rate which was uniformly low and apparently affected by uncontrolled influences. Thus conception rate data were considered valueless as a criterion of the effects from the injection or associated phenomena.

The fastest rate of uterine involution was seen in primiparous non-nervous Holstein cows which calved in the fall.

The results indicate that ECP is effective in inducing estrus in postpartum dairy cows. It probably should be administered later than four days after calving. The treatment should not decrease conception rate.

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