The bovine postpartum interval : blood plasma steroid levels and the effect of hormone treatment, mastectomy and induced parturition
by Verne Allan LaVoie

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Animal Science
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Abstract:
Four studies were conducted to evaluate various aspects of bovine postpartum anestrus. In the first study, 18 beef cows were assigned to a NON-LACTATING, SUCKLED 2X DAILY or SUCKLED AD LIBITUM group to determine the effect of suckling during puerperium on blood plasma progesterone and testosterone concentrations and on the occurrence and intensity of estrus. Suckling increased (P<.05) the postpartum interval from 20 days in the NON-LACTATING group to 38 days in the SUCKLED AD LIBITUM group and increased intensity of estrus score (P<.05). In analyses excluding 3 cows with silent first estrus, progesterone averaged .8 ng/ml at parturition and ranged between .1 and .4 ng/ml through day 18 postpartum and was lowest in suckled cows (P<.01). Progesterone ranged between .1 and .4 ng/ml from 18 through 5 days, increased rapidly to 1.8 ng/ml at 3 days and returned to .3 ng/ml at 1 day prior to estrus. This pre-estrus progesterone peak was highest in SUCKLED AD LIBITUM cows (P<.05). Testosterone was low (mean=.2 ng/ml) over the postpartum period. The second study consisted of TRIALS A and B and progesterone and estrogen were given in single doses of 20 mg and 2 mg, respectively, between 30 to 90 days postpartum to determine if this treatment could be used in routine dairy management to improve reproductive performance.

The treatment decreased the interval from calving to estrus 25 days (P<.07, TRIAL A; P<.01 TRIAL B) but did not decrease the interval from calving to conception nor improve reproductive performance as measured by first service conception rate, conceptions per service and pregnancy rate. Treatment did not affect ovary diameter at 10 through 44 days or milk production from 3 through 50 days postpartum. The third study was designed to determine if mastectomized cows could be managed to reduce the average calving interval to less than 365 days. Nine mastectomized cows had a mean interval from calving to first estrus of 30 days but showed low fertility as measured by first service conception rate (56%) and conceptions per service (35%). The interval from calving to conception was 76 and 79 days for the mastectomized and control herds, respectively, indicating that mastectomy had little effect in reducing the calving interval to less than 365 days. In the fourth study, 31 cows were used to test the effect of flumethasone induced calving (5 mg injected 17 days prior to term) on postpartum reproduction. Treatment groups were: NT=nontreated, INDU=treated and induced and NI=treated but not induced. A breed difference was noted in response to treatment with more Angus responding than Herefords (P<.01) postpartum interval to first estrus was 45, 47 and 40 days in the NT, INDU and NI groups, respectively, but when postpartum interval was calculated from expected natural calving date, the intervals were 43, 32 and 37 days, respectively. Cows were in estrus 1.2, 1.1 and 1.3 times prior to 60 days postpartum, pregnancy rates were 58, 90 and 67% and days open were 76, 69 and 77 days in the NT, INDU and NI groups, respectively.

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ABSTRACT

Four studies were conducted to evaluate various aspects of bovine postpartum anestrus. In the first study, 18 beef cows were assigned to a NON-LACTATING, SUCKLED 2X DAILY or SUCKLED AD LIBITUM group to determine the effect of suckling during puerperium on blood plasma progesterone and testosterone concentrations and on the occurrence and intensity of estrus. Suckling increased ($P<.05$) the postpartum interval from 20 days in the NON-LACTATING group to 38 days in the SUCKLED AD LIBITUM group and increased intensity of estrus score ($P<.05$). In analyses excluding 3 cows with silent first estrus, progesterone averaged .8 ng/ml at parturition and ranged between .1 and .4 ng/ml through day 18 postpartum and was lowest in suckled cows ($P<.01$). Progesterone ranged between .1 and .4 ng/ml from 18 through 5 days, increased rapidly to 1.8 ng/ml at 3 days and returned to .3 ng/ml at 1 day prior to estrus. This pre-estrus progesterone peak was highest in SUCKLED AD LIBITUM cows ($P<.05$). Testosterone was low (mean=.2 ng/ml) over the postpartum period. The second study consisted of TRIALS A and B and progesterone and estrogen were given in single doses of 20 mg and 2 mg, respectively, between 30 to 90 days postpartum to determine if this treatment could be used in routine dairy management to improve reproductive performance. The treatment decreased the interval from calving to estrus 25 days ($P<.07$, TRIAL A; $P<.01$ TRIAL B) but did not decrease the interval from calving to conception nor improve reproductive performance as measured by first service conception rate, conceptions per service and pregnancy rate. Treatment did not affect ovary diameter at 10 through 44 days or milk production from 3 through 50 days postpartum. The third study was designed to determine if mastectomized cows could be managed to reduce the average calving interval to less than 365 days. Nine mastectomized cows had a mean interval from calving to first estrus of 30 days but showed low fertility as measured by first service conception rate (56%) and conceptions per service (35%). The interval from calving to conception was 76 and 79 days for the mastectomized and control herds, respectively, indicating that mastectomy had little effect in reducing the calving interval to less than 365 days. In the fourth study, 31 cows were used to test the effect of flumethasone induced calving (5 mg injected 17 days prior to term) on postpartum reproduction. Treatment groups were: NT=nontreated, INDU=treated and induced and NI=treated but not induced. A breed difference was noted in response to treatment with more Angus responding than Herefords ($P<.01$) postpartum interval to first estrus was 45, 47 and 40 days in the NT, INDU and NI groups, respectively, but when postpartum interval was calculated from expected natural calving date, the intervals were 43, 32 and 37 days, respectively. Cows were in estrus 1.2, 1.1 and 1.3 times prior to 60 days postpartum, pregnancy rates were 58, 90 and 67% and days open were 76, 69 and 77 days in the NT, INDU and NI groups, respectively.

CHAPTER 1

INTRODUCTION

Rising production costs, competition from other animal and synthetic protein sources and a rapidly increasing hungry world population emphasize the need for more efficient production in the cattle industry. One poorly understood but highly important aspect of beef and dairy cow reproduction that greatly affects efficiency of production is the postpartum interval.

The postpartum interval has been defined as the interval beginning with parturition and ending with a designated event. This event may be first ovulation, first estrus, completion of uterine involution, first breeding or conception (Casida, 1971). As implied by this definition, the postpartum interval is characterized by a series of events which culminate in the renewed ability to reproduce. Not only must the animal regain the ability to show estrus and ovulate but her uterus must return to a condition favorable to fertilization, implantation and normal gestation.

The relationship between the postpartum interval and fertility is negatively correlated. As the length of the interval increases, conception occurs later in the breeding season and if the interval is too long a return to a functional reproductive state does not occur until the breeding season is over. Therefore, considerable economic loss can result if the parturition to conception interval is unduly prolonged.

A cow must conceive within 82 days postpartum if she is to have a 12 month calving interval. As reviewed by Casida (1968) the literature reports mean intervals from parturition to estrus ranging from 46 to 104 days for beef herds and 30 to 72 days for dairy herds. Many dairy cows have intervals greater than 82 days (Casida, 1968). Wiltbank (1970) found in a group of beef cattle that the interval from calving to estrus was too long to permit a 12 month calving interval in 32% of three-year-old cows and 11% of cows age five years or older.

Application of these statistics show that Montana commercial beef producers lose an estimated $11,000,000 annually because of prolonged postpartum anestrus and low postpartum fertility, and the annual loss of income to U. S. beef producers is conservatively estimated to be $621,000,000. In dairy cattle not only is calf production affected, but average annual milk production is also decreased by long calving intervals (Schmidt and Van Vleck, 1974).

The purpose of this investigation was to study the postpartum interval to gain knowledge that could be used to improve reproductive efficiency in cattle. Four experiments were conducted using beef and dairy cows at the Montana Experiment Station, Bozeman. The first experiment was designed solely to obtain basic physiological information on hormonal mechanisms controlling postpartum anestrus while the other experiments consisted of hormone and surgical treatments that would hopefully lead to a better understanding of the postpartum interval and to development of techniques to control the postpartum interval.

CHAPTER 2

LITERATURE REVIEW

Various aspects of bovine postpartum physiology have been reviewed by Casida (1971), Erb et al. (1971), Foote (1971) Morrow (1971) and Wagner and Oxenreider (1971) at the IX Biennial Symposium on Animal Reproduction at Purdue University in 1969. Other excellent reviews of the early literature on this subject include those by Casida et al. (1968), Morrow et al. (1969) and Moller (1970).

In the following review, the emphasis has been placed on the more recent publications that have direct bearing on the specific objectives of this investigation. The early literature is reported rather superficially as background information for the more extensive reviews of the postpartum interval in relation to blood hormone levels, exogenous hormone treatments, lactation, uterine environment and induced parturition.

Postpartum Interval

In order for a cow to resume a fully functional reproductive state following parturition not only must she regain the ability to show estrus and ovulate but her reproductive tract must return to a condition favorable to fertilization, implantation and gestation. The following discussion is a comprehensive review of postpartum ovarian activity and uterine involution, the factors that affect them and their relation to fertility.

Follicular activity

Follicles were not detected on the ovary at the time of parturition (Benesch and Wright, 1951; Labhsetwar *et al*., 1964) but follicles develop within 16 to 30 days postpartum (Casida and Venzke, 1936; Higaki *et al*., 1959; Labhsetwar *et al*., 1964). Mean days to ovulation and corpus luteum development range from 20 to 71 days in different studies (Casida *et al*., 1968) and ovulation has been reported to occur prior to 20 days in some instances (Labhsetwar *et al*., 1964; Morrow *et al*., 1966; Wagner and Hansel, 1969).

First estrus

There is wide variation in reports on the interval from parturition to first estrus with means of 30.0 to 76.3 days reported in 13 studies of dairy cattle and 52.2 to 80.2 days in five studies of beef cattle (Morrow *et al*., 1969), Casida *et al*. (1968) in a survey of the literature indicated that different groups of dairy cows had averages ranging from 30 to 72 days and of beef cows from 46 to 104 days.

Numerous studies indicate that a high percent of early postpartum ovulations are not accompanied by observed behavioral estrus, and that the incidence of these silent estruses decreases as days from parturition increase (Casida and Wisnicky, 1950; Kidder *et al*., 1952; Trimberger and Fincher, 1956; Menge *et al*., 1962; Labhsetwar *et al*., 1963). Saiduddin *et al*. (1968) reported that the incidence of non-standing behavioral estrus also decreases as time from parturition increases.

In cows with short intervals to first estrus there is a tendency for them to have a shortened first estrous cycle of about 13 days (Olds et al., 1949; Menge et al., 1962).

Uterine involution

The time after parturition required for complete involution of the uterus as determined by rectal palpation varies considerably but ranges between 25 and 50 days. As reviewed by Morrow et al., (1969) postpartum interval to uterine involution ranges from 26.2 to 52.0 in six studies with dairy cows and 37.7 to 56.0 days in three studies with beef cows. Two studies based on histological criteria suggest a parturition to involution interval of 25 to 30 days for most animals (Gier and Marion, 1968; Wagner and Hansel, 1969).

Several workers have shown that a delay in uterine involution may result in a delay of first postpartum estrus (Albrechtsen, 1917; Buch et al., 1955; Higaki, 1959) while others show no significant relationship between the two events (Foote et al., 1960; Menge et al., 1962).

Cervical involution

Information on involution of the cervix is scanty but available studies indicate that it occurs very rapidly and the cervix is completely closed by 36 to 96 hours postpartum (Benesch and Wright, 1951; Jubb and Kennedy, 1963; Boyd, 1925).

Factors affecting postpartum interval

Parturition and postparturient disease. The postpartum interval to first estrus (Chapman and Casida, 1937; Buch *et al.*, 1955; Morrow, 1971) and to uterine involution is increased by abnormal parturitions, dystocia and disease including retained placenta, brucellosis, pyometria and others. A high proportion of cows have uteri contaminated with microorganisms shortly after parturition (Rasbech, 1950; Higaki *et al.*, 1959; Elliott *et al.*, 1968; Gier *et al.*, 1962).

Suckling. Suckling delayed the onset of first estrus as compared to milking (Clapp, 1937; Wiltbank and Cook, 1868, Wagner and Hansel, 1969) and drying cows off soon after calving (Saiduddin *et al.*, 1967a). The effect of suckling on uterine involution is not clear as one research group reports that suckling hastens involution (Lauderdale *et al.*, 1968; Riesen *et al.*, 1968), another reports no effect (Wagner and Hansel, 1969), while yet another reports that suckling prolongs involution (Wiltbank and Cook, 1958).

Level of production. There is conflicting data on the effect of level of milk production on the interval to first estrus with some researchers reporting that the interval is prolonged by increased production (Olds and Seath, 1953; Carman, 1955; Saiduddin *et al.*, 1969) while others report no effect (Clapp, 1937; Herman and Edmondson, 1950). In one study there was no effect of level of milk production on interval to uterine involution (Morrow *et al.*, 1966), but Menge *et al.* (1962)

reported a significant positive correlation of production level on this interval.

Nutrition. Low pre- and postpartum energy levels have been reported to decrease the interval from parturition to first estrus (Wiltbank et al., 1962; Wiltbank et al., 1964; Dunn et al., 1969) and to increase the incidence of silent estrus (Saiduddin et al., 1967b). Hypoglycemia has been associated with a decrease in follicular development and could be an important factor affecting postpartum interval (Oxenreider and Wagner, 1971).

Season. Postpartum interval to first estrus appears to be shortest in the fall and longest in the spring (Chapman and Casida, 1937; Buch et al., 1955, Carman, 1955) while interval to uterine involution is shortest in the summer and spring (Marion et al., 1968). However, several reports find no effect of season on these intervals (Herman and Edmondson, 1950; Warnick, 1955; Wiltbank and Cook, 1958; Morrow et al., 1966).

Age and parity. Most authors conclude that postpartum interval to first estrus tends to decrease with increased parity up to 7 years of age and then increases again (Hammond and Sanders, 1923; Herman and Edmondson, 1950; Wiltbank and Cook, 1958). Other reports show this interval to increase with parity (Casida and Wisnicky, 1950) or to not be affected by parity (Clapp, 1937; Buch et al., 1955; Foote et al., 1960). Postpartum interval to uterine involution is longer in primaparous cows (Rasbech, 1950; Morrow et al., 1966). However, Tennant et al. (1967) maintained that age had no effect on the rate of involution.

Other factors. Other factors reported to delay the appearance of postpartum estrus are the occurrence of cystic follicles (Morrow et al., 1966), anemia, feeding of thyroprotein (Wagner and Hansel, 1969), and the occurrence of cystic and retained corpora lutea although the latter two are probably not causes of postpartum anestrus (Asdell et al., 1949; Morrow et al., 1966; Donaldson and Hansel, 1968).

Postpartum interval and fertility

Reproductive efficiency of beef cattle has been observed to improve as the time from parturition to first service increase (Edwards, 1950; Shannon et al., 1952; Warnick, 1955; Perkins and Kidder, 1963; Graves et al., 1968; Saiduddin et al., 1968).

VanDemark and Salisbury (1950) found in a 28 year study involving 1,674 pregnancies in 593 dairy cows that fertility increased with the length of the postpartum interval in a curvilinear relationship. In the cows bred less than 20 days after calving, only 35% conceived while nearly 58% of the cows conceived when first bred 100 to 120 days after calving. Conception rate of cows bred 201 days or more following calving was 46.3%. There was a signficant linear regression (r=-.116) between the postpartum interval to first service and the number of services required for conception within 80 days after parturition.

Casida et al. (1968) reviewed literature on fertility at first service following parturition and found conception at first service (unweighted means of 5 studies) to be 39.3, 53.2, 61.6, 62.2, 64.7 and 64.3% for consecutive months one through six postpartum in dairy cows. In beef cows, conception at first service (unweighted mean of 3 studies) was 33.4, 58.1, 68.6 and 74.4% for consecutive months one through four postpartum.

Ovarian activity usually occurs before uterine involution is completed (Buch et al., 1955) and the question arises as to whether cows can conceive at ovulation prior to complete involution. Most reports indicate that the degree of uterine involution does not seriously affect fertility (Foote et al., 1960; Perkins and Kidder, 1963; Tennant and Peddicord, 1967) and the interval to first estrus is a more important effect. It is difficult to see how the effect of uterine involution and the interval to first estrus can truly be separated.

Foote et al. (1960) estimated the relative importance of the effect of interval to first estrus and interval to uterine involution on fertility. Of the two the interval to first breeding was the most important with standard partial regression on fertility on interval to involution of the uterus being .02 and on interval to first service being .40. However, these studies did not consider the degree of involution at the time of breeding.

Postpartum Endocrinology

The hormonal mechanisms controlling postpartum anestrus are not well understood. It is evident from the literature to be presented later that this anestrus is not caused by a lack of gonadotrophins nor is there a lowered sensitivity of the ovaries to gonadotrophins (Casida et al., 1943). Follicles large enough to ovulate develop on the ovary shortly after parturition, yet ovulation does not normally occur until sometime later (Wagner and Oxenreider, 1971). This inability to ovulate early postpartum is undoubtedly related to the lack of an ovulatory surge of LH and this concept will be further developed.

In the following discussion, literature will be reported relative to mechanisms of LH release, pituitary and blood levels of hormones during the postpartum interval and other endocrine factors of postpartum anestrus.

Postpartum anestrus and prepubertal anestrus are similar in some respects and may be related. Therefore, a study of one may give insight into the other and for this reason data on the prepubertal heifer has been included when appropriate. In the section on mechanisms of gonadotrophin release data from other species including rats are included.

Role of the hypothalamo-hypophyseal axis

Mechanisms of ovulation. Ovulation in the bovine is the result of a surge of LH that may increase as much as 200 times above basal luteal phase levels within a 12 hr period (Geschwind, 1972). Prolactin also increases coincidentally with the LH peak (Davis *et al.*, 1971; Swanson and Hafs, 1972). In rats it has been demonstrated that increased levels of prolactin are not necessary for ovulation to occur (Wuttke, Cassell and Meites, 1971).

Rondell (1970) has postulated a mechanism by which LH may cause ovulation. In this model, LH either acts directly on the follicular wall or indirectly via an induced steroid secretion (progesterone?) causing fibrocytes and/or other cells common to both thecal layers to produce a collagenase enzyme. This enzyme has been identified in follicular tissue and its action affects the bonding between collagen fibrils to increase the distensibility and plasticity of the follicular wall. The wall becomes thinner and thinner until rupture occurs. This proposed mechanism is supported by the fact that intrafollicular pressure does not increase and in fact may decrease slightly just prior to ovulation.

Hypothalamic control of gonadtrophins. The secretions of the anterior pituitary are controlled by small peptide molecules arising from the hypophysiotrophic area of the hypothalamus (figure 1). Releasing hormones exist for GH (GRH), TSH (TRH), ACTH (CRH), LH (LRH)