Fertility of beef cattle after PGF2a controlled estrus in two breeding management systems
by William Mearle Greene

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Animal Science
Montana State University

Abstract:
Three studies were conducted to evaluate fertility of cattle after Prostaglandin F2*alpha;(PGF2α) controlled estrus. In the first study lactat-ing cows were randomly assigned to either a Conventional system (non-treated controls n=202) or a PGF2α system (n=204). The breeding season for both systems consisted of 25 days artifical insemination (AI) followed by 20 days natural service. Estrus detection was periodic during daylight hours (hrs) and cattle in both systems were bred approximately 12 hours after observed estrus except for the non-estrus breeding of some PGF2α treated cattle. PGF2α (25 mg Prostin F2α) was administered intramuscular (IM) on the 5th day of actual breeding to only those animals in the PGF2α system not detected in estrus prior to injection. Breeding was conducted under the general breeding scheme after PGF2α for 80 hrs at which time all PGF2α animals not previously detected in estrus were bred non-estrus. Pregnancy was determined by rectal palpation. There were no significant differences between breeding systems for total pregnancy (TP), total AI pregnancy (AIP) or AI first service pregnancy rates. The average day of conception for the PGF2α system (day 20) was significantly closer (P<.01) to the start of the breeding season than the conventional system (day 23). In the second study, two trials were conducted using heifers in trial I and lactating cows in trial 2. Animals in both trials were assigned to one of three treatments. Treatment one was non-treated controls and were bred for 45 days natural service. Treatment two received two injections of 15 mg PGF2α (IM) and treatment three received two injections of 25 mg PGF2α (IM) Il days apart. Cattle in treatments 2 and 3 were bred about 74 hours post the second PGF2α injection without regard to estrus. Approximately 48 hours after insemination PGF2α treated cattle were exposed to natural breeding for 18 days. On day 21 of the breeding season bulls were removed and estrus detection commenced. Al resumed on day 22 and continued until day 26 of the breeding season at which time natural service resumed until day 45 of the breeding season. TP rates were determined by rectal palpation. There were no significant differences between treatments 1,2 and 3 for TP. Study three analyzed breeding trials conducted during fall 1974(F74), summer 1975(875), fall 1975(F75) and summer 1976(876) to test the effect of on fertility when administered for 2 years to the same cattle. Methods and materials for this study are similar to study one in all respects except for the F74 nonestrus breeding which occurred at 72 hrs post PGF2α treatment. TP and AIP rates were not different between breeding systems after year 1; however TP and AIP rates were greater (P=.035 and P=.006, respectively) in the PGFg^ system after year 2. In the conventional system TP and AIP rates -decreased (P<.001) from year I to year 2. Similar trends were observed in the PGF2α system for TP(P=.001) and AIP(P>.10) from year 1 to year 2.

STATEMENT OF PERMISSION TO COPY

In presenting this thesis in partial fulfillment of the requirements for an advanced degree at Montana State University, I agree that the Library shall make it freely available for inspection. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by my major professor, or, in his absence, by the Director of Libraries. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Signature William M Greene

Date May 17, 1977

FERTILITY OF BEEF CATTLE AFTER $PGF_{2\alpha}$ CONTROLLED ESTRUS IN TWO BREEDING MANAGEMENT SYSTEMS

by

WILLIAM MEARLE GREENE

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Animal Science

Approved:

E. L. Moody
Chairperson, Graduate Committee

J. L. Van Horn
Head, Major Department

Henry L Parsons
Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

May, 1977

ACKNOWLEDGMENTS

I wish to express my sincere appreciation to Dr. E. L. Moody for the invaluable advice, guidance, encouragement and personal interest which he has extended to me, not only during this project, but throughout my graduate program. I would also like to thank Mr. David Han, Dr. P. J. Burfening and Dr. J. E. Catlin.

Special thanks is given to Mr. Paul W.Lambert for his many hours of consultation and companionship while gathering data for this study.

A very special thanks to Dr. Ervin Smith and Mr. Robert Friedrich for their appreciated assistance in the analysis of this project.

I would like to thank the Montana State Prison for the use of its animals and facilities and extend a special thanks to Mr. Don Smith for his cooperation in the management of this study. An acknowledgment is extended to the American Breeders Service for furnishing the beef semen and to UpJohn Company of Kalamazoo, Michigan for supplying the Prostaglandin $F_{2\alpha}$ used in this study.

My thanks are extended to my fellow graduate students for their companionship and assistance throughout my program.

A special thanks go to my parents, Mr. and Mrs. Ford M. Greene, Jr. for their help and encouragement in furthering my education.

A very deep and special appreciation must also be offered to my wife and typist, Sherry, for without her patience, understanding, encouragement and hard work, this project could not have been completed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Three studies were conducted to evaluate fertility of cattle after Prostaglandin $F_{2\alpha}$($PGF_{2\alpha}$) controlled estrus. In the first study lactating cows were randomly assigned to either a Conventional system (non-treated controls n=202) or a $PGF_{2\alpha}$ system (n=204). The breeding season for both systems consisted of 25 days artifical insemination (AI) followed by 20 days natural service. Estrus detection was periodic during daylight hours (hrs) and cattle in both systems were bred approximately 12 hours after observed estrus except for the non-estrus breeding of some $PGF_{2\alpha}$ treated cattle. $PGF_{2\alpha}$ (25 mg Prostin $F_{2\alpha}$) was administered intramuscular (IM) on the 5th day of actual breeding to only those animals in the $PGF_{2\alpha}$ system not detected in estrus prior to injection. Breeding was conducted under the general breeding scheme after $PGF_{2\alpha}$ for 80 hrs at which time all $PGF_{2\alpha}$ animals not previously detected in estrus were bred non-estrus. Pregnancy was determined by rectal palpation. There were no significant differences between breeding systems for total pregnancy (TP), total AI pregnancy (AIP) or AI first service pregnancy rates. The average day of conception for the $PGF_{2\alpha}$ system (day 20) was significantly closer ($P<.01$) to the start of the breeding season than the conventional system (day 23). In the second study, two trials were conducted using heifers in trial 1 and lactating cows in trial 2. Animals in both trials were assigned to one of three treatments. Treatment one was non-treated controls and were bred for 45 days natural service. Treatment two received two injections of 15 mg $PGF_{2\alpha}$ (IM) and treatment three received two injections of 25 mg $PGF_{2\alpha}$ (IM) 11 days apart. Cattle in treatments 2 and 3 were bred about 74 hours post the second $PGF_{2\alpha}$ injection without regard to estrus. Approximately 48 hours after insemination $PGF_{2\alpha}$ treated cattle were exposed to natural breeding for 18 days. On day 21 of the breeding season bulls were removed and estrus detection commenced. AI resumed on day 22 and continued until day 26 of the breeding season at which time natural service resumed until day 45 of the breeding season. TP rates were determined by rectal palpation. There were no significant differences between treatments 1,2 and 3 for TP. Study three analyzed breeding trials conducted during fall 1974(F74), summer 1975(S75), fall 1975(F75) and summer 1976(S76) to test the effect of $PGF_{2\alpha}$ on fertility when administered for 2 years to the same cattle. Methods and materials for this study are similar to study one in all respects except for the F74 nonestrus breeding which occurred at 72 hrs post $PGF_{2\alpha}$ treatment. TP and AIP rates were not different between breeding systems after year 1; however TP and AIP rates were greater ($P=.035$ and $P=.006$, respectively) in the $PGF_{2\alpha}$ system after year 2. In the conventional system TP and AIP rates decreased ($P<.001$) from year 1 to year 2. Similar trends were observed in the $PGF_{2\alpha}$ system for TP($P=.001$) and AIP($P>.10$) from year 1 to year 2.

CHAPTER 1

INTRODUCTION

In order to increase the quantity and quality of beef produced many beef producers have looked to artifical insemination for the following reasons;

1. Utilization of superior sires for rapid genetic improvement.
2. Facilitation of cross-breeding schemes.
3. Protection against venereal disease.

Under present day management schemes, artifical insemination (AI) has been shown to be comparable to natural service on a cost per calf basis, (Syntex Corporation, 1975; Moore, 1974; Stevens and Mohr, 1969).

During the last decade many estrus synchronizing agents have been studied. A successful estrus synchronizing agent for beef cattle would facilitate artifical insemination for many producers. With estrus control, producers could inseminate a larger number of cows in a shorter period of time thus reducing labor requirements for an AI breeding program. Because of the shorter breeding season a shorter calving season would result. A shorter calving season would reduce the age variation between calves at weaning thus a producer could have a more uniform product to market.

The main objectives of this study was to evaluate fertility

after Prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) controlled estrus and the practical application of management systems utilizing $PGF_{2\alpha}$ under range beef production conditions.

CHAPTER 2

LITERATURE REVIEW

2.1. General Endrocrinology of the Bovine Estrous Cycle

The hormonal interrelationships which are responsible for regulation of the estrous cycle in the cow are very complex. Figure 1 illustrates the relationship between the pituitary gland, hypothalmus, ovaries and uterus in the cycling bovine. The hypothalmus secretes gonadotropic relasing hormones (GnRH) into the hypothalmic-hypophyseal portal system which causes the release of follicle stimulating hormone (FSH), and lutenizing hormone (LH) (Figure 1) from the adenohypophysis (Niswender et al. 1974).

FSH is responsible for the early maturation of ovarian follicles (Ganong, 1975; Schwartz, 1974). FSH and LH together are responsible for the final maturation of the ovarian follicle and ovulation. LH and FSH act synergistically to cause the production and secretion of estrogen by the follicle. Increasing levels of estrogen during the maturation of the ovarian follicles exerts a feedback (Figure 1) on the hypothalamo-hypophyseal axis causing the release of peak levels of LH and FSH (Niswender et al. 1974). Ovulation in the bovine occurs from 25 to 30 hours after LH reaches its peak level (Foote, 1974). There is little evidence that prolactin plays an important luteotropic or luteolytic role in any of the domestic animals (Hansel et al. 1973). After ovulation the levels of gonadtropins and estrogen are greatly reduced and the level of progesterone is increased. LH at this reduced

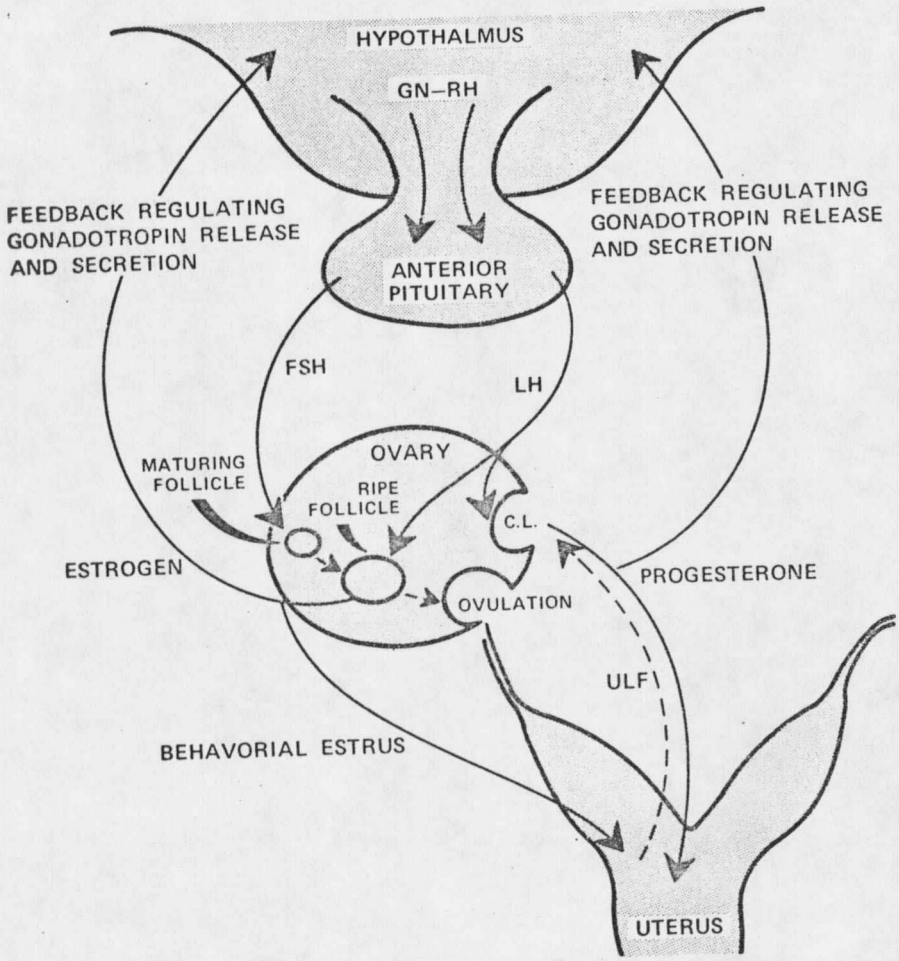


FIGURE 1. PRINCIPLE ENDOCRINE PATHWAYS INVOLVED IN THE CONTROL OF OVARIAN FUNCTION

level is partially responsible for the mitotic proliferation of granulosa cells from the ruptered follicle into luteal cells, which secrete progesterone and form the corpus luteium (CL). Progesterone prepares the uterus for acceptance of the fertilized ova (Niswender et al. 1974).

At about day 16 of a 21 day bovine cycle the CL will begin to regress in a non-pregnant cow causing a decrease in progesterone (Hansel et al. 1973). Regression of the CL or luteolysis in this review is defined as a net loss of total luteal cell numbers, and a decrease in progesterone secretion. Following CL regression more follicles will mature and estrogen will again predominate over progesterone. The cycle may be thought of in terms of an alteration in the dominance of progesterone and estrogen, both ovarian steroid hormones (Perry 1971). Ovarian steroid homrones exert feedback on the pituitary hypothalmic axis and regulate secretion and release of gonadotripins which regulate follicular maturation, estrogen production and ovulation.

On day 12 or 13 of the ovine estrous cycle the uterus has been shown to impose its luteolytic effect and initiate a new estrous cycle. In the pregnant animal the conceptus maintains the CL by neutralizing the luteolytic factor secreted from the uterus (Caldwell et al. 1969).

2.2. The Uterine Luteolytic Factor (ULF)

2.2.1 ULF History

Since early work by Loeb (1923) much interest has been shown in the field of uterine control of the life span of the corpus luteum. Loeb reported that in the non-pregnant guinea pig, total or almost total hysterectomy is followed by prolonged corpora lutea for 60 to 80 days. In later years Loeb suggested that prolongation of the CL during pregnancy was due to functional inactivation of the uterine mucosa under the influence of the developing embryo and placenta. Hechter et al. (1940) implied that the uterus may produce a hormone which causes the CL to regress and in the absence of this hormone the CL are maintained.

2.2.2. ULF Origin

Investigations by Wiltbank and Casida (1956) revealed that hysterectomy prolonged the life span of the CL past the normal time of regression in the ewe and cow. They also reported that removal of half of the uterus in the ewe did not extend the life span of the CL however, partial removal of the uterus in the cow increased the life of the CL. Later experiments by LaVoie et al. (1975) and Stellflug et al. (1975 a) using hysterectomized bovine demonstrated that the uterus is implicated in luteolysis. Estrous cycles, CL size and progesterone content for hysterectomized cows were similar to mid cycle

intact animals.

Further evidence to support the theory that the luteolysin is produced by the endometrium of the uterus and that the luteolysin could be $PGF_{2\alpha}$ was presented by Oxender (1974). Dilute iodine solution (DIS) was infused in the uterus of cows on day 4 or day 15 of the estrous cycle. The DIS rapdily destroyed the endometrium and it did not regenerate for 4 or 5 days. When DIS was infused on day 4, the estrous cycle was shortened and when DIS was infused on day 15, the estrous cycle was lengthened to 25 days. When DIS was infused on day 15 and $PGF_{2\alpha}$ was infused on day 16 the estrous cycle was reduced from 25.1 to 19.1 days. The results of this experiment indicate that the luteolysin is produced by the endometrium of the uterus.

2.2.3. Localized Effect of the ULF

Evidence indicates that the uterine luteolytic effect in the cow is local and depends on the presence of the uterine horn ispilateral to the CL (Hansel et al. 1973). Ispilateral regression of the CL has been observed in partially hysterectomized sows (du Mesnil du Buisson, 1961) and ewes (Inskeep and Butcher, 1966).

Hansel and co-workers (1973) reported that when the ovary containing the active CL was surgically isolated from all nerve and circulatory ties with the uterus on day 10-12 of the bovine cycle, the CL were maintained in 4 of 5 animals as indicated by weights and

progesterone concentrations obtained at the time of their removal 30-36 days postsurgery. None of the experimental animals exhibited estrus during this period.

Ovarian transplant experiments have exhibited some of the most impressive evidence for a local luteolytic role of the uterus in the ewe and cow. Ewes with ovaries transplanted to the neck, did not undergo regular estrous cycles and the progesterone content of ovarian effluent blood remained high for long periods of time (McCracken et al. 1971). Hansel and Snook (1970) observed irregular estrous cycles in one cow in which the ovary was transplanted to the neck for over one year.

From the evidence cited, it is obvious that the uterus secretes a substance that is responsible for luteolysis and that the ovary and uterus must be in close proximitiy for luteal regression to occur normally. For pregnancy to be maintained, the corpus luteum must be functional until the placenta is capable of producing adequate progesterone to maintain pregnancy. Thus, the life span of a corpus luteum is of considerable importance since it regulates the length of the estrous cycle and is essential for maintenance of pregnancy.

2.2.4 Embryo Effect on the Luteolytic Process

A sequence of investigations by Moor and Rowson (1966 a,b,c,d) were performed to determine the time at which the embryo exerts its

influence on the luteolytic process. The transfer of embryos to non-pregnant ewes throughout the estrous cycle indicated that the embryo must be in the uterus by day 12 or 13 in order to extend the life span of the CL thus neutralizing the ULF. The removal of embryos from pregnant ewes confirmed these results.

2.3. The Relationship of $PGF_{2\alpha}$ to the Uterine Luteolytic Factor

Many observations clearly indicate that the uterus produces a substance which causes luteolysis in the bovine (Hansel et al. 1973; Melampy and Anderson, 1968; Lukaszewaska and Hansel, 1970). During a group discussion in 1966, Babcock first suggested that prostaglandins might be the uterine luteolytic factor.

Pharriss and Wyngarden (1969) indicated that prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) caused the CL to regress in rats. $PGF_{2\alpha}$ has since been reported to be luteolytic in guinea pigs (Blatchley and Donovan, 1969), rabbits (Pharriss, 1970), sheep (McCracken, Glew and Scaramuzzi, 1970), hamsters (Lauderdale, 1972; Gutknecth, Wyngarden and Pharriss, 1971; Laphsetwar, 1971), cows (Rowson, Tervit, and Brand, 1972; Inskeep, 1973; LaVoie, 1975) and horses (Douglas and Ginther, 1972; Allen, 1972).

2.3.1. General Description and Origin of Prostaglandins

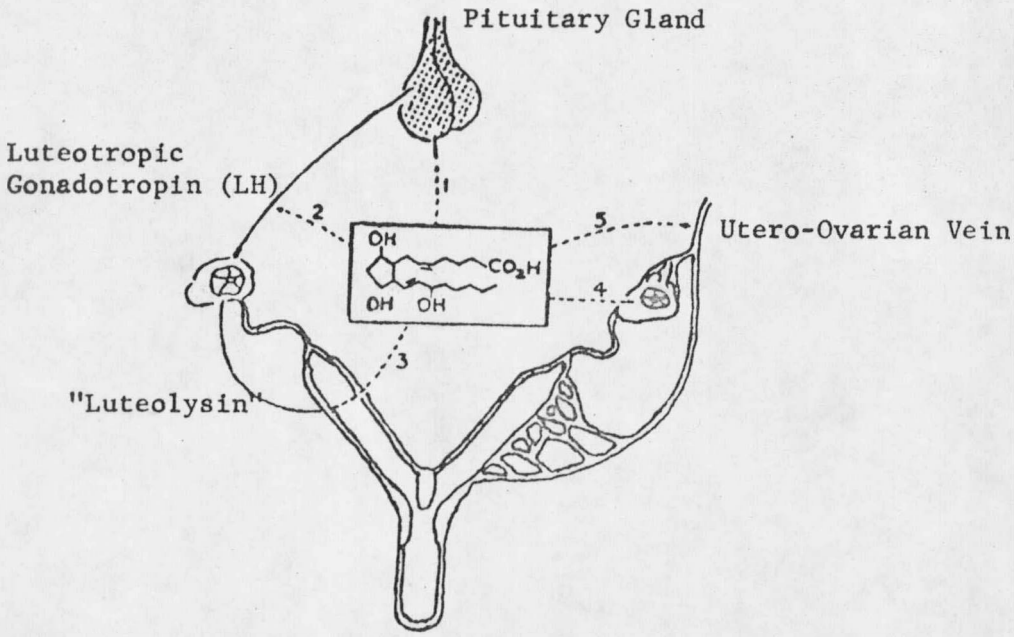
Prostaglandins were discovered in the 1930's (Goldblott, 1933; Von Euler, 1934) and have since been associated with the reproductive processes in many mammalian species. Prostaglandins are 20-carbon

hydroxy fatty acids with a cycleopentane ring and two side-chains. Prostaglandins are divided into four groups (E, F, A and B), indicating differences in the five-membered cyclopentane ring. Precursors for the biosynthesis of prostaglandins are 8, 11, 14-Eicosatetranoic acid, arachidonic acid and 5,8, 11, 14, 17-Eicosapentaneoic acid. These precursor acids are derived from linoleic acid (Karim, 1975). Prostaglandins have been isolated or released from lung, thymus, brain, spinal cord, kidney, iris, umbilical cord, endometrium over ova, fat, adrenals, ovaries, stomach, intestines, nerves, menstrual fluid, amniotic fluid, seminal plasma, blood, skeletal muscle, cardiac muscle, salivary glands, thyroid, pancreas, and uterus (Bergstrom et al. 1968).

2.3.2. Postulated Mechanisms of $PGF_{2\alpha}$ Induced Luteolysis

The mechanism in which $PGF_{2\alpha}$ exerts its luteolytic effect is unknown. Pharris et al. (1972) postulates five possible modes of action by which $PGF_{2\alpha}$ may cause luteolysis. Figure 2 depicts the five postulated areas where $PGF_{2\alpha}$ could be exerting its primary effect.

Postulate one states $PGF_{2\alpha}$ either totally blocks the pituitary or has the ability to suppress the secretion of the luteotropic complex in different species (Figure 2, #1). If $PGF_{2\alpha}$ directed its luteolytic effect through the hypotholmus or pituitary then luteolysis should occur throughout the entire estrous cycle. Numerous investigations have found that $PGF_{2\alpha}$ is only effective in causing luteolysis



1 = direct feedback on pituitary gland
2 = antigonadotropic effect
3 = stimulation of uterus to produce luteolysin
4 = direct toxicity of corpus luteum
5 = constriction of utero-ovarian vein.
From Behrman et al., Ann. N.Y. Acad. Sci. 180, 437 (197). In. Pharris et al., (1972).

Figure 2. Possible mechanisms of prostaglandin $F_{2\alpha}$ in luteolysis.

when the corpus luteum is mature. Gutknect et al. (1969) demonstrated that $PGF_{2\alpha}$ given prior to day 4 of pregnancy in the rat was not luteolytic, but if treatment occurred on day 6 or later, $PGF_{2\alpha}$ was luteolytic. Rowson, Tervit and Brand (1972) showed that $PGF_{2\alpha}$ given on day 3 of the estrous cycle of the bovine did not cause luteolysis. Louis, Hafs and Seguin (1973) demonstrated $PGF_{2\alpha}$ to be ineffective in decreasing serum progesterone levels if administered before day 4 (estrus days) of the bovine estrous cycle.

Pharriss et al. (1968 as reviewed by Pharris et al. 1972) reported that LH levels were unaffected by $PGF_{2\alpha}$ treatment, while Chamley et al. (1974) showed that ovarian arterial infusions of $PGF_{2\alpha}$ induced luteolysis at doses, which were ineffective when given systemically. Pharriss et al. (1972) suggested that the hypothalmus and pituitary are not directly involved in $PGF_{2\alpha}$ induced luteolysis. Thus the literature indicates that $PGF_{2\alpha}$ does not block the pituitary or suppress the secretion of luteotropic hormones.

A second postulated method by which $PGF_{2\alpha}$ could induce luteolysis is through the uterus (Figure 2, #3). With $PGF_{2\alpha}$ being a strong smooth-muscle stimulator it is possible that $PGF_{2\alpha}$ could excite the uterus to contract and release an endogenous uterine luteolysin, however, LaVoie et al. (1975) and Stellflug et al. (1975 a) demonstrated that $PGF_{2\alpha}$ was luteolytic in hysterectomized bovine. Because luteolysis occurs in hysterectomized bovine with exogenous $PGF_{2\alpha}$ this postulate is

disproven.

A third suggested mechanism for $PGF_{2\alpha}$ action would be a direct toxic effect on the corpus luteum (Figure 2, #4). There is conflicting data on the effect $PGF_{2\alpha}$ has on the corpus luteum. Pharriss et al. (1968) and Spiroff and Ramwell (1970) (as reviewed by Pharriss et al. 1972) have reported that $PGF_{2\alpha}$ stimulates secretion of progesterone by luteal tissue in vitro. Henderson and McNatty (1975) and O'Grady et al. (1972) indicate that $PGF_{2\alpha}$ inhibits secretion of progesterone in vitro. Louis et al. (1973), LaVoie et al. (1975) and Stellflug et al. (1975 b) have reported that $PGF_{2\alpha}$ causes a decrease of serum progesterone levels in vivo. Thus this postulate is not disproven and requires more research to determine if $PGF_{2\alpha}$ actually has a toxic effect on the CL.

A fourth postulated mode of action is that $PGF_{2\alpha}$ may exert an antigonadotropic effect in the circulatory system or at the corpus luteum receptor sites (Figure 2, #2). Pharriss and Hunter (1971) reported that $PGF_{2\alpha}$ inhibits FSH-like (Pregnant Mare Serum) and LH-like (Human Chorionic Gonadotropin) activity in the rat. $PGF_{2\alpha}$ inhibited PMS stimulation of ovarian weight gain by 30-60% and almost totally blocked HCG-induced ovulations. Hichens et al. (1974) indicated that $PGF_{2\alpha}$ causes a decline in hormone binding capacity at the corpus luteum binding sites. These data support the postulate that antagonism with luteotropins by $PGF_{2\alpha}$ is a possible mechanism whereby $PGF_{2\alpha}$ exerts its luteolytic effect.

Pharriss's fifth and final postulate for the luteolytic effect of $PGF_{2\alpha}$ is the alteration of ovarian blood flow (Figure 2, #5). After a single dose of $PGF_{2\alpha}$ in rats, there is a spontaneous decrease in blood flow of 50 to 60% of the control level which lasts about 25 minutes (review by Pharriss, 1970). McCracken et al. (1970) measured ovarian blood flow in sheep in which the uterus, ovary and intact vascular supply had been transplanted into the neck. They reported that $PGF_{2\alpha}$ caused a decline in ovarian blood flow, however, there was a reduction in progesterone prior to the decrease in blood flow. Niswender et al. (1976) reported that $PGF_{2\alpha}$ or $PGF_{2\alpha}$ analogs administered to sheep caused a decline of progesterone from 4 ng/ml to 1 ng/ml ($P<.05$) within 6 hours. Blood flow to the luteal ovary decreased within 4 hours ($P<.05$). Blood flow to the non-luteal ovary did not change. The hemodynamic changes seen in the $PGF_{2\alpha}$ treated ewes were similar to those in cycling ewes. These data support the postulate that $PGF_{2\alpha}$ alters ovarian blood flow in causing luteolysis as a possible mechanism.

The methods in which $PGF_{2\alpha}$ exerts its luteolytic effect is still unknown. The two hypothesis that best support $PGF_{2\alpha}$ induced luteolysis at present are the gonadotropin antagonism and alteration of ovarian blood flow.

2.3.3. Postulated Mechanisms of $PGF_{2\alpha}$ Transfers

Now that evidence has been presented to establish the origin of the luteolysin and the possible modes of action of $PGF_{2\alpha}$ induced luteolysis, the questions arises on how does the luteolysin get to the ovary. Barrett et al. (1971) showed that by separating the ovarian artery from the utero-ovarian vein, CL regression was prevented in sheep. This suggested that the luteolytic factor present in the uterine vein reached the ovary by a counter current mechanism operating between the utero-ovarian vein and the ovarian artery. McCracken et al. (1971, 1972) supported the counter current exchange mechanism by infusing H-labelled $PGF_{2\alpha}$ into the uterine vein and measuring the amount of radioactivity associated with $PGF_{2\alpha}$ in the ovarian artery and simultaneously in the iliac artery. The amount of radioactivity was many times higher in ovarian arterial blood than in iliac arterial blood, indicating that transport of $PGF_{2\alpha}$ by way of a counter current mechanism can occur. Further evidence that transfer of the ULF from the bovine uterus to the ovary is local and not systemic was presented by Hixon and Hansel (1974). In this experiment the broad ligament was sectioned ipsilateral to the corpus luteum on day 13 of the estrous cycle of 5 normal cycling dairy animals. This procedure isolated the ovarian vein from the uterine venous input and any branches between the uterine and ovarian arteries. The estrous cycle of four of five animals were extended to at least 30 days, as

measured by plasma progesterone levels and the presence of marked corpora lutea at laparotomy on day 30.

Ginther (1974) reported that the wall of the ovarian artery was thinnest at the area of contact with the utero-ovarian vein. This relationship between the two vessels may favor the direct passage of a ULF between the utero-ovarian vein and the ovarian artery by a counter current exchange.

Karim (1975) reported over 90% of prostaglandins E and F are metabolized by passing through the lungs once and only minute doses are required to stimulate uterine muscle *in vivo*. This data suggest that prostaglandins act locally as modulators rather than as classical circulating hormones.

2.3.4. Metabolic Precursors to $PGF_{2\alpha}$

There is a great deal of evidence to suggest that $PGF_{2\alpha}$ is the endogenous luteolytic substance, however, one type of evidence which argues against this point is the description of the chemical nature of the active material extracted from bovine endometrium. Various investigators (Łukaszewaska and Hansel, 1970; Caldwell *et al*. 1968) have reported that the molecular weight of the endogenous uterine luteolytic factor is quite high; a protein or other polymer which would exclude $PGF_{2\alpha}$, however Pharriss et al. (1972) reported that the prostaglandins have a high binding affinity for many proteins.

Lukaszewaska and Hansel (1970) were not successful in an attempt to purify the uterine luteolytic factor from bovine endometrial extracts. Hansel et al. (1973) showed that the active luteolysin was protein bound and could be removed from the bound protein by lipid solvents and that the remaining protein residue had no luteolytic activity. Evidence was also presented to indicate that the active substance was not a prostaglandin.

Hansel et al. (1975) conducted a series of experiments which led to the isolation and identification of a luteolytic agent in extracts from bovine endometrial tissue. Luteolytic activity was measured by CL weights and progesterone contents in the ovaries of pseudo-pregnant hysterectomized hamster's injected with the fraction. The luteolysin was removed from a protein and identified as arachidonic acid by thin layer chromatography and gas liquid chromatogrphy. It was suggested that arachidonic acid may be the substance secreted from the uterus and the precursor to $PGF_{2\alpha}$. Although the role of arachadonic acid in causing luteolysis in the bovine needs further study it seems that control of $PGF_{2\alpha}$ concentration at the CL could reside in the uterine endometrium. The uterine endometrium could control arachondic acid secretion thus controlling a precursor to $PGF_{2\alpha}$. Arachadonic acid could be transported to the ovary by the counter current exchange and then be transformed to $PGF_{2\alpha}$ at the ovary.

2.4. $PGF_{2\alpha}$ Induced Luteolysis in the Bovine

Administration of $PGF_{2\alpha}$ to cows 5 days after estrus was followed by a decrease in both serum progesterone, size of the corpus luteum (Louis et al. 1973), and a return to estrus approximately 3 days post-treatment (Rowson, Tervit and Branch, 1972; Lauderdale, 1972; Louis et al. 1973; Inskeep, 1973). Prostaglandin $F_{2\alpha}$ has been found to be luteolytic from days 5 to 16 of the estrous cycle (Lauderdale, 1972).

Intra-uterine infusions were used during early experimental work with $PGF_{2\alpha}$. Hafs et al. (1974) reported that 5 mg $PGF_{2\alpha}$ infused in the uterine horn ipsilateral to the CL on days 7, 11 and 15 caused over 70% luteal regression within 24 hours based on CL diameter. Rate of CL regression did not differ significantly between days treated. With intervening control estrous cycles between each $PGF_{2\alpha}$ treatment, animals were given 5 mg $PGF_{2\alpha}$ in the contralateral uterine horn on day 11 of the estrous cycle. $PGF_{2\alpha}$ administered in the contralateral uterine horn on day 11 resulted in more rapid ($P \simeq .03$) decline in blood progesterone than after $PGF_{2\alpha}$ in the ipsilateral uterine horn.

Intrauterine injections are time consuming and involve risk of uterine infection (Hearnshaw et al. 1974; Henricks et al. 1974) and are impractical under many farm and ranch conditions, therefore more practical means of administering $PGF_{2\alpha}$ have been developed. One of the first studies using $PGF_{2\alpha}$ for estrus synchronization was done by

Lauderdale et al. (1974). Cattle in this experiment were divided into one of three groups at each of four locations. Treatment one (non-treated controls) was observed for estrus at least twice daily and inseminated about 12 hours after the onset of estrus during an 18 to 25 day interval. Cattle in treatments II and III were injected either intramuscularly or subcutaneously with 30 mg $PGF_{2\alpha}$ tham salt. Treatment II animals were detected for estrus at least twice daily and inseminated approximately 12 hours after the onset of estrus detected during the seven days after $PGF_{2\alpha}$ injection. Animals assigned to treatment III were inseminated twice at about 72 and 90 hours after $PGF_{2\alpha}$ with no regard to estrus. Fertility of $PGF_{2\alpha}$ treated cows was similar to controls when cattle were inseminated at the synchronized estrus following treatment and when inseminated at the predefined intervals 72 and 90 hours post $PGF_{2\alpha}$ treatment. Percent cows pregnant at 35 to 60 days after AI was 53.3, 52.2 and 55.8 respectively for treatments I, II and III. It was concluded that there was no significant difference in fertility among control and treated animals.

Hafs et al. (1974) administered 30 mg $PGF_{2\alpha}$ (IM) to 25 heifers. Thirteen heifers served as controls and were inseminated at 12 hours after the onset of estrus and 12 were inseminated without regard to estrus at 72 and 90 hours after treatment. Seven of 13 controls (54%) and six of 12 $PGF_{2\alpha}$ treated (50%) animals were diagnosed pregnant from the first insemination. There was no significance between treatments.

These data suggest that ovulation control with $PGF_{2\alpha}$ is feasible and may permit artifical insemination in herds where detection of estrus is difficult.

Stellflug et al. (1975 b) administered either two 15 mg injections of $PGF_{2\alpha}$ at 6 hour intervals, or a single injection of 60 mg or 30 mg $PGF_{2\alpha}$ intramscular into heifers to determine if luteolysis proceeded more rapidly with different dosages. Two heifers were assigned to each dose level of $PGF_{2\alpha}$ during three consecutive estrous cycles. Heifers were observed twice daily for signs of estrus and time of ovulation was estimated by ovarian palpations twice daily during and after estrus. Blood was assayed for plasma progesterone estradiol and LH. Results demonstrated that neither the decline in progesterone, the increase in blood estradiol, the duration of the LH peak, the interval to onset of estrus, nor the interval to ovulation was affected significantly by the dose of $PGF_{2\alpha}$. These data indicate that a 30 mg (IM) injection of $PGF_{2\alpha}$ is an ample dose to cause luteolysis in heifers.

Roche (1974) designed an experiment to evaluate fertility of cattle when injected (IM) with 20 mg or 30 mg of $PGF_{2\alpha}$. Thirty-three heifers between days 5 and 20 of their estrous cycle were divided into three groups. Group one (Controls, n=11) received no treatment and were inseminated at estrus. Group two (n=11) received 30 mg of $PGF_{2\alpha}$ and were bred after observed estrus. Group three (n=11) received 20 mg $PGF_{2\alpha}$ and were inseminated after observed estrus. The numbers of

animals displaying estrus during the subsequent 4 days post injection for the 30 mg and 20 mg treatments were 8 and 11 respectively. Estrus responses in the $PGF_{2\alpha}$ treated animals was not influenced by dosage or stage of the cycle when treated between days 5 and 20 of the estrous cycle. AI Pregnancy rates for Groups I, II and III were 73%, 75% and 70% respectively (non-significant).

2.4.1. Managment Schemes Designed to Use $PGF_{2\alpha}$ As An Estrous Synchronizing Agent

Different breeding schemes have been developed to compensate for $PGF_{2\alpha}$ not acting on cows in days 0 to 4 and 17 to 21 of their estrous cycle (Rowson et al. 1972). Since prostaglandin $F_{2\alpha}$ is only luteolytic between the 5th and 16th day of the bovine estrous cycle, means that in any random group of cows only 50% of the animals may fall within the effective period (Van Niekerk et al. 1974). However cows within day 17 to 21 of their estrous cycle do not require any consideration in an estrus synchronizing program using $PGF_{2\alpha}$ because these animals will be in estrus due to normal CL regression. Cows between days 0 and 4 of their estrous cycle require manipulation to effectively utilize $PGF_{2\alpha}$ as an estrus synchronizing agent. One method presented by Roche (1974) would be to inject all animals initially, regardless of the stage of the estrous cycle, and then to re-treat those animals not responding 10 days later. This breeding scheme would synchronize all cattle between days 5 to 21 of their estrous cycle and allow those

animals between days 0 to 4 of their estrous cycle to progress to days 10 to 14 of their estrous cycle.

2.4.2. Double Injection System Using $PGF_{2\alpha}$

In 1974 King and Robertson reported using a two injection system with $PGF_{2\alpha}$ in which thirty randomly cycling Holstein heifers were injected with 30 mg $PGF_{2\alpha}$ 10 days apart. Twenty-five of the thirty (83%) heifers were in estrus 2 to 4 days following the second injection and ten of the twenty-five (40%) were pregnant at 60 days post insemination. This was compared to the control group, where thirteen of the 15 control heifers (87%) were detected in estrus within a 21 day period and seven of the thirteen (54%) were pregnant at 60 days post insemination. This data indicates that the proportion of animals showing estrus and subsequent pregnancy in the treated and control groups were not significantly different. From the results of this experiment King and Robertson (1974) suggested that the two injection systems utilizing $PGF_{2\alpha}$ may have commercial application for the regulation of the ovulatory cycle of cattle. Hafs *et al*. (1975) and Kinkie *et al*. (1976) used similar experimental design with $PGF_{2\alpha}$ in a two injection (IM) management scheme and indicated that $PGF_{2\alpha}$ when used in a two injection scheme is a practical method for estrus synchronization.

Burfening et al. (1976) used a two injection system with $PGF_{2\alpha}$ and

only reinjected those animals not responding to the first injection 11 days later. This type of estrus synchronizing scheme provided decrease labor requirements and a conception rate that was comparable to the controls which received no treatment.

2.4.3. Single Injection System Using $PGF_{2\alpha}$

Lambert et al. (1975) reported using $PGF_{2\alpha}$ as an estrus synchronizing agent to field test its effectiveness when used in a single injection scheme. Cattle in the $PGF_{2\alpha}$ system were observed for estrus and inseminated accordingly until the 5th day of the breeding season at which time all cattle in the $PGF_{2\alpha}$ system which had not been previously inseminated were injected (IM) with 33.5 mg $PGF_{2\alpha}$-Tham salt. Cattle responding with behavioral estrus were bred accordingly until 72 hours post injection, at which time those cattle not responding to treatment were bred and recorded as non-estrus animals. The cattle assigned to the conventional systems were only inseminated to observed estrus. Genetic markers were used to determine which breeding resulted in conception. The breeding season consisted of 25 days AI followed by a 20 day natural breeding period for both the $PGF_{2\alpha}$ and conventional systems. Results showed total pregnancy rate (85%) for the $PGF_{2\alpha}$ system was not significantly different than for the conventional system (82%). Total AI pregnancy rate for the $PGF_{2\alpha}$ system (54%) was significantly higher (P=.04) than for the conventional system (42%).

There was no significant difference for AI first service pregnancy rates between the $PGF_{2\alpha}$ (43%) and conventional (45%) systems. The percent of cattle pregnant the first ten days of the AI breeding season with one AI service in the $PGF_{2\alpha}$ system (38%) was significantly higher (P=.001) when compared to the conventional system (19%). The average day of conception in the $PGF_{2\alpha}$ system (day 22) was significantly (P<.05) closer to the beginning of the breeding season than the conventional system (day 26).

Lambert et al.(1976) performed a later experiment using 240 virgin heifers and 669 postpartum cows. Cattle were assigned to treatment groups and managed the same as described by Lambert et al. (1975). Total pregnancy rate (83%; P=.018), total AI pregnancy rate (52%; P=.01) and AI first service pregnancy rate (47%; P=.009) were significantly greater for the $PGF_{2\alpha}$ system than for the conventional system (77%, 41% and 38% respectively). The percent pregnant the first ten days of the AI breeding season with one AI service was significantly greater (P<.001) for the $PGF_{2\alpha}$ system (48%) than for the conventional system (20%). The average day of conception in the $PGF_{2\alpha}$ system (day 14) was significantly closer (P<.001) to the beginning of the breeding season than the conventional system (day 21). Results of these studies demonstrates that $PGF_{2\alpha}$ does not hinder fertility in cattle when compared to a conventional system under range beef cattle management conditions. The single $PGF_{2\alpha}$ injection breeding scheme

requires treated cattle to be handled only twice and is an effective method of synchronizing estrus in beef cows.

2.4.4. Time Breeding Schemes Using $PGF_{2\alpha}$

The ultimate goal of an estrus synchronization program in beef cattle is time clock breeding. Time clock breeding would allow the producer to predetermine the labor requirements, omit estrus detection and limit variation in age of calves.

Because progesterone is known to surpress both estrus and ovulation when administered to cycling cows, it has been used with $PGF_{2\alpha}$ to synchronize estrus and control ovulation. VanNiekerk and co-workers (1974) reported using a management scheme with $PGF_{2\alpha}$ and progesterone. Eleven Friesland cows and five heifers received 150 mg progesterone subcutaneous on day 1. On day three each animal was administered 100 mg progesterone intramuscular. All animals received 500 mg $PGF_{2\alpha}$ analogue (ICI80996) intramscular on day 5 followed 12 hours later by 1000 I.U. PMSG intramuscular. Exogenous progesterone was successful in suppressing follicular growth and inhibiting estrus in all animals and allowed cattle between days 0-5 of their estrous cycle to progress beyond day 5 of the estrous cycle. With one heifer having a silent heat, 14 of the 15 remaining animals showed estrus between 24 and 60 hours after the PMSG injection and one animal came into estrus after 96 hours. The conception rate was 57% for the first

post synchronized estrus and three animals were found to be sterile.

Wishart (1974) treated twenty heifers with 6 mg SC21009 (a potent progestin) for 5 days followed by 30 mg of $PGF_{2\alpha}$ administered transcervically, while another group of 20 heifers received just 30 mg of $PGF_{2\alpha}$. In the group of cattle given SC21009 and PGF_2 , 18 were in estrus over a 5 day period and 12 of the 18 inseminated conceived first service. In the $PGF_{2\alpha}$ treated group, 14 were in estrus over a 5 day period and 7 out of the 14 heifers conceived to the first breeding.

In 1974 Heersche et al. placed Syncro-Mate βimplants (6 mg) in 50 beef heifers for 7 days at which time each heifer was injected (IM) with 30 mg of $PGF_{2\alpha}$ and rectally palpated for corpra lutea. Artifical inseminations were from 12 to 18 hours after observed estrus. The number of heifers showing estrus within 84 hours post injection was 47. First service conception rates for $PGF_{2\alpha}$ treated and control animals was 63.8% and 65% respectively.

Hafs et al. (1975) assigned 960 heifers and 392 suckled cows in 36 commercial herds as either non-treated controls or treated animals. Treated cattle received two injections (IM of 30 mg $PGF_{2\alpha}$-tham salt or .5 mg ICI80996) at 10 to 12 day intervals. Prostaglandin treated animals were either bred once at 80 hours or twice at 70 and 88 hours after the second injection without regard to estrus. Pregnancy was determined by either rectal palpation or by non-return to estrus. The AI pregnancy rate of prostaglandin treated animals inseminated without

regard to estrus was equal to the controls. AI pregnancy rate from a single 80 hours breeding was equal to the AI pregnancy rate from two inseminations at 70 and 88 hours post the second prostaglandin injection.

Inskeep et al. (1975) administered $PGF_{2\alpha}$ and estradiol benzoate beef heifers and lactating beef cows 40 or more days postpartum. Only animals judged to be cycling by palpation were used in this experiment. Animals assigned to treatment I were treated with 33.4 mg $PGF_{2\alpha}$ (IM) on days 0 and 12. Treatment II consisted of the same injections of $PGF_{2\alpha}$ plus 500 μg estradiol benzoate intramuscular 48 hours after the second $PGF_{2\alpha}$ treatment. Animals were observed for estrus twice daily between days 8 and 17 of the experiment and artifically inseminated 12 hours after estrus. Pregnancy was determined by rectal palpation 40 to 50 days after inseminations. Sixty-four and 95% of the animals in treatments I and II, respectively were in estrus between 48 and 84 hours after the second $PGF_{2\alpha}$ injection ($P<.01$). Conception rates for treatments I and II were 59% and 52% respectively. The percent pregnant of treated cattle inseminated to estrus at 48 to 84 hours after the second $PGF_{2\alpha}$ injection was 36 for treatment I and 51 for treatment II ($P>.05$).

Kaltenbach et al. (1974) and Convey (1973) have shown that GnRH causes an LH release as seen prior to ovulation. Graves et al. (1974) randomly divided 108 cows into three groups. Group I (controls, n=35)

received 8 mg $PGF_{2\alpha}$ (IM) on days 1 and 12 and 4 mg $PGF_{2\alpha}$ on days 2 and 13. These animals were inseminated at the second post-treatment estrus. Group II (n=36) received $PGF_{2\alpha}$ as described in Group I but were inseminated at the first post-treatment estrus. Group III (n=34) received the same $PGF_{2\alpha}$ treatment as Group II plus 250 µg GnRH (IM) 60 hours after day 12 $PGF_{2\alpha}$ injection and bred 12 hours later. Pregnancy rates were 48.6, 33.3 and 38.2% ($P>.25$) for groups I, II and III respectively. These results tend to indicate that estrus can be synchronized with a double $PGF_{2\alpha}$ treatment and ovulation can be synchronized with $PGF_{2\alpha}$ and GnRH without significantly affecting fertility.

The feasibility of breeding beef cattle at a predetermined time without regard to estrus was studied by Rodriguez et al. (1975). One-hundred and eighty-eight cycling heifers and 25 cycling cows of various beef breeds expressing estrus were assigned to one of three treatments. Treatment I was controls, treatments II and III were animals between days 7 and 23 of their estrous cycle. Treatment II received 50 mg $PGF_{2\alpha}$ (S.C.) followed 48 hours later with an (IM) injection of 100 µg GnRH and bred at 63 hours post $PGF_{2\alpha}$ injection. Treatment II animals received 30 mg $PGF_{2\alpha}$ and were inseminated at detected estrus within 7 days post $PGF_{2\alpha}$ injection. Total pregnancy rates were 38, 22 and 32% respectively for groups I, II and III. There was no significance between groups.

2.5. The Bovine Postpartum Interval

To effectively utilize $PGF_{2\alpha}$ in an estrus synchronization program two important criteria must be satisfied. (1) estrous cycles of aniamls between days 1 to 4 and 17 to 21 need to be manipulated and (2) a large percent of cattle must be cycling. As discussed earlier many different management schemes have been designed to manipulate bovine estrous cycles so that $PGF_{2\alpha}$ can be employed as an estrus synchronizing agent. To have all cattle cycling at the beginning of the breeding season is an underlying problem faced by all producers.

Beef cattle have an indefinite anestural period following calving (Foote and Hunter, 1964). This period of time has been called the postpartum interval and is defined as starting 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).

For a cow to calve on a 12 month cycle, she must conceive 82 days postpartum based on a 283 day gestation. Factors affecting postpartum interval are post parturient diseases, suckling, level of production, nutrition, season, age and parity.

2.5.1. Factors Affecting Postpartum Interval

Postparturient diseases. The postpartum interval is increased by diseases consisting of abortion, dystocia, retained fetal membranes,

metritis, milk fever, active mastitis, ketosis, displaced abomosum or other debilitating diseases (Morrow, 1971).

Suckling. Clapp (1937) found that the average interval from calving to first estrus was 46 days for cows milked twice daily and 69 days for cows milked four times per day and 72 days for cows suckling calves. Wagner and Hansel (1969) reported the onset of first postpartum estrus was delayed by suckling calves and milking. Wiltbank and Cook (1958) observed the interval from calving to first estrus was approximately 30 days longer in nursed cows than for cows milked twice daily. Short et al. (1972) observed significant differences in the postpartum interval between suckled, nonsuckled and mastectomized cows with the intervals being 65, 25 and 12 days respectively. These data suggest that the greater the suckling frequency and level of production the longer the postpartum interval from parturition to first estrus. Many conflicts exist on the effect suckling has on uterine involution. Lauderdale et al. (1968) and Riesen et al. (1968) reported that suckling hastens involution. Wagner and Hansel (1969) reported that suckling has no effect, while Wiltbank and Cook (1958) reported that suckling prolongs uterine involution.

Level of Production. It is not clear on the effect of level of milk production on the interval to first estrus. Some researchers reported that the interval is prolonged by increased production (Carman, 1955; Saiduddin et al. 1967), however Clapp (1937) and Herman

and Edmondson (1950) report that the level of milk production has no effect on the interval from parturition to first estrus but Menge et al. (1962) reported a positive correlation of milk production on the interval from parturition to uterine involution. Morrow et al. (1966) reported that the level of milk production had no effect on the interval from parturition to uterine involution.

Nutrition. Nutrition is a factor affecting the postpartum interval in mature hereford cows (Wiltbank et al. 1962). Prepartum and postpartum energy intake has been shown to influence reproductive performance of beef cows (Wiltbank et al. 1962, 1964). Dunn et al. (1969) observed cows on a low level of energy prepartum to have a longer interval from parturition to first estrus and differences in conception rates were noted in cows fed varying levels of energy following calving, with animals on high energy level having higher conception rates.

Season. Winter calving was observed by Buch et al. (1955) to be accompanied by the longest postpartum intervals, while summer calving resulted in the shortest. Marian et al.(1968) observed the interval from parturition to uterine involution to be shortest in the summer and spring. However several reports indicate no effect of season on the intervals from parturition to first estrus or uterine involution (Herman and Edmondson, 1950; Warnick, 1955; Wiltbank and Cook, 1958; Morrow et al. 1966).

Age and Parity. Postpartum interval to first estrus was reported to decrease with increased parity up to 7 years of age and then increase again (Herman and Edmondson, 1950; Wiltbank and Cook, 1958). However Casida and Wisnicky (1950) observed postpartum interval to increase with parity, while Buch et al. (1955) and Foote et al. (1960) show this interval not to be affected by parity. There is conflicting data on the effect of age on the rate of uterine involution. Tennant et al. (1967) maintains that age has no effect on rate of involution, while Morrow et al. (1966) reports the postpartum interval to uterine involution is longer in cows which have calved for consecutive years.

2.5.2. Summary of Bovine Postpartum Management

The length of the postpartum interval from calving to first breeding is an important factor in determining the likelihood of pregnancy. Casida (1968) and Foote (1971) showed that as the days postpartum increases up to approximately 60 days the likelihood of first service conception increases. Present economic conditions dictate that producers strive for a 12 month calving interval. Likelihood of pregnancy during the breeding season is influenced by postpartum diseases, suckling, level of production, nutrition, season and age of cattle. Proper beef cattle management will decrease the detrimental effect these factors have on the percent calf crop weaned from cows exposed during the breeding season.

CHAPTER 3

$PGF_{2\alpha}$ AS AN ESTRUS SYNCHRONIZING AGENT USING A SINGLE INJECTION MANAGEMENT SYSTEM

3.1. Materials and Methods

Lactating straight and cross bred beef cows were randomly assigned according to age and days postpartum into either a conventional (non-treated control, n=202) breeding system or a prostaglandin $F_{2\alpha}$ breeding system (n=204). Days postpartum from parturition to the start of the breeding season for mature cows ranged from 38-89 and for first calf heifers 47 to 124. Figure 3 depicts the breeding schemes for the $PGF_{2\alpha}$ and conventional breeding systems. The breeding season for both systems consisted of 25 days artifical insemination followed by 20 days natural service. Straight bred Herefords were inseminated with Hereford semen while all other cows were bred with Black Angus semen. Cows with an estrous cycle of less than 15 days were bred with Red Angus semen on the second breeding to serve as a genetic marker. This study was conducted under range beef management conditions during the months of July and August 1976. Cows were on pastures during the entire AI period ranging in size from 500 to 800 acres. During the natural service period the cattle were moved to mountain pastures.

Estrus detection was periodic during daylight hours. Cattle detected in estrus prior to 10 a.m. were bred near 6 p.m. that day while those detected in estrus after 10 a.m. were bred near 6 a.m. the next day. Detection of estrus started on day -1/2 and AI commenced

Day of Breeding Season	$PGF_{2\alpha}$ System	Conventional System
-1/2	(PM) Estrus Detection began	(PM) Estrus Detection began
0	(AM) First Day AI Breeding	(AM) First Day AI Breeding
4	(PM) $PGF_{2\alpha}$ Injection (to all animals not previously detected in estrus)	
7	(PM) 80 hr. non-estrus breeding. (All animals not previously detected in estrus were inseminated)	
8	(AM) Resumed breeding only to observed estrus	
25	(PM) End of AI Breeding Season (Bulls turned in with cows)	(PM) End of AI Breeding Season (Bulls turned in with cows)
45	End of Breeding Season. (Bulls removed)	End of Breeding Season. (Bulls removed)

FIGURE 3. OUTLINE FOR $PGF_{2\alpha}$ BREEDING SYSTEM (USING ONE INJECTION) AND CONVENTIONAL BREEDING SYSTEM FOR SPRING 1976 BREEDING SEASON

in the a.m. of the next day (day 0) of each trial. $PGF_{2\alpha}$ (25 mg Prostin $F_{2\alpha}$) was administered intramuscular on the 4th day (a.m.) of the breeding season (5th day of actual breeding) to only those animals in the $PGF_{2\alpha}$ system not detected in estrus prior to injection. Breeding was conducted under the general breeding scheme after $PGF_{2\alpha}$ treatment for approximately 80 hours; at which time all treated animals not detected in estrus were bred non estrus. At the time of the non estrus breeding, half of the cattle in this group were reinjected with 25 mg Prostin $F_{2\alpha}$ immediately after insemination and the remaining half served as untreated controls (Appendix Table I).

Pregnancy was determined by rectal palpations at 63 days after the end of the breeding season. Total pregnancy rate, Total AI pregnancy rate, AI first service pregnancy rate and AI first service conception rate when bred to an observed estrus were calculated for both the $PGF_{2\alpha}$ and conventional breeding system. AI first service conception rate when bred non-estrus and received $PGF_{2\alpha}$ was calculated for the $PGF_{2\alpha}$ system. The percent pregnant the first ten days of the breeding season and the average day of conception for the 45 day breeding season were determined. A subgroup of cattle was made in the $PGF_{2\alpha}$ system consisting of only those animals which actually received $PGF_{2\alpha}$. This subgroup excluded cattle preassigned to the $PGF_{2\alpha}$ system that were bred previous to treatment. Comparisons were made between breeding system ($PGF_{2\alpha}$ and Conventional systems) and the subgroup

within the $PGF_{2\alpha}$ breeding system. Days postpartum was calculated for $PGF_{2\alpha}$ treated mature cows and first calf heifers on an individual basis from parturition to $PGF_{2\alpha}$ injection and animals were grouped into 4 day intervals. Days postpartum at $PGF_{2\alpha}$ injection for mature cows ranged from 43 to 94 and for first calf heifers 52 to 129. Estrus response, AI first service pregnancy rate when bred to an observed estrus and AI first service pregnancy rate when bred non-estrus were compared to days postpartum at $PGF_{2\alpha}$ injection, to determine the optimum time for $PGF_{2\alpha}$ treatment (Figures 5-10). Data were analyzed for statistical significance by two way Chi-square. One way classification analysis of variance was used to test for significance between systems for average day of conception.

3.2. Results and Discussion

Total pregnancy rates for the $PGF_{2\alpha}$ system and cattle actually receiving $PGF_{2\alpha}$ were 78 and 76% respectively. Total pregnancy rate for the conventional system was 77%. No significant differences were found between the systems (Table I).

Total AI pregnancy rate for the $PGF_{2\alpha}$ system and cattle actually receiving $PGF_{2\alpha}$ were 49 and 45% respectively. Total AI pregnancy rate for the conventional system was 40%. There was no significant difference between systems, however, the $PGF_{2\alpha}$ system tended to have a higher total AI pregnancy rate when compared to the conventional

system (Table I).

The AI first service pregnancy rates for the $PGF_{2\alpha}$ system and cattle actually receiving $PGF_{2\alpha}$ were 42 and 38% respectively. AI first service pregnancy rate for the conventional system was 40%. No significant difference was found between systems (Table I).

Because all cattle in the $PGF_{2\alpha}$ system were inseminated before day eight of the breeding season, a large number of animals (50%) were bred nonestrus at the 80 hour breeding. The AI first service pregnancy rates when bred to an observed estrus for the $PGF_{2\alpha}$ system and cattle actually receiving $PGF_{2\alpha}$ were 59 and 55% respectively. The AI first service pregnancy rate when bred to an observed estrus for the conventional system was 60%. No statistical significance was found between systems (Table II). The AI first service pregnancy rate of cattle receiving $PGF_{2\alpha}$ and bred nonestrus (26%) was lower than the AI first service pregnancy rate of cattle bred to an observed estrus in the PGF_2 (59%) and conventional (60%) systems.

These data demonstrate that overall fertility between systems did not differ significantly. These data are consistant with the results of Lambert *et al.* (1975,1976), Lauderdale *et al.* (1974), Hafs *et al.* (1974) and Roche (1974) which reported no significant differences in fertility between $PGF_{2\alpha}$ treated and control cattle.

The percent of beef cattle pregnant the first ten days of the AI breeding season with one AI service was significantly greater

(P .001) for the $PGF_{2\alpha}$ (42%) system than for the conventional system (18%; Table III). Figure 4 graphically depicts this difference in the percent of beef cattle pregnant the first 10 days of the 25 day AI breeding season. To further explain this trend, Figure 5 portrays the synchronizing effect of $PGF_{2\alpha}$ by the number of cows bred to an observed estrus on any given day of the AI breeding season. It is interesting to observe the increase in the number of cattle bred in the conventional system (days 12, 13, 14 of the breeding season) after $PGF_{2\alpha}$ synchronized estrus. This trend may be a result of visual estrus stimulation and/or phermones from the large number of cows in the $PGF_{2\alpha}$ system showing estrus on days 7 and 8. As a result of more animals in the $PGF_{2\alpha}$ system conceiving earlier in the AI breeding season the average day of conception was advanced (P .10) three days for the PGF_2 system (Table IV).

Data in Figures 6, 7 and 8 suggest that about 55 days postpartum is the optimum time to employ $PGF_{2\alpha}$ to achieve maximum estrus response, AI first service pregnancy rate when inseminated to an observed estrus and AI first service pregnancy rate when inseminated nonestrus for mature cows.

Figures 9, 10 and 11 indicate about 70 to 75 days postpartum is the optimum time to employ $PGF_{2\alpha}$ as an estrus synchronizing agent to achieve maximum estrus response, AI first service pregnancy rate when inseminated to an observed estrus and AI first service pregnancy rate

when inseminated nonestrus for first calf heifers. Due to the limited number of animals used in this study, no conclusive results can be obtained for these parameters.

Results of this study demonstrate that a single injection of $PGF_{2\alpha}$ when administered on the fifth day of the breeding season can be employed to synchronize estrus in beef cattle under range conditions without effecting fertility. Advantages of this type of estrus synchronization are that the producer can achieve more AI pregnant cattle in ten days thus utilizing labor more efficiently by concentrating labor requirements at predetermined times. This may also decrease the variation in calf age at weaning. The single $PGF_{2\alpha}$ injection system to synchronize estrus also only requires the cattle to be handled a maximum of two times.

TABLE I. PREGNANCY RATE OF COWS IN A $PGF_{2\alpha}$ BREEDING SYSTEM COMPARED TO A CONVENTIONAL BREEDING SYSTEM FOR SPRING 1976 BREEDING SEASON

Parameters	Treatments	Cows
Total Pregnancy Rate		
Total Pregnant / Total in Group	$PGF_{2\alpha}$ System *	78% (158/204)
	Receiving $PGF_{2\alpha}$	76% (135/177)
	Conventional System	77% (156/202)
Total AI Pregnancy Rate		
Total AI Pregnant / Total in Group	$PGF_{2\alpha}$ System *	49% (99/204)
	Receiving $PGF_{2\alpha}$	45% (78/177)
	Conventional System	40% (81/202)
AI 1st Service Pregnancy Rate		
AI 1st Service Cattle / Total in Group	$PGF_{2\alpha}$ System *	42% (86/204)
	Receiving $PGF_{2\alpha}$	38% (67/177)
	Conventional System	40% (81/202)

* $PGF_{2\alpha}$ was given in the p.m. on day 4 of the breeding season to those cattle in the $PGF_{2\alpha}$ system which had not been bred or were not in estrus on or before day 4 (a.m.) of the breeding season.

TABLE II. AI FIRST SERVICE CONCEPTION RATES OF ESTRUS AND NONESTRUS BREEDINGS FOR COWS IN A $PGF_{2\alpha}$ BREEDING SYSTEM COMPARED TO A CONVENTIONAL BREEDING SYSTEM FOR SPRING 1976 BREEDING SEASON

Parameters	Treatment	Cows
AI 1st Service Conception Rate When Bred to an Observed Estrus		
Conceived First Service AI / Total Group-Nonestrus Cattle	$PGF_{2\alpha}$ System *	59% (60/102)
	Receiving $PGF_{2\alpha}$	55% (41/75)
	Conventional System	60% (81/136)
AI First Service Conception Rate When Bred Nonestrus		
Conceived First Service AI / Received $PGF_{2\alpha}$ and Bred Nonestrus	Receiving $PGF_{2\alpha}$	26% (26/102)

* $PGF_{2\alpha}$ was given in the p.m. on day 4 of the breeding season to those cattle in the $PGF_{2\alpha}$ system which had not been bred or were not in estrus on or before day 4 (a.m.) of the breeding season.

TABLE III. PERCENT OF BEEF CATTLE PREGNANT THE 1st TEN DAYS IN THE AI BREEDING SEASON WITH ONE AI SERVICE IN A $PGF_{2\alpha}$ BREEDING SYSTEM COMPARED TO A CONVENTIONAL BREEDING SYSTEM FOR SPRING 1976 BREEDING SEASON

Trials	$PGF_{2\alpha}$ System	Conventional System
Cows	42%* (86/204)[a]	18%* (36/202)[b]

a,b $P < .001$

*Cattle pregnant 1st ten days of AI breeding / Total in Group

TABLE IV. THE AVERAGE DAY OF CONCEPTION IN A $PGF_{2\alpha}$ BREEDING SYSTEM COMPARED TO A CONVENTIONAL BREEDING SYSTEM (AI AND SUBSEQUENT NATURAL BREEDING SEASON INCLUDED) FOR SPRING 1976 BREEDING SEASON

Trials	n	$PGF_{2\alpha}$ System Day	n	Conventional System Day
Mature Cows	160	20^{a}	156	23^{b}

a,b $P < .01$

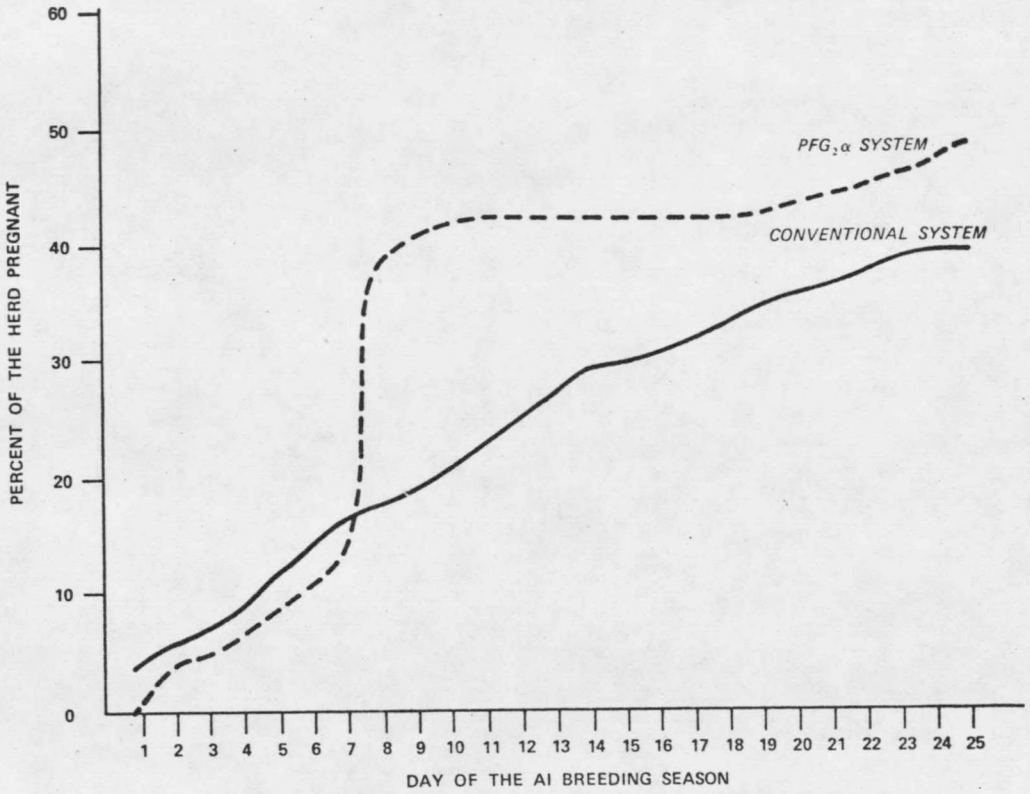


FIGURE 4. PERCENT OF THE HERD PREGNANT PER DAY OF THE AI SEASON IN THE $PGF_{2\alpha}$ AND CONVENTIONAL BREEDING SYSTEMS FOR SPRING 1976

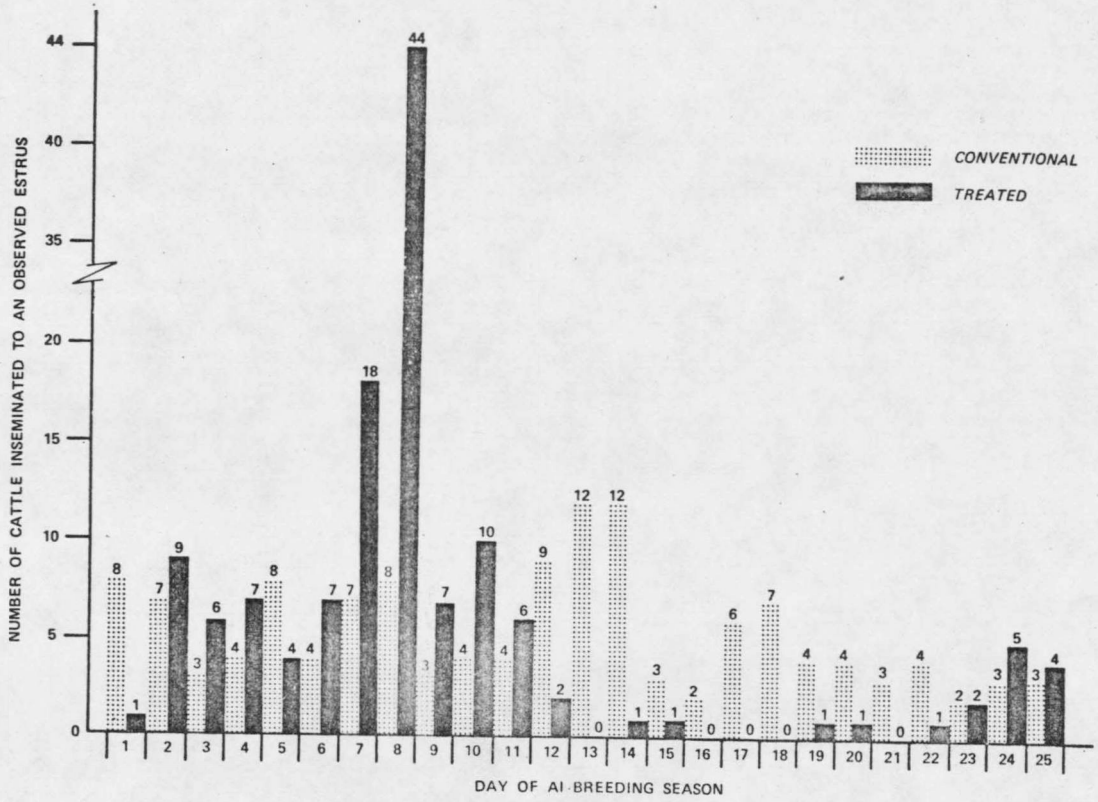


FIGURE 5. NUMBER OF CATTLE INSEMINATED IN THE $PGF_{2\alpha}$ AND CONVENTIONAL BREEDING SYSTEMS TO AN OBSERVED ESTRUS PER DAY OF THE AI BREEDING SEASON FOR SPRING 1976

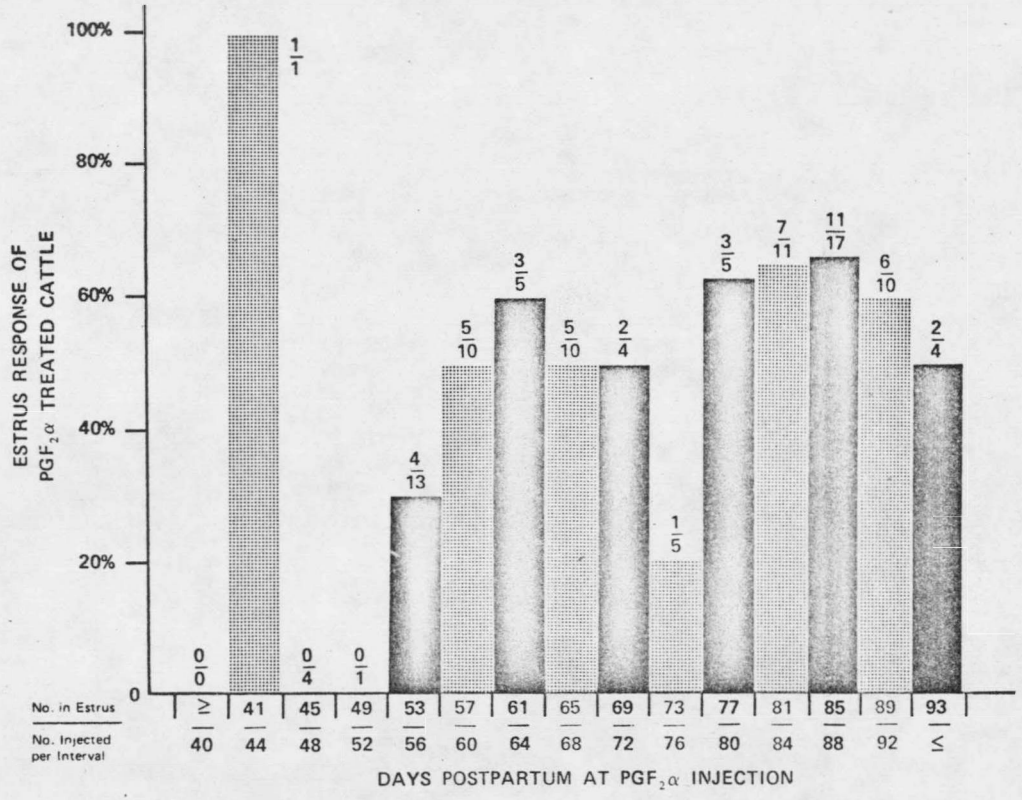


FIGURE 6. ESTRUS RESPONSE OF $PGF_{2\alpha}$ TREATED CATTLE vs. DAYS POSTPARTUM ON THE DAY OF $PGF_{2\alpha}$ INJECTION FOR MATURE COWS DURING THE SPRING 1976 BREEDING SEASON

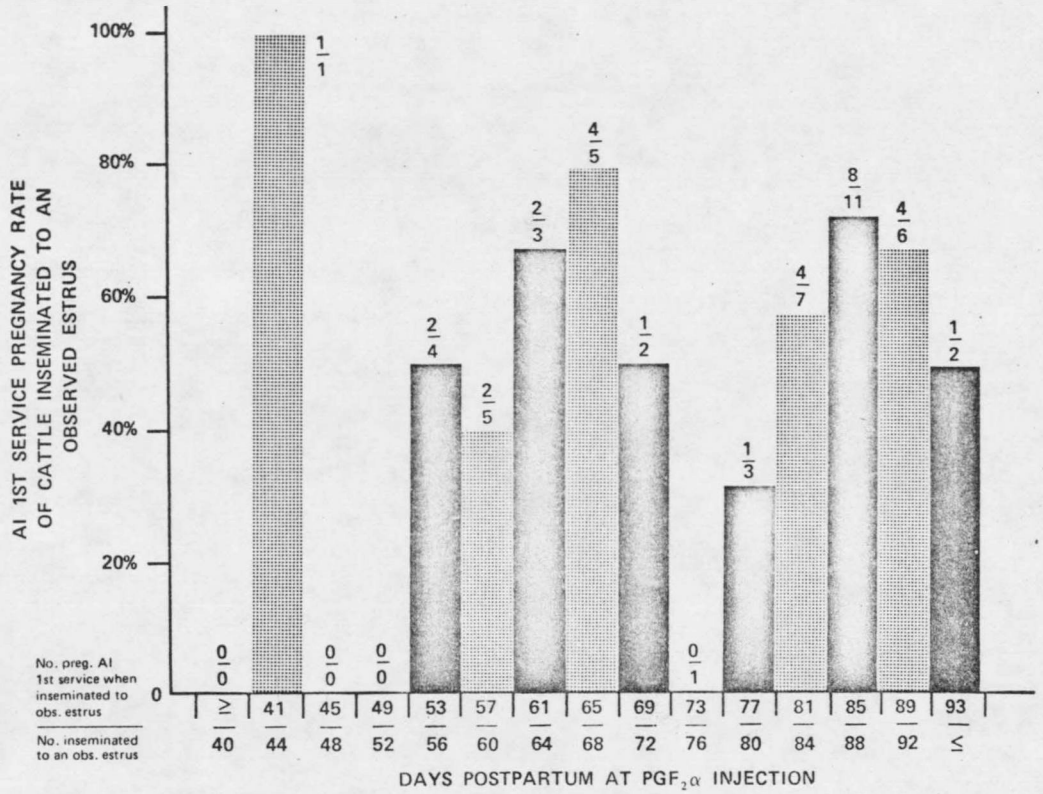


FIGURE 7. AI FIRST SERVICE PREGNANCY RATE OF CATTLE INSEMINATED TO AN OBSERVED ESTRUS vs. DAYS POSTPARTUM ON THE DAY OF $PGF_{2\alpha}$ INJECTION FOR MATURE COWS DURING SPRING 1976 BREEDING SEASON

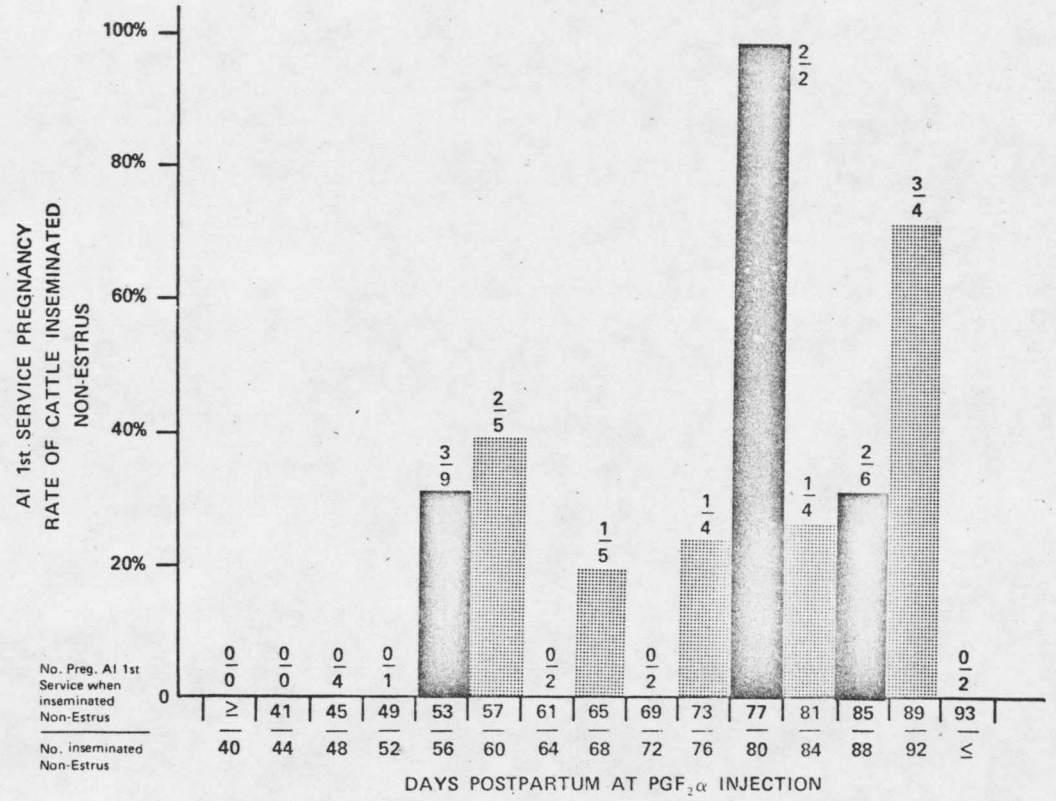


FIGURE 8. AI FIRST SERVICE PREGNANCY RATE OF CATTLE INSEMINATED NON-ESTRUS vs. DAYS POSTPARTUM ON THE DAY OF $PGF_{2\alpha}$ INJECTION FOR MATURE COWS DURING SPRING 1976 BREEDING SEASON

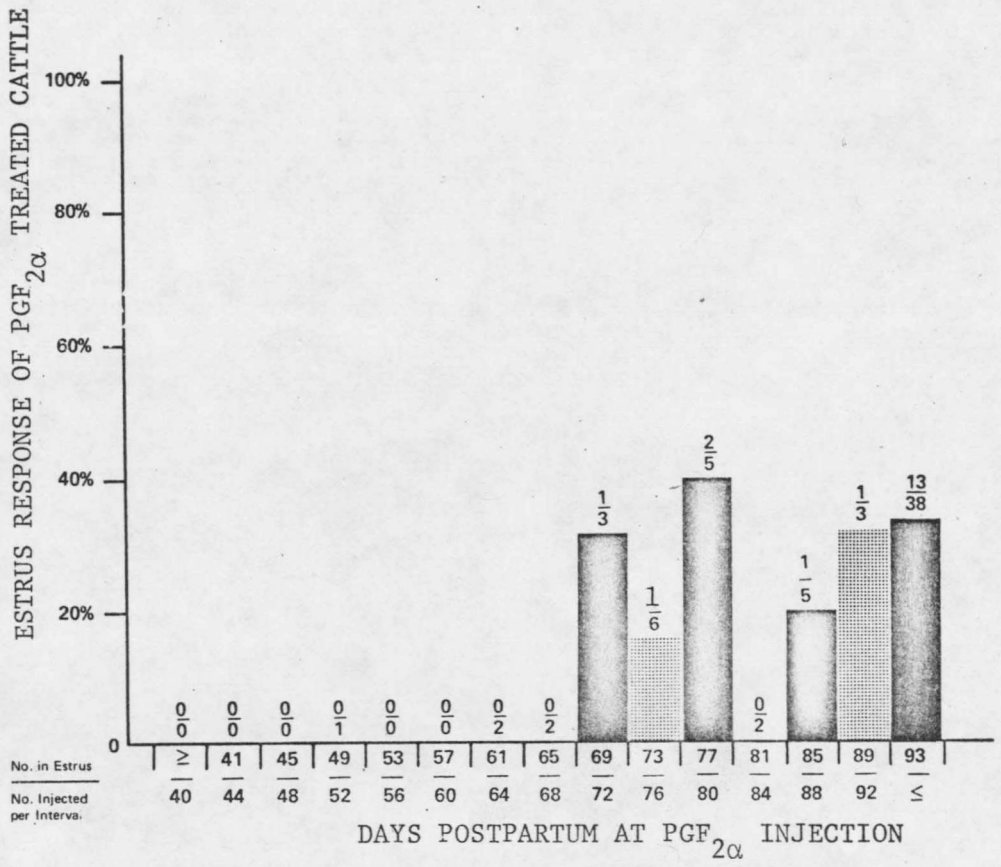


FIGURE 9. ESTRUS RESPONSE OF $PGF_{2\alpha}$ TREATED CATTLE vs. DAYS POSTPARTUM ON THE DAY OF $PGF_{2\alpha}$ INJECTION FOR FIRST CALF HEIFERS DURING SPRING 1976 BREEDING SEASON

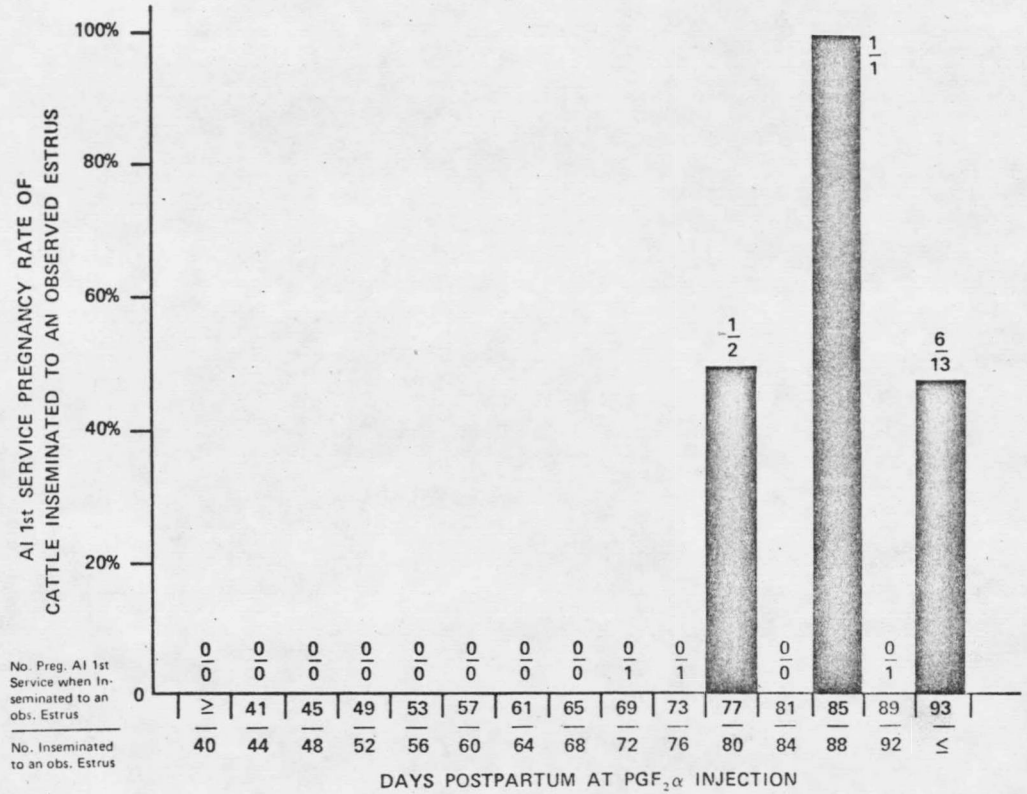


FIGURE 10. AI FIRST SERVICE PREGNANCY RATE OF CATTLE INSEMINATED TO AN OBSERVED ESTRUS vs. DAYS POSTPARTUM ON THE DAY OF $PGF_{2\alpha}$ INJECTION FOR FIRST CALF HEIFERS DURING SPRING 1976 BREEDING SEASON

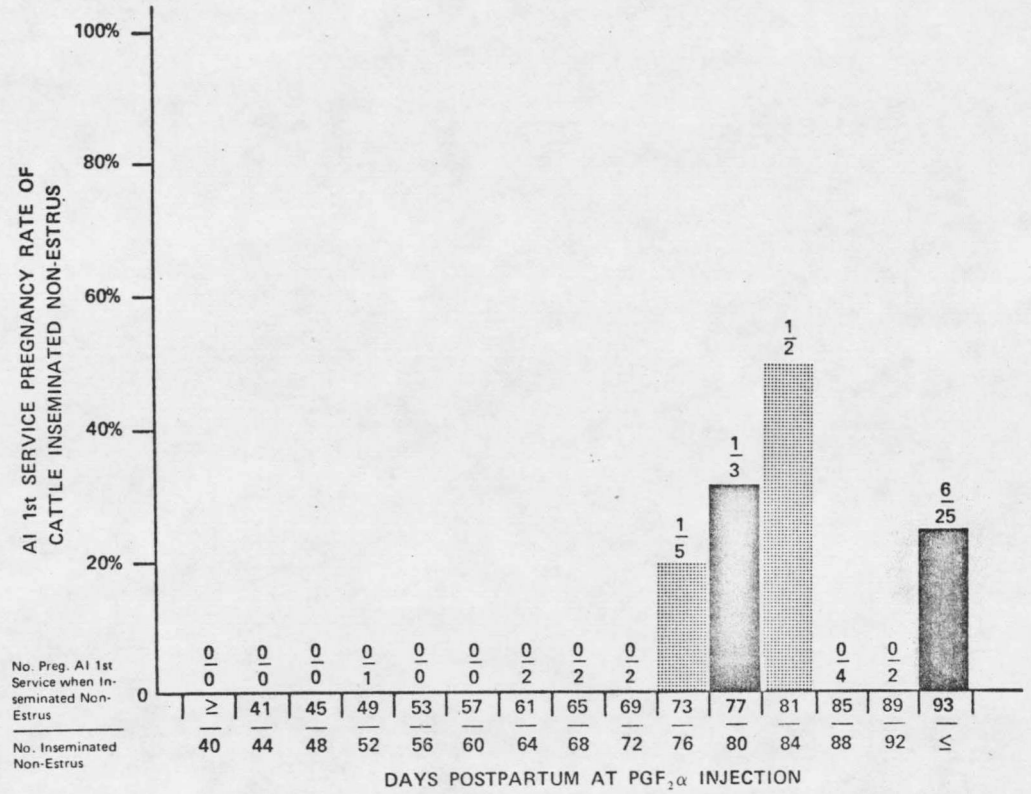


FIGURE 11. AI FIRST SERVICE PREGNANCY RATE OF CATTLE INSEMINATED NON-ESTRUS vs. DAYS POSTPARTUM ON THE DAY OF $PGF_{2\alpha}$ INJECTION FOR FIRST CALF HEIFERS DURING SPRING 1976 BREEDING SEASON

CHAPTER 4

$PGF_{2\alpha}$ AS AN ESTRUS SYNCHRONIZING AGENT USING A TWO INJECTION MANAGEMENT SYSTEM

4.1. Materials and Methods

Two trials were conducted using straight and cross bred Hereford heifers (Trial A) and lactating straight and cross bred Hereford beef cows (Trial B). Cattle in Trial A were randomly assigned by chute run, to either a $PGF_{2\alpha}$ breeding system or a control breeding system. Figure 12 illustrates the breeding scheme used during this experiment. The control breeding system in Trial A (treatment 0; n=39) consisted of 45 days natural service with Hereford bulls. Trial A heifers in the $PGF_{2\alpha}$ breeding system were randomly assigned to either Treatment 1 (25 mg Prostin-$F_{2\alpha}$; n=58) or Treatment 2 (15 mg Prostin-$F_{2\alpha}$; n=55). Cattle in the $PGF_{2\alpha}$ breeding system (Treatment I and II) were injected (IM) on days -11 and 0 of the breeding season. Trial A heifers in the $PGF_{2\alpha}$ breeding system were artifically inseminated, without regard to estrus, at a mean interval of 76.1 hours after the second $PGF_{2\alpha}$ injection (day 0). Approximately 48 hours after insemination (p.m. day 4 of the breeding season) cattle in the $PGF_{2\alpha}$ breeding system from Trial A were subjected to natural breeding with Hereford bulls for 18 days. On day 21 (a.m.) of the breeding season all bulls were removed and estrus detection commenced in the p.m. AI began in the a.m. of day 22 and continued until the p.m. of day 26 of the breeding season. Natural service resumed on day 27 (a.m.) of the breeding

Day of Breeding Season	$PGF_{2\alpha}$ System	Control System
--11	1st $PGF_{2\alpha}$ Injection	
0	2nd $PGF_{2\alpha}$ Injection	Start Natural Service
3	AI Breeding (animals bred AI at mean intervals of 76.1 hours for heifers and 72.4 hours for cows post second $PGF_{2\alpha}$ treatment without estrus detection)	
4	(PM) Start natural service with Hereford bulls approx. 48 hours after AI Breeding	
21	Remove bulls in the AM and began estrus detection in the PM	
22	(AM) Began inseminating cows approx. 12 hours after being observed in standing heat	
26	(PM) Last Day AI Breeding	
27	(AM) Start natural service with Hereford bulls and continue until end of breeding season	
44	Last day of breeding season	

FIGURE 12. OUTLINE OF $PGF_{2\alpha}$ BREEDING SYSTEM (USING TWO INJECTIONS) AND CONTROL BREEDING SYSTEM FOR FALL 1976 BREEDING SEASON

season and ended on day 45 of the breeding season.

Estrus detection between days 21 (a.m.) and 26 (p.m.) of the breeding season was periodic during daylight hours. During days 21 and 26 of the breeding season cattle detected in estrus prior to 11 a.m. were inseminated near 5 p.m. that day while those cattle detected in estrus after 11 a.m. were bred near 8 a.m. the following day. All heifers in the $PGF_{2\alpha}$ breeding system (Treatments I and II) from Trial A were bred with Black Angus semen, except for Angus x Hereford cross bred which were bred with Jersey semen. The Black Angus and Jersey semen served as genetic marker so subsequent calf color would determine which breeding (AI or natural service) resulted in conception. The control and $PGF_{2\alpha}$ breeding systems in Trial A were managed in separate pastures during the first 26 days of the breeding season.

Total pregnancy rates for Trial A were determined for the $PGF_{2\alpha}$ breeding system (Treatments I and II) and the control breeding system (Treatment 0) by rectal palpation 59 days after the end of the breeding season. Data were analyzed between treatments (0, I and II) by two way Chi-square.

Trial B cattle were randomly preassigned to either a $PGF_{2\alpha}$ breeding system or a control breeding system according to days postpartum. Figure 12 illustrates the breeding schemes used during this experiment. The control breeding system in Trial B (Treatment 0; n=68) consisted of 45 days natural service with Hereford bulls. Trial B animals

preassigned to the $PGF_{2\alpha}$ breeding system were randomly assigned to either Treatment I (25 mg Prostin-$F_{2\alpha}$; n=110) or Treatment II (15 mg Prostin-$F_{2\alpha}$; n=104). Trial B cattle in Treatments I and II were managed identically as cattle in Treatments I and II of Trial A with the following exceptions. The mean interval from the second injection of $PGF_{2\alpha}$ (day 0) to insemination was 72.4 hours, and cattle in the $PGF_{2\alpha}$ breeding system were inseminated with Black Angus semen except for Angus x Hereford and Charolais cross bred cows which were inseminated with Charolais semen. The Black Angus and Charolais semen served as genetic markers so subsequent calf color would determine which breeding (AI or natural service) resulted in conception. The control and $PGF_{2\alpha}$ breeding systems in Trial B were managed in two different areas during the first 26 days of the breeding season.

Total pregnancy rates for Trial B were determined for the $PGF_{2\alpha}$ breeding system (Treatments I and II) and the control breeding system (Treatment 0) by rectal palpation 46 days after the end of the breeding season. Data were analyzed between treatments (0, I and II) by two way Chi-square.

4.2. Results and Discussion

Total pregnancy rates for Trial A heifers in Treatments 0 (controls; n=39), I (25 mg Prostin-$F_{2\alpha}$; n=58) and II (15 mg Prostin-$F_{2\alpha}$; n=55) were 80, 60 and 69% respectively. There was no significance between Treatments 0, I and II in Trial A (Table V), however due to

TABLE V. TOTAL PREGNANCY RATE OF HEIFERS IN THE PGF$_{2\alpha}$ AND CONTROL BREEDING SYSTEMS FOR FALL 1976 BREEDING SEASON

Trial A	n	Total Pregnancy Rate *
0 (controls)	39	80%
1 (25 mg Prostin-F$_{2\alpha}$)	58	60%
2 (15 mg Prostin-F$_{2\alpha}$)	55	69%

* Total Pregnancy Rate = $\frac{\text{Total Pregnant}}{\text{Total in Group}}$

extenuating circumstances no conclusions can be made from this data at present. It was discovered after this experiment had begun that all cattle in Trial A had been exposed to neighboring bulls one month prior to the start of the breeding season for approximately two weeks. If cattle in Treatments I and II had conceived to the neighboring bull prior to the first $PGF_{2\alpha}$ injection (day -11 of the breeding season) the $PGF_{2\alpha}$ treatment could have induced abortions (Lauderdale, 1972). This could tend to decrease the total pregnancy rate in the $PGF_{2\alpha}$ treated heifers due to an unfavorable condition in the uterus as a result of aborting. The control system cattle would also have been exposed to a longer breeding season. Hopefully with the help of the genetic markers (sire color) utilized in this experiment, subsequent calving data will provide more conclusive results.

Total pregnancy rates for mature cows in Trial B were 88%, 86%, and 86% for Treatments 0, I and II respectively (Table VI). There was no significance between Treatments 0, I and II in Trial B. Due to the experimental design total AI pregnancy rate and total AI first service pregnancy rate could not be determined by rectal palpation. These parameters will be calculated on forth coming calving data.

These data demonstrate that total pregnancy rate is not affected by the additional handling of cattle required to use $PGF_{2\alpha}$ as an estrus synchronizing agent. The two injection breeding scheme as used in all cattle managed in the $PGF_{2\alpha}$ breeding system, as described for

TABLE VI. TOTAL PREGNANCY RATE OF MATURE COWS IN THE $PGF_{2\alpha}$ AND CONTROL BREEDING SYSTEMS FOR FALL 1976 BREEDING SEASON

Trial B	n	Total Pregnancy Rates*
0 (controls)	68	88%
1 (25 mg Prostin-$F_{2\alpha}$)	110	86%
2 (15 mg Prostin-$F_{2\alpha}$)	104	86%

* Total Pregnancy Rate = $\frac{\text{Total Pregnant}}{\text{Total in Group}}$

this experiment, are inseminated by day 4 of the breeding season. Due to near total estrus synchronization in the beginning of the breeding season a similar estrus response may be observed between days 21 and 26 of the breeding season. This could provide an opportunity for the producer to inseminate all cattle, treated with PGF_2 twice in a 25 day period and only have to detect estrus for 5 days. Because all cattle in the PGF_2 system are inseminated by day 3 of the breeding season could result in more AI pregnant cows earlier in the breeding season thus reducing variation in calf age at weaning. The two injection breeding scheme using PGF_2 for estrus synchronization and breeding by appointment approximately 3 days post the second PGF_2 injection and inseminating to an observed estrus between days 21 and 26 reduces the labor required for a conventional AI breeding scheme.

CHAPTER 5

EFFECT OF TWO CONSECUTIVE YEARS IN A $PGF_{2\alpha}$ OR CONVENTIONAL AI BREEDING SYSTEM

5.1. Materials and Methods

Breeding trials were conducted during fall 1974 (F74), summer 1975 (S75), fall 1975 (F75) and summer 1976 (S76) breeding seasons. Cattle were randomly assigned in replicates to either a breeding system utilizing $PGF_{2\alpha}$ to synchronize estrus ($PGF_{2\alpha}$ system) or to a non-synchronized control (conventional system).

Breeding season for both systems consisted of 25 days artifical insemination (AI) followed by 20 days natural service. Hereford cows were bred with Hereford semen while all cross-bred and Black Angus cows were inseminated with Black Angus semen. Cattle with estrous cycles less than 15 days were inseminated with Red Angus semen on the second breeding to determine which breeding resulted in conception. Cattle were detected for estrus periodically during the daylight hours. Cattle in both breeding systems observed in estrus prior to midmorning (0900 hours for F74, S75, F75, and 1000 hours for S76) were bred near 1700 hour that day while those observed in estrus after midmorning were bred prior to 0600 hour the next day. Detection of estrus started on day -1/2 and AI commenced on day 0 in all trials. $PGF_{2\alpha}$ (25 mg or 33.5 mg $PGF_{2\alpha}$-tham salt) was administered intramscular in the morning of day 4 of the breeding season (5th day of actual breeding) to only

those animals in the $PGF_{2\alpha}$ system not detected in estrus prior to injection. $PGF_{2\alpha}$ injected animals displaying behavioral estrus were bred according to the general breeding scheme until a predetermined cut-off time (72 hours for F74 and 80 hours for S75, F75 and S76) when all treated animals not detected in estrus by that time were inseminated.

Results for the F74, S75 and F75 are based on actual calving information, while the results for S76 are based on pregnancy diagnosis obtained by rectal palpation 63 days after the end of the breeding season.

The complete fertility results have previously been published for F74 (Lambert et al., 1975), S75 and F75 (Lambert et al., 1976).

The objective of this study was to evaluate the subsequent reproductive performance of mature cows from the previous trials that were present in either the PGF_2 or conventional breeding systems for two consecutive years. One-hundred-ninety mature cows (n=95 $PGF_{2\alpha}$ system; n=95 conventional system) were in the same breeding system for two consecutive years. The average days postpartum for cows entering the first breeding season (year 1) in the $PGF_{2\alpha}$ and conventional breeding system were 60.9 and 63.8 days for F74, respectively, and 69.7 and 73.8 days for S75, respectively.

Measurements of reproductive performance were: 1) total pregnancy rate = number pregnant x 100 ÷ number in group; 2) total AI pregnancy

rate = number AI pregnant x 100 ÷ number in group. Total pregnancy and total AI pregnancy rates were tested across years and breeding systems by Two Way Chi-Square Analysis.

5.2. Results and Discussion

Total pregnancy rate decreased significantly from year 1 to year 2 in the conventional system for fall (100% vs 71% P<.001), summer (96% vs 83% P=.045) and combined (98% vs 77% P<.002) breeding seasons and in the $PGF_{2\alpha}$ system for the combined (100% vs 88% P=.001) breeding seasons (Table VII).

Total pregnancy rate was not different between conventional and PGF_2 breeding systems after year 1 for fall (100% vs 100%), summer (96% vs 100%) and combined (98% vs 100%) breeding seasons; however, total pregnancy rate was significantly lower (77% vs 88% P=.035) in the conventional system than in the $PGF_{2\alpha}$ system after year 2 for the combined breeding seasons (Table VII).

Total AI pregnancy rate decreased significantly from year 1 to year 2 in the conventional system for fall (67% vs 33% P=.001) and combined (61% vs 36% P<.001) breeding seasons and in the $PGF_{2\alpha}$ system for the fall (73% vs 47% P=.035) breeding season (Table VIII).

Total AI pregnancy rate was not different between conventional and PGF_2 breeding systems after year 1 for fall (67% vs 73%), summer (55% vs 58%) and combined (61% vs 63%) breeding seasons; however, total

TABLE VII. TOTAL PREGNANCY RATE FOR COWS MANAGED FOR TWO CONSECUTIVE YEARS IN EITHER A $PGF_{2\alpha}$ OR CONVENTIONAL BREEDING SYSTEM *

Breeding Seasons	Year	Management Systems: Conventional	Management Systems: $PGF_{2\alpha}$
Fall 1974	1	100%[a] (48)/(48)	100% (30)/(30)
Fall 1975	2	71%[b] (34)/(48)	83% (25)/(30)
Summer 1975	1	96%[c] (45)/(47)	100% (65)/(65)
Summer 1976	2	83%[d] (39)/(47)	91% (59)/(65)
Combined	1	98%[e] (93)/(95)	100%[g] (95)/(95)
Combined	2	77%[f] (73)/(95)	88%[h] (84)/(95)

a,b P<.001

c,d P=.045

e,f P<.001

g,h P=.001

f,h P=.035

* Total Pregnancy Rate = Total Pregnant / Total in Group

TABLE VIII. TOTAL AI PREGNANCY RATE FOR COWS MANAGED FOR TWO CONSECUTIVE YEARS IN EITHER A $PGF_{2\alpha}$ OR CONVENTIONAL AI BREEDING SYSTEM *

Breeding Season	Year	Management Systems	
		Conventional	$PGF_{2\alpha}$
Fall 1974	1	67%[a] (32)/(48)	73%[f] (22)/(30)
Fall 1975	2	33%[b] (16)/(48)	47%[g] (14)/(30)
Summer 1975	1	55% (26)/(47)	58% (38)/(65)
Summer 1976	2	38%[c] (18)/(47)	60%[h] (39)/(65)
Combined	1	61%[d] (58)/(95)	63% (60)/(95)
Combined	2	36%[e] (34)/(95)	56%[i] (53)/(95)

a,b P=.001
c,h P=.023
d,e P<.001
f,g P=.035
e,i P=.006

* Total AI Pregnancy Rate = Total AI Pregnant / Total in Group

AI pregnancy rate was significantly lower in the conventional system after year 2 for summer (38% vs 60% P=.023) and combined (36% vs 56% P=.006) breeding seasons (Table VIII).

The decrease in total pregnancy rate from year 1 to year 2 is inherent in the experimental design for this study. Open cows after the breeding season in year 1 were culled from the herd and were not present for year 2 (excluding two open cows in the conventional system after S75 breeding). Therefore, the total pregnancy rate after year 1 represents a maximum in both breeding systems.

These data suggest that consecutive management with the $PGF_{2\alpha}$ breeding system may increase total pregnancy rate and AI pregnancy rate in comparison to the conventional breeding system. An explanation for these results may reside in the fact that all cows in the $PGF_{2\alpha}$ system are inseminated once by day 8 of the breeding season (estrus and nonestrus breedings), while in the conventional system, cows are inseminated only after an observed estrus. Therefore, more cows in the $PGF_{2\alpha}$ system have the opportunity to conceive earlier and repeat breeders have additional opporutnities to conceive during the remaining breeding season. The effect of this trend over two consecutive years is seen in the higher total pregnancy rate (P=.035, Table VII) and total AI pregnancy rate (P=.006, Table VIII) in the $PGF_{2\alpha}$ system compared to the conventional system after year 2 (combined breeding seasons). This observation is supported by previous studies conducted

under similar management conditions which demonstrated increased AI first service pregnancy rates during the first 10 days of breeding and earlier average day of conception in the $PGF_{2\alpha}$ system compared to the conventional system (Lambert et al., 1975 and 1976).

APPENDIX

APPENDIX TABLE I. THE EFFECT OF THE SECOND INJECTION OF $PGF_{2\alpha}$ AT THE 80 HOUR NONESTRUS BREEDING ON TOTAL PREGNANCY AND TOTAL AI PREGNANCY RATES

	Percent Total Pregnant	Percent Total AI Pregnant
Received Second $PGF_{2\alpha}$ Injection	74% (37/50)	30% (15/50)
Controls	69% (35/51)	37% (19/51)

LITERATURE CITED

LITERATURE CITED

Allen, W. R. 1972. Some recent studies upon reproduction in the Mare. Bull. Thoroughbred Breeders, London.

Babcock, J. C. 1966. Luteotrophic and Luteolytic mechanisms in bovine corpora lutea. In "Ovarian Regulatory Mechanisms" J. Reprod. Fertil. Suppl. 1, p. 47.

Barrett, S., M. A. de B. Blockey, J. M. Brown, I. A. Cumming, J. R. Goding, B. J. Mole and J. M. Obst. 1971. Inititation of the oestrous cycle in the ewe by infusions of $PGF_{2\alpha}$ to the auto-transplanted ovary. J. Reprod. Fert. 24:136.

Bergstrom, S., L. A. Carlson and J. R. Weeks. 1968. The Prostaglandin: A family of biologically active lipids. Pharm. Rev. 20:1.

Blatchley, F. R. and B. T. Donovan. 1969. Luteolytic effect of prostaglandin in the guinea-pig. Nature 221:1065.

Buch, N. C., W. J. Tyler and L. E. Casida. 1955. Postpartum estrus and involution of the uterus in an experimental herd of Holstein-Friesian cows. J. Dairy Sci. 38:73.

Burfening, P. J., D. C. Anderson, R. L. Friedrich and J. Williams. 1976. Fertility of cows treated with PGF_2 and GnRH. Proc. West. Sec. Amer. Soc. Anim. Sci. 27:209.

Caldwell, B. V., R. M. Moor, and R. A. S. Lawson. 1968. Effects of endometrial grafts and extracts on the length of pseudopregnancy in the hysterectomized hamster. J. Reprod. Fert. 17:567.

Caldwell, B. V., L.E.A. Rowson, R. M. Moor and M. F. Hay. 1969. The Utero-Ovarian Relationship and its Possible Role in Fertility. J. Reprod. Fert. Suppl. 8, 59.

Carman, G. M. 1955. Interrelationships of milk production and breeding efficiency in dairy cows. J. Anim. Sci. 14:753.

Casida, L. E. and W. Wisnicky. 1950. Effects of diethylstilbestrol dipropionate upon postpartum changes in the cow. J. Anim. Sci. 9:238.

Casida, L. E. 1968. The Postpartum Cow - A Resume. In Studies on the Postpartum Cow. Wis. Agr. Exp. Sta. Bull. 270:48.

Casida, L. E. 1971. Postpartum interval and its relation to fertility in the cow, sow and ewe. J. Anim. Sci. 32:66 suppl. 1.

Chamley, W. A., J. C. Cerini, M. E. Cerini, I. A. Cumming, J. R. Goding and J. D. O'Shea. 1974. Luteal function following the infusion of prostaglanding $F_{2\alpha}$ into the uterine vein of the ewe. Biol. Reprod. 11:191.

Clapp. H. 1937. A factor in the breeding efficiency of cattle. Proc. Amer. Soc. Anim. Prod. 30:259.

Convey, E. M. 1973. Neuroendocrine relationships in farm animals: a review. J. Anim. Sci. 37:745.

Douglas, R. H. and O. J. Ginther. 1972. Effect of prostaglanding F_2 on lenght of diestrus in mares. Prostaglandins 2:265.

du Mesnil du Buisson, F. 1961. Regression unilateral des corpus jaunes apres hysterectomie partielle chez la truie. Ann. Biol. Anim. Biochem. Biophys. 1, 105-106.

Dun, T. G., J. E. Ingalls, D. R. Zimmerman and N. J. Wiltbank. 1969. Reproductive performance of 2-year-old Hereford and Angus heifers as influenced by pre-and post-calving energy intake. J. Anim. Sci. 29:719.

Foote, W. D., E. R. Hauser, and L. E. Casida. 1960. Some causes of varialion in postpartum reproductive activity in Hereford cows. J. Anim. Sci. 19:238.

Foote, W. D., and J. E. Hunter. 1964. Postpartum intervals of beef cows treated with progesterone and estrogen. J. Anim. Sci. 23:517.

Foote, W. D. 1971. Endocrine changes in the bovine during the post partum period. J. Anim. Sci. 32 suppl. 1.

Foote, W. D. 1974. Cattle. In E.S.E. Hafez (ed) Reproduction in Farm Animals. (3rd ed.) Lea and Febriger, Philadelphia.

Ganong, W. F. 1975. The Gonands: Development and function of the reproductive system. In Review of Medical Physiology (7th ed) Lange Medical Publications, Los Altos, California.

Ginther, O. J. 1974. Internal regulation of physiological processes through local venoarterial pathways: A Review. J. Anim.Sci. 39:550.

Goldblatt, M. W. 1933. A depressor substance in seminal fluid. Chem. Ind. 52:1056.

Graves, N. W., R. E. Short, R. D. Randel, R. A. Bellows, C. C. Kaltenbach and T. G. Dunn. 1974. Estrus and pregnancy following MAP, $PGF_{2\alpha}$ and GnRH. J. Anim. Sci. 39:208 (Abstr.).

Graves, N. W., T. G. Dunn, C. C. Kaltenbach, R. E. Short, J. B. Carr. 1975. Estrus and ovulation with Prostaglanding $F_{2\alpha}$, norgestament, and gonadotropin releasing hormone. Proc. West. Sec. Amer. Soc. Anim. Sci. 26:193.

Gutknecth, G. D., J. C. Cornette and B. B. Pharriss. 1969. Anti-fertility properties of prostaglandin $F_{2\alpha}$. Biol. Reprod. 1,367.

Gutknecth, G. D., L. J. Wyngarden and B. B. Pharris. 1971. The effect of prostaglandin $F_{2\alpha}$ on ovarian and plasma progesterone levels in the pregnant hamster. Proc. Soc. Exp. Biol. Med. 136:1151.

Hafs, H. D., T. M. Louis, P. A. Noden and W. D. Oxender. 1974. Control of the estrous cycle with Prostaglandin $F_{2\alpha}$ in Cattle and Horses. J. Anim. Sci. 38:10 (Suppl. 1).

Hafs, H. D., J. G. Mans and G. E. Lemming. 1975. Fertility of cattle from AI after $PGF_{2\alpha}$. J. Anim. Sci. 41:355 (Abstr.).

Hansel, W. and Snook, R. B. 1970. Pituitary ovarian relationships in the cow. J. Dairy Sci. 53, 945-960.

Hansel, W., P. W. Concannon and J. H. Lukaszewaska. 1973. Corpora lutea of the large domestic animals. Biol. of Reprod. 8:222-245.

Hansel, W., M. Shemesh, J. Hixon and J. Lukaszewaska. 1975. Extraction, Isolation and Identification of a luteolytic substance from bovine endometrium. Biol. of Repro. 13, 30-37.

Hearnshaw, H., P. E. Mattner, C. D. Nancarrow and B. J. Restall. 1974. The effect of the mode of administration of prostaglandin $F_{2\alpha}$ on the synchronization of oestrus in cattle. J. Reprod. Fert. 36:486.

Hechter, O., M. Fraenkel, M. Lev and S. Soskin. 1940. Influence of the uterus on the corpus luteum. Endocrin 26:680.

Heersche, G.,Jr., G. H. Kiracafe, R. M. McKee, D. C. Davis and G. R. Brower. 1974. Control of estrus in heifers with $PGF_{2\alpha}$ and Syncro-Mate B. J. Anim. Sci. 38:225.

Henderson, K. M. and K. P. McNatty. 1975. A biochemical hypothesis to explain the mechanism of luteal regression. Prost. 9:779.

Henricks, D. M., J. T. Long, J. R. Hill and J. F. Dickey. 1974. The effect of prostaglandin $F_{2\alpha}$ during various stages of the oestrus cycle of beef heifers. J. Reprod. Fert. 41:113.

Herman, H. A. and J. H. Edmondson. 1950. Factors affecting interval between parturition and first estrus in dairy cattle. Mo. Agr. Exp. Sta. Bull. 462:1.

Hichens, M., D. L. Grinwich and R. R. Behrman. 1974. $PGF_{2\alpha}$ induced loss of corpus luteum gonadotropin receptors. Prost. 7:457.

Hixon, J. E. and W. Hansel. 1974. Evidence of preferential transfer of prostaglandin $F_{2\alpha}$ to the ovarian artery following intrauterine administration in cattle. Biol. of Reprod. 11, 543-552.

Inskeep, E. K. and R. L. Butcher. 1966. Local component of utero-ovarian relationship in the ewe. J. Anim. Sci. 25, 1164-1171.

Inskeep, E. 1973. Potential uses of PG's in control of reproductive cycles of domestic animals. J. Anim. Sci. 36:1149.

Inskeep, E. K., J. A. Welch, M. R. McClung, E. A. Linger and J. O. Heishman. 1975. Control of estrus by $PGF_{2\alpha}$ and estradiol Benzoate. J. Anim. Sci. 40:187 (Abstr.).

Kaltenbach, C. C., T. G. Dunn, T. E. Kiser, L. R. Corah, A. M. Akbar and G. D. Niswender. 1974. Release of FSH and LH in beef heifers by synthetic gonadotrophin releasing hormone. J. Anim. Sci. 38:357.

Karim, S. M. M. 1975. Prostaglandins and Reproduction. University and Park Press. Baltimore, Maryland, 21202.

King, G. J. and H. A. Robertson. 1974. A two injection schedule with Prostaglandin $F_{2\alpha}$ for the regulation of the ovulatory cycle of cattle. Theriogenology 1:123.

Kinkie, R. A., D. C. Anderson, E. L. Moody and P. J. Burfening. 1976. Breeding heifers by appointment with $PGF_{2\alpha}$ and GnRH. Proc. West. Sect. Amer. Soc. Anim. Sci. 27:205.

Lambert, P. W., D. R. Griswold, V. A. LaVoie and E. L. Moody. 1975. AI Beef management with prostaglandin $F_{2\alpha}$ controlled estrus. Proc. West. Sec. Amer. Soc. Anim. Sci. 26:181.

Lambert, P. W., W. M. Greene, J. D. Strickland, D. K. Han and E. L. Moody. 1976. $PGF_{2\alpha}$ Controlled Estrus in Beef Cattle. Proc. West. Sec. Amer. Soc. Anim. Sci. 27:211.

Laphsetwar, A. P. 1971. Luteolytic and ovulation inducing properties of prostaglandin $F_{2\alpha}$ in hamsters. Nature 230:528.

Lauderdale, J. W., W. E. Graves, E. R. Hauser and L. E. Casida. 1968. Relation of postpartum interval to corpus luteum development, pituitary prolactin activity, and uterine involution in beef cows. Wis. Agr. Exp. Sta. Bull. 270:42.

Lauderdale, J. W. 1972. Effects of $PGF_{2\alpha}$ on pregnancy and estrous cycles of cattle. J. Anim. Sci. 35:246 (Abstr.).

Lauderdale, J. W., B.E. Seguin, J. N. Stellflug, J. R. Chenault, W. W. Thatcher, C. K. Vincent, and A. F. Loyancano. 1974. Fertility of cattle following $PGF_{2\alpha}$ injection. J. Anim. Sci. 38:964.

LaVoie, V. A., G. R. Poncelet, D. K. Han, C. L. Soliday, P. W. Lambert and E. L. Moody. 1975. Effect of prostaglandin $F_{2\alpha}$ on the estrous cycle, corpora lutea and progesterone levels of hysterectomized cows. J. Anim. Sci. 41:166.

Liehr, R. A., Marion, G. B. and H. H. Olson. 1972. Effects of prostaglandin in cattle oestrus cycles. J. Anim. Sci. 35:247.

Loeb, L. 1923. The effect of extirpation of the uterus on the life and function of the corpus luteum in the guinea pig. Proc. Soc. Exp. Biol. med. 20:441.

Louis, T. M., H. D. Hafs, and D. A. Morrow. 1972. Estrus and ovulation after uterine prostaglandin $F_{2\alpha}$ in cows. J. Anim. Sci. 35:247.

Louis, T. M., H. D. Hafs, and B. E. Seguin. 1973. Progesterone, LH, estrus and ovulation after prostaglandin $F_{2\alpha}$ in heifers. Proc. Soc. Exp. Biol. Med. 143:152.

Lukaszewaska, J. H. and W. Hansel. 1970. Extraction and partial purification of luteolytic activity from bovine endometiral tissue. Endocrinology 86, 261-270.

Marion, G. B., J. S. Norwood and H. T. Gier. 1968. Uterus of the cow after parturition: Factors affecting regression. Amer. J. Vet. Res. 29:71.

McCracken, J. A., M. E. Glew and R. J. Scaramuzzi. 1970. Corpus luteium regression induced by prostaglandin $F_{2\alpha}$. J. Clin. Endocrinol. Metab. 30:544.

McCracken, J. A., D. T. Baird, J. R. Goding. 1971. Factor's affecting the secretion of steroids from the transplanted ovary in the sheep. Recent Progr. Horm. Res. 27, 537-647.

McCracken, J. A., J. C. Carlson, M. E. Glew, J. R. Goding, D. T. Baird, K. Green and B. Samuelson. 1972. Prostaglandin $F_{2\alpha}$ identified as a luteolytic hormone in sheep. Nature (London) 238, 129-134.

Melampy, R. M. and L. L. Anderson. 1968. Role of the uterus in corpus luteum function. J. Anim. Sci. 27:77 (suppl. 1).

Menge, A. C., S. E. Mares, W. J. Tyler and L. E. Casida. 1962. Variation and association among postpartum reproductive and productive and production characteristics in Holstein-Friesian cattle. J. Dairy Sci. 45:233.

Moor, R. M., L. E. A. Rowson. 1966 a. Local uterine mechanism affecting luteal function in the sheep. J. Reprod. Fert. 11,307.

Moor, R. M., L. E. A. Rowson. 1966 b. Local maintenance of the corpus luteum in sheep with embroy transferred to various isolated portions of the uterus. J. Reprod. Fert. 12, 539.

Moor, R. M., L. E. A. Rowson. 1966 c. The corpus luteum of the sheep: functional relationship between the embryo and corpus luteum. J. Endocr. 34, 233,

Moor, R. M., L. E. A. Rowson. 1966 d. The corpus luteum of the sheep: effect of the removal of embryo on luteal function. J. Endocr. 34, 497.

Moore, J. M. 1974. Costs and returns of the herd bull vs. artifical insemination in the beef herd. Publication 608. Extension Division Virginia Polytechnic Institute and State University Blacksburg, Virginia

Morrow, D. A., S. J. Roberts, K. McEntee and H. G. Grey. 1966. Postpartum ovarian activity and uterine involuation in dairy cattle. J. Am. Vet. Med. Assoc. 149:1596.

Morrow, D. A. 1971. Effects of peripartuient diseases on postpartum reproduction in dairy cattle. J. Anim. Sci. 32:17 (suppl. 1).

Niswender, G. D., T. M. Nett and A. M. Akbar. 1974. The hormones of reproduction. In E. S. E. Hofez (ed) Reproduction in Farm Animals (3rd ed). Lea and Febiger, Philadelphia.

Niswender, G. D., T. J. Reimers, M. A. Diekman and T. M. Nett. 1976. Blood flow: A mediator of ovarian function. Biol. Reprod. 14:64.

O'Grady, J. P., E. I. Kohorn, R. H. Glass, B. V. Caldwell, W. A. Brock and L. Speroff. 1972. Inhibition of progesterone synthesis in vito by prostaglandin $F_{2\alpha}$. J. Reprod. Fert. 30:153.

Oxender, W. D. 1974. Prostaglandin $F_{2\alpha}$ control of ovulation in cows and mares. Proceedings Fifth Technial Conference National Assoc. of Animal Breeders.

Perry, J. S. 1971 Ovarian Cycles of Mammals. Hafner Publishing Company, Inc. New York, N. Y.

Pharriss, B. B. and L. J. Wyngarden. 1969. The effects of $PGF_{2\alpha}$ on the progesterone content of ovaries from pseudopregnant rats. Proc. Soc. Exp. Biol. Med. 130:92.

Pharriss, B. B. 1970. The possible vascular regulation of luteal function. Perspect. Biol. Med. 13:434.

Pharriss, B. B. and K. K. Hunter. 1971. Interrelationships of Prostaglandin $F_{2\alpha}$ and Gonadotropins in the immature female rat. Proc. Soc. Exp. Biol. Med. 136:503.

Pharriss, B. B., S. A. Tillson and R. R. Erickson. 1972. Prostaglandins in luteal function. Recent Progress in Hormone Res. 28:51.

Reid, J. T. 1960. Effect of energy intake upon reproduction in farm animals. J. Dairy Sci. 43:103 (suppl).

Riesen, J. W., S. Saiduddin, W. J. Tyler and L. E. Casida. 1968. Relation of postpartum interval to corpus luteum development, pituitary prolaction activity, and uterine involution in dairy cows. Wis. Agr. Exp. Sta. Bull. 270:27.

Roche, J. R. 1974. Synchronization of oestrus and fertility following artifical insemination in heifers given prostaglandin $F_{2\alpha}$. J. Reprod. Fert. 37:135.

Rodriguez, T. R., M. J. Fields, W. C. Burns, D. E. Franke, J. F. Hentges, W. W. Thatcher and A. C. Warnick. 1974. Breeding at a predetermined time in the bovine following $PGF_{2\alpha}$ and GnRH. J. Anim. Sci. 40:188 (Abstr.).

Rowson, L. E. A., R. Tervit and A. Brand. 1972. The use of prostaglandin for synchronization of oestrus in cattle. J. Reprod. Fert. 29:145 (Abstr.).

Saiduddin, S., J. W. Riesen, W. E. Graves, W. J. Tyler and L. E. Casida. 1967. Effect of suckling on the interval from paturition to first estrus in dairy cows. J. Anim. Sci. 26:950.

Schwartz, N. B. 1974. The role of FSH and LH and of their antibodies on follicle growth and on ovulation. Biol. of Reprod. 10, 236-272.

Short, R. V. 1972. Role of hormones in sex cycles. In C. R. Austin and R. V. Short (ed) Reproduction in Mammals #3 Hormones in Reproduction. Cambridge University Press.

Short, R. E., R. A. Bellows, E. L. Moody and B. E. Howland. 1972. Effects of suckling and mastectomy on bovine postpartum reproduction. J. Anim. Sci. 34:70.

Stellflug, J. N., T. M. Louis, R. C. Gorewit, W. D. Oxender and H. D. Hafs. 1975 a. Luteolysis after $PGF_{2\alpha}$ in hysterectomized cattle. J. Anim. Sci. 41:380 (Abstr.).

Stellflug, J. N., T. M. Louis, H. D. Hafs and B. E. Seguin. 1975 b. Luteolysis, estrus and ovulation and blood prostaglandin $F_{2\alpha}$ after intramuscular administration of 15, 30 or 60 mg prostaglandin $F_{2\alpha}$. Prostaglandins 9:609.

Stevens, D. M. and T. Mohr. 1969. Artifical insemination of range cattle in Wyoming - An Economica Analysis. Experimental Station Bull. 496. University of Wyoming.

Syntex Corporation. 1976. The Cowpedia. Syntex's Practical Guide to Efficient Cow Herd Management. Syntex Agribusiness Inc. Denver, Colorado.

Tennant, B., J. W. Kendrick and R. G. Peddicord. 1967. Uterine involution and ovarian function in the postpartum cow. A retrospective analysis of 2,338 genital organ examinations. Cornell Vet. 57:543.

van Niekerk, C. H., P. C. Belonje, J. C. Morgenthal. 1974. Oestrous Synchronization in cattle using progesteroneand a PGF analogue. Theriogenology 2:73.

Von Euler, U. S. 1934. Zurkenntnis derpharmakologischen Wirkung von nativsekreten und extrakten mannlicher accessorischer geschlechtsdrusen. Arch. Exp. Pathol. Pharmak. 175:78.

Wagner, W. C. and W. Hansel. 1969. Reproductive physiology of the postpartum cow. I. Clinical and Histological findings. J. Reprodu. Fertil. 18:493.

Warnick, A. C. 1955. Factors associated with the inveral from parturition to first estrus in beef cattle. J. Anim. Sci. 14:1003.

Wiltbank, J. N. and L. E. Casida. 1956. Alteration of ovarian activity by hysterectomy. J. Anim. Sci. 15:134.

Wiltbank, J. N. and A. C. Cook. 1958. The comparative reproductive performance of nursed and milked cows. J. Anim. Sci. 17:640.

Wiltbank, J. N., W. W. Rowden, J. E. Ingalls, K. E. Gregory, and R. M. Koch. 1962. J. Anim. Sci. 21:219.

Wiltbank, J. N., W. W. Rowden, J. E. Ingalls and D. R. Zimmerman. 1964. Influence of postpartum energy levels on reproductive performance of Hereford cows restricted to energy intake prior to calving. J. Anim. Sci. 26:1049.

Wishart, D. F. and I. M. Young. 1974. Artifical insemination of progestin (SC21009) - treated cattle at predetermined times. Vet. Rec. 95:503.

Greene, William M
Fertility of beef cattle after PGF_2, controlled estrus in two breeding management systems

DATE	ISSUED TO
NOV 10 1978	Riki Scott 7-4553
	Riki Scott 7-455
APR 17	[illegible]
MAY	[illegible]
	ARROYAVE, G. 811 S WILSON 581
	[illegible]