Evaluation of estrous synchronization management systems using prostaglandin F2a
by Vickie Lee Adkins

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

Abstract:
A simulation model was developed to evaluate various estrous synchronization systems which considered whether or not to palpate; whether to use one injection, five-day prebreeding or two injection system; and whether to breed by detection, 80 hour appointment or a combination of the two. Total cost (palpation, prostaglandin, semen and breeding supplies), total pregnancy rate and cost per pregnancy were calculated for each of seven systems for 11 different cycling rates (0 to 100 percent) and eight different conception rates (10 to 80 percent). For most cycling rates, five-day prebreeding systems resulted in one of the highest pregnancy rates and the lowest cost per pregnant cow. Single injection systems were usually favored over double injection systems in terms of lower total cost and lower cost per pregnancy. Palpation was desirable in the majority of systems except when 90 percent or more of the herd was cycling. Breeding by detection resulted in a lower cost per pregnancy than other breeding methods except when cows were palpated prior to injection and breeding.

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Date December 4 1980

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by

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A thesis submitted in partial fulfillment
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ABSTRACT

A simulation model was developed to evaluate various estrous synchronization systems which considered whether or not to palpate; whether to use one injection, five-day prebreeding or two injection system; and whether to breed by detection, 80 hour appointment or a combination of the two. Total cost (palpation, prostaglandin, semen and breeding supplies), total pregnancy rate and cost per pregnancy were calculated for each of seven systems for 11 different cycling rates (0 to 100 percent) and eight different conception rates (10 to 80 percent). For most cycling rates, five-day prebreeding systems resulted in one of the highest pregnancy rates and the lowest cost per pregnant cow. Single injection systems were usually favored over double injection systems in terms of lower total cost and lower cost per pregnancy. Palpation was desirable in the majority of systems except when 90 percent or more of the herd was cycling. Breeding by detection resulted in a lower cost per pregnancy than other breeding methods except when cows were palpated prior to injection and breeding.

Chapter 1

INTRODUCTION

Cow-calf producers often look to artificial insemination (AI) as one means of increasing pounds of calf weaned per cow bred. AI provides access to superior sires, facilitates crossbreeding programs and helps protect against venereal disease. Despite these advantages, many producers are reluctant to use AI because of the difficulty in detecting estrus under range conditions and the lack of adequate feed and facilities for confining cows during the normal breeding season.

Estrous synchronization would facilitate the use of AI for many producers by minimizing the need for heat detection and allowing cows to be bred during a shorter breeding period. A shorter breeding period reduces the length of the calving season and results in more uniformity in age and size of calves at weaning. More calves are born in the early part of the calving season and are older and heavier at weaning. Cows that calve early also tend to remain early calvers and produce more pounds of calf in their lifetime.

Although many estrous synchronizing agents are currently under study, only Prostaglandin F2α ($PGF_{2\alpha}$) has been cleared by the Food and Drug Administration for use in the United States. In developing a herd estrous synchronization program with $PGF_{2\alpha}$, a producer is faced with several decisions. The first decision is whether or not to palpate in order to determine the proportion of cows cycling. Once

the decision is made to synchronize, a producer must then decide whether to use a one or two injection system. Finally, a producer must choose whether to breed by detection, appointment, or a combination of both. When all possible options are considered, several synchronization systems are feasible. In order to choose the most suitable system, a producer must be able to predict the effect of each breeding alternative on the overall pregnancy rate and total breeding cost. The best alternative for a particular producer will depend on the AI pregnancy rate desired, length of the breeding period, availability of labor and facilities, and the cost of prostaglandin and semen.

The purpose of this study was to evaluate various estrous synchronization systems in terms of expected breeding performance and related costs.

Chapter 2

LITERATURE REVIEW

Response to $PGF_{2\alpha}$

Prostaglandins were discovered in the 1930's by Goldblatt (1933) and Von Euler (1934) and have been been identified as playing an integral role in the reproductive process of the beef female (Rowson et al., 1972). Prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$), which is formed by the endometrium and secreted by the uterus (Wilson et al., 1972; Hansel et al., 1975), has been shown to cause regression of the corpus luteum (CL) and to consequently control the onset of estrus and ovulation (Lauderdale, 1972; Stellflug et al., 1973; La Voie et al., 1975). The specific method of action of $PGF_{2\alpha}$ on the estrous cycle is complex and has been the subject of several review papers (Inskeep, 1973; Henricks et al., 1974; Louis et al., 1974; Thatcher et al., 1976).

One of the first attempts to use $PGF_{2\alpha}$ to control estrus in cattle indicated $PGF_{2\alpha}$ would shorten the lifespan of the corpus luteum by causing it to regress when administered to cows five or more days after estrus (Louis et al., 1973). Regression of the corpus luteum caused return to estrus and ovulation, usually within two to four days after $PGF_{2\alpha}$ was administered (Rowson, et al, 1972). Therefore Lauderdale (1972) concluded that a cow must have a functional corpus luteum between days five and 16 of the estrous cycle in order for

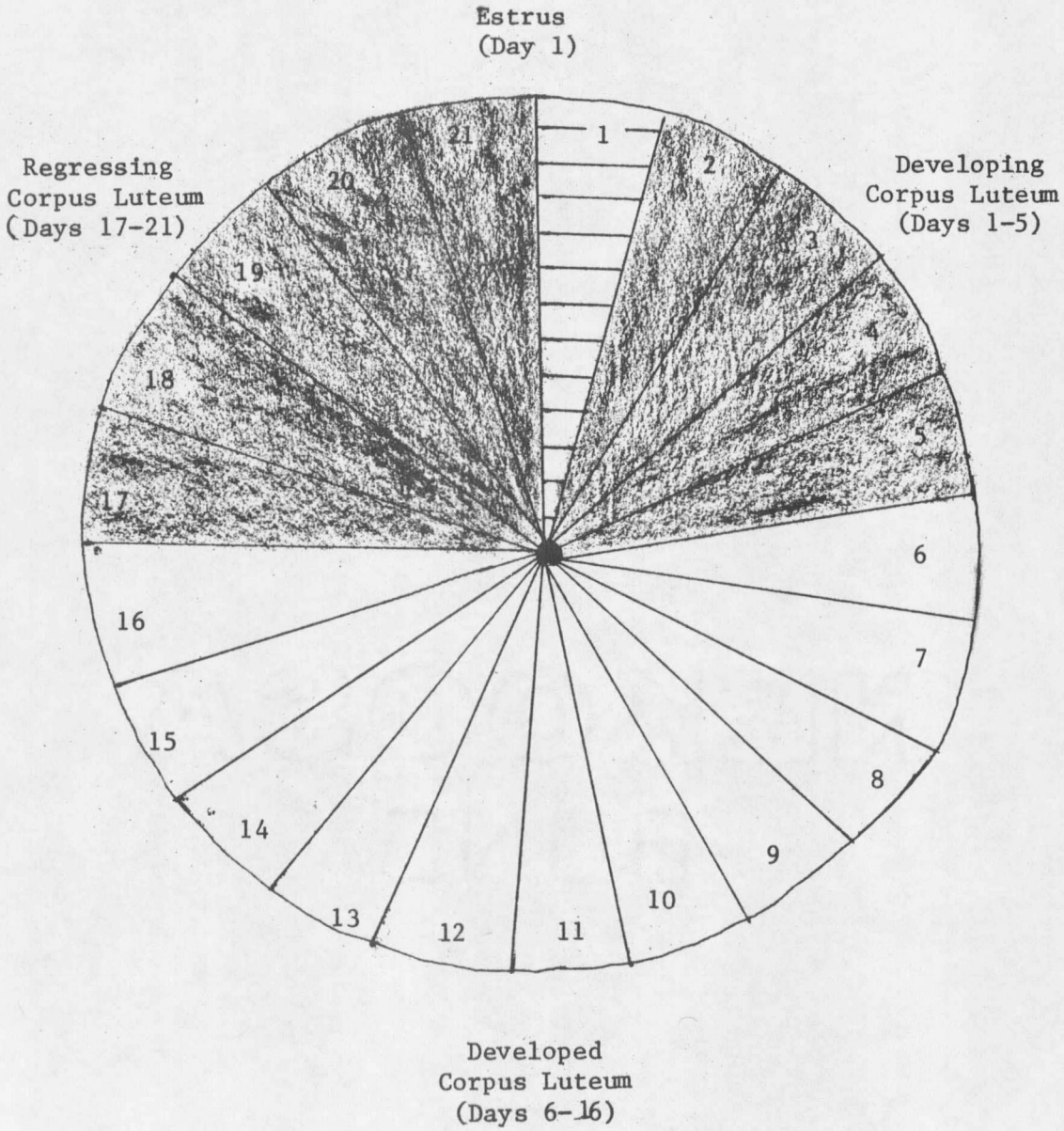
prostaglandins to regress the CL and allow the cow to advance to a new estrus.

Fertility of the synchronized estrus has been comparable to control cows when bred in a similar fashion. Rodriguez et al. (1974) used 188 heifers and 25 cycling cows between day seven and 21 of their estrous cycles to compare control and treated groups bred by detection. Treated animals were injected intramuscularly with 30 mg $PGF_{2\alpha}$ and both groups were inseminated at detected estrus. Pregnancy rates of 38 and 32 percent for control and treated groups were not different ($P > .05$). Lauderdale et al. (1974) also compared control and treated cycling cows bred by detection. Treated cows were given a 30 mg injection. Pregnancy rates of 53.3 and 52.2 percent for the control and treated cows were not significantly different. Moody et al. (1978) performed a similar experiment to compare fertility of control and treated groups bred for 30 days by detection of estrus. Treated cows received a single 25 mg injection. Pregnancy rates at the end of the 30 day breeding season were 72 and 61 percent for treated and control groups, respectively.

Estrous Synchronizing Systems

The objective of synchronization is to manipulate the cow's reproductive cycle so that all cycling cows in a herd show estrus during a short period of time (Figure 1). Prostaglandins are only

Figure 1: Estrous Cycle Of The Cow



effective on cows with functional corpra lutea (day six to 16 of the estrous cycle). Cows between day 17 and 21 of the cycle do not respond to prostaglandin because the corpus luteum is regressing. However, cows in this stage of the cycle exhibit estrus within the next one to five days due to normal CL regression (Louis et al., 1973) and are consequently fairly well synchronized with the cattle responding to $PGF_{2\alpha}$ (Rowson et al., 1972). Cows between day one and five of the cycle do not respond to $PGF_{2\alpha}$ because the corpus luteum is immature (Rowson et al, 1972). Since these cows do not show estrus until 15 to 20 days later, most synchronization systems are designed to manipulate cattle in day one to five of the cycle in order to include them in the synchronized breeding.

Single Injection System

One of the simplest synchronization systems involves a single injection of $PGF_{2\alpha}$. This system requires cattle to be handled only twice (injection and breeding) and results in a short AI season. However, only 75 percent of the cycling cows are synchronized with a single injection: those cows between days six and 16 of their estrous cycle and those cows between days 17 and 21 of their cycle. Approximately 25 percent of the herd, those cows from day zero to five in their estrous cycle, will not respond to the prostaglandin injection.

Several studies have indicated the single injection system is an effective method of synchronizing estrus in beef cows (Lauderdale, 1973; Hafs et al., 1974; Turman et al., 1975). Roche (1974) compared pregnancy rates of control and treated heifers between day five and 20 of their estrous cycle when all heifers were bred at detected estrus. Treated heifers were injected with 30 mg of $PGF_{2\alpha}$. The 75 percent pregnancy rate at the synchronized heat in heifers treated with $PGF_{2\alpha}$ did not differ significantly from the 73 percent pregnancy rate obtained in the untreated control heifers.

La Voie and Self (1979) also compared pregnancy rates of treated and untreated cows when bred by detection. Control cows were bred 12 hours after the detection of estrus while treated cows were given a 25 mg $PGF_{2\alpha}$ injection and bred them in a like manner. First service pregnancy rates and total pregnancy rates were 38 and 60; 23 and 59 percent for control and treated groups of young cows. First service pregnancy rates and total pregnancy rates for control and treated groups of old cows were 51 and 53; 60 and 65 percent and were not significantly different. Daily et al. (1979) performed a similar experiment with 483 dairy heifers to compare pregnancy rates of control and treated groups bred by detection of estrus. Treated heifers received a 25 mg injection of $PGF_{2\alpha}$. Total pregnancy rates for the control (47.5) and treated heifers (52) were not significantly different.

Lauderdale et al. (1974) compared pregnancy rates of control animals to those of treated cattle bred by detection or appointment. Control cows were observed for estrus and inseminated accordingly. Treated cattle were given a 30 mg injection of $PGF_{2\alpha}$ and either inseminated at detected estrus for seven days after $PGF_{2\alpha}$ or inseminated at 70 and 92 hours after $PGF_{2\alpha}$ treatment without regard to estrus. Percent cows pregnant at 35 to 60 days after AI was 53.3, 52.2 and 55.8 respectively for control cows, treated cows bred by detection of estrus and treated cows bred by appointment. There was no significant difference in fertility among control and treated animals bred by detection or appointment.

These studies indicate that a single injection of $PGF_{2\alpha}$ is an effective method of synchronizing estrus in beef cows and that $PGF_{2\alpha}$ does not effect the pregnancy rate at breeding when compared to a conventional system.

Five-day Prebreeding

Another method to manipulate cows in days one to five of their estrous cycle is to inseminate those cows detected in estrus for five days and then give a single injection of $PGF_{2\alpha}$ to all cattle not previously inseminated. The remaining unbred cattle must be inseminated according to detection of estrus for four additional days or bred by appointment. Breeding those cows in heat for five days

before injection eliminates those animals that would not have responded to the $PGF_{2\alpha}$ treatment so that on the fifth day all cycling cows should respond. In addition, it provides an opportunity to determine what percent of the herd is cycling and to evaluate the feasibility of synchronization. Although cattle are handled three times in this system, fewer cows have to be injected and all cycling cows are included in the system.

Doornbos and Anderson (1979) compared this system of five-day prebreeding to a conventional AI system using lactating Hereford cows. Treated cows were inseminated to observed estrus until the fifth day of the breeding season at which time all cattle not previously inseminated were injected with 33.5 mg of $PGF_{2\alpha}$. Control and treated cattle were bred 12 hours after detected estrus. First service pregnancy rates and total pregnancy rates after 45 days were 76 and 90; 75 and 100 percent for the control and treated groups. Results show no difference in first service pregnancy rates, but that total pregnancy rate of the treated cows was higher than for the untreated control cows.

Lambert et al. (1975) used $PGF_{2\alpha}$ to compare a conventional AI system to treated cows bred by a combination of detection and appointment. Cattle assigned to the conventional system were inseminated at observed estrus. Animals in the $PGF_{2\alpha}$ system were inseminated for five days prior to the breeding season. On the fifth day, cows which

hadn't been previously inseminated were injected with 33.5 mg $PGF_{2\alpha}$. Cattle were bred at detected estrus until 75 hours post-injection at which time all remaining cattle were inseminated. AI first service pregnancy rates were not significantly different between the control (45) and $PGF_{2\alpha}$ (43) systems. However, the total AI pregnancy for the $PGF_{2\alpha}$ system (54 percent) was higher ($P < .05$) than for the conventional system (42 percent).

Lambert et al. (1976) did a similar experiment with 240 virgin heifers and 669 postpartum cows. Total pregnancy rates (83 and 77 percent; $P < .018$), total AI pregnancy rates (52 and 41 percent; $P < .01$), and AI first service pregnancy rates (47 and 38 percent; $P < .009$) were higher for the $PGF_{2\alpha}$ system than the conventional system.

Results of these experiments demonstrate that this single injection $PGF_{2\alpha}$ system does not decrease pregnancy rates of cattle when compared to a conventional system under range beef cattle management conditions.

Double Injection--Single Insemination

The only system of estrus synchronization approved by the Food and Drug Administration for use in the United States is a two injection system which involves injecting all animals with $PGF_{2\alpha}$ regardless of the stage of their cycle and then reinjecting eleven days later. Cows in days zero to five of their estrous cycle will not return to estrus

in response to the first injection but should be at about day 11 to 16 at the time of the second injection. The first injection will regress the CL of cows in days six to 16 of their cycle causing them to return to estrus two to five days later and they should be at approximately day seven of their next cycle at the time of the second injection. Cows in days 17 to 21 of the cycle will come into heat at about the same time as the cows responding to the first injection and should be at about day seven to ten of their next cycle at the time of the second injection.

This double injection system is a means to maximize the percentage of a herd responding to treatment and it facilitates breeding by appointment since all cycling cows are synchronized at the time of the second injection. However, cows require two injections with Prostaglandin $F_{2\alpha}$ and must be handled three times.

This system of two injections of $PGF_{2\alpha}$ 10 to 12 days apart has been shown to synchronize estrus in randomly cycling cows and heifers (Cooper, 1974; Roche, 1974; Hafs et al., 1975). A two injection system was first tried by King and Robertson (1974). Thirty randomly cycling Holstein heifers were injected twice with 30 mg $PGF_{2\alpha}$ ten days apart. Fifty-four percent of the 15 control heifers were pregnant at 60 days post insemination compared to 40 percent pregnant for the treated group. Pregnancy rates in the treated and control groups were not significantly different. Ellicott et al., (1975) used a similar

experimental design with a two injection management scheme and also found that the pregnancy rates of the $PGF_{2\alpha}$ system were comparable to that of a conventional system.

In 1976, Manns, Wenkoff and Adams assigned Hereford heifers to either a control group which was bred at estrus in a 30 day AI program or a treated group which received two 25 mg injection of $PGF_{2\alpha}$ 12 days apart. Treated heifers were then bred at 80 hours after the second injection. The pregnancy rate of the treated cows were comparable to those in the control group with 46.8 and 46.2 percent respectively.

Manns et al. (1977) assigned two year old heifers to either a control group (n = 33) or a treated group (n = 33) which received two 25 mg injections of $PGF_{2\alpha}$ 11 days apart and were bred at 80 hours after estrus. Pregnancy rates for the control and Prostaglandin $F_{2\alpha}$ groups were 48 and 53 percent respectively. First service conception rates were 42 and 52 percent for control and $PGF_{2\alpha}$ heifers.

On the basis of these experiments, it was concluded that the two injection system may have practical application for synchronization of estrus in the bovine, particularly under range conditions.

Double Injection--Split Insemination

A variation of the two injection method is to breed cows two times, following the first and second injection. In this system all animals are injected with $PGF_{2\alpha}$ and then inseminated for four days

according to detection of estrus. Eleven days after the first injection, those animals which were not inseminated are reinjected with $PGF_{2\alpha}$ and then bred when estrus is detected or at a predetermined time. Although this system requires that some animals be handled three times (twice for injection and once for breeding), fewer cows have to be injected a second time and the system facilitates timed insemination following the second injection, thereby allowing the producer to omit detection of estrus after the second injection.

Burfening et al. (1976) performed an experiment with 143 lactating Hereford cows in which he only reinjected those animals not bred after the first injection. Forty-six cows served as a control group and 97 cows were treated with 33.5 mg $PGF_{2\alpha}$ and bred at estrus (T1). Treated cows not exhibiting estrus (n = 49) were reinjected with $PGF_{2\alpha}$ on day 11 and bred at 84 hours post $PGF_{2\alpha}$ (T2). There was no significant difference in first service conception rates for controls (72 percent), T1 (67 percent) and T2 (67 percent). Total pregnancy rates were 87, 90 and 85 percent.

Burfening et al., (1978) did a similar experiment with 193 lactating Hereford cows and 59 Hereford heifers which were managed in the same manner as before. First service conception rates and conception rates at the end of the AI season were 61 and 88; 53 and 86; and 28 and 69 percent for the control, T1 and T2 groups. Burfening concluded that $PGF_{2\alpha}$ applied to cycling cattle will synchronize estrus

with pregnancy rates at the synchronized estrus being comparable to non-synchronized controls.

Doornbos and Anderson (1979) conducted a trial using 76 yearling heifers to evaluate differences in pregnancy rates between an untreated control group (n = 37) and a treated group (n = 39). Treated heifers were injected intramuscularly with $PGF_{2\alpha}$ on the first day of the AI season (A) and were bred 12 hours after estrus. All heifers not yet bred on day eight were treated again with $PGF_{2\alpha}$ (B) and again bred at detected estrus. Percent pregnant to first service and after 45 days AI for control, A and B heifers were 73 and 92; 78 and 93; and 75 and 83, respectively. Both treatments resulted in pregnancy rates comparable to contemporaries in control groups.

Studies using the split insemination system indicate that it is an effective method of synchronizing estrus in beef cows and results in pregnancy rates that are comparable to cows bred in the conventional AI manner.

Pregnancy Rates for Breeding Systems

Three methods of breeding synchronized cows are commonly used. Cows may be bred by detection of estrus; by appointment at a specific interval after $PGF_{2\alpha}$; or by detection of estrus until a predetermined time and then bred by appointment.

Pregnancy rates of cattle inseminated at estrus following $PGF_{2\alpha}$

and of cattle inseminated at timed intervals after $PGF_{2\alpha}$ has been shown to be similar (Han et al., 1977; Burfening et al., 1976). Many experiments have been done varying appointment breeding intervals from as low as 60 or 63 hours (Ellicott et al., 1975; Rodriguez et al., 1974) to 75 or 80 (Manns et al., 1976; Manns et al., 1977) and as high as 90 to 96 hours (Lauderdale et al., 1974; Burfening et al., 1978).

One of the early studies using $PGF_{2\alpha}$ for estrus synchronization was done by Lauderdale et al. (1973). Non-treated controls were inseminated 12 hours after the onset of estrus. Treated cattle were injected intramuscularly with 30 mg $PGF_{2\alpha}$ and either inseminated at estrus detected during the seven days after $PGF_{2\alpha}$ or inseminated at 72 and 90 hours after $PGF_{2\alpha}$. Percent cows pregnant was 58, 57 and 58 respectively for controls, treated cows bred by detection and treated cows bred by appointment at 72 and 90 hours. Hafs et al. (1974) did a similar study using the same treatment groups. Percent pregnant cows was 58, 57 and 58 respectively for controls, treated cows bred by detection and treated cows bred by appointment at 72 and 90 hours. These two studies demonstrate that the pregnancy rates of cattle inseminated during the estrus after treatment with $PGF_{2\alpha}$ and those of cattle inseminated by appointment at 72 and 90 hours after injection was equivalent to that of the controls.

Turman et al. (1975) tested different appointment breeding intervals, 64 and 88 hours after estrus using 39 mature, cycling, non-lactating Hereford cows. Treated cows were injected with 30 mg $PGF_{2\alpha}$ and either inseminated 12 hours after estrus was detected or bred at 64 and 88 hours following estrus. Conception rates for control, treated cows bred by detection and treated cows bred by appointment at 64 and 88 hours were 84.6, 76.9 and 92.3 percent, respectively. Differences between cows bred by detection and cows bred by appointment were not significant.

In recent years, breeding by appointment 80 hours after injection has become the most popular method (Green et al., 1977; Manns et al., 1977; Burfening et al., 1978). Moody and Lauderdale (1977) used 1442 lactating cows, 270 non-lactating cows and 935 beef heifers to compare breeding by detection to breeding at 80 hours after $PGF_{2\alpha}$ treatment. All animals were given two injections of $PGF_{2\alpha}$ eleven days apart. Pregnancy rates were 53, 49 and 53 percent for control, cows bred by appointment and cows bred by detection. Pregnancy rates were similar following AI at either 80 hours or at estrus on days two through five after the second injection when compared to AI in non-treated cattle.

Han and Moody (1979), also demonstrated that breeding by appointment at 80 hours was not significantly different than breeding by detection of estrus when using mature, lactating beef cows. Group 1

served as a control group. Group 2 was given a 25 mg $PGF_{2\alpha}$ injection on day zero of the breeding season and bred at observed estrus. Group 3 was bred at observed estrus until day five when they were injected with 25 mg $PGF_{2\alpha}$. Treated cows were then detected for estrus until 80 hours at which time all remaining unbred cows were inseminated. First service pregnancy rates, AI pregnancy rates and total pregnancy rates were 58.8, 22.3 and 88.3; 69.1, 42.1 and 90.5; and 51.1, 53.4 and 94.3 percent for groups 1, 2 and 3, respectively.

Results of these experiments indicate that similar pregnancy rates are achieved regardless of the breeding system used.

Chapter 3

MATERIALS AND METHODS

Identifying Systems

In identifying herd estrous synchronization systems, a number of options were considered. The first option was whether or not to palpate ovaries to estimate the number of cycling cows and identify those cows with a corpus luteum that would respond to $PGF_{2\alpha}$. The second option was to use either one or two injections of $PGF_{2\alpha}$. The third option was to select a breeding method: breeding by detection of estrus, breeding by appointment or breeding by a combination of detection and appointment. After considering all possible combinations of palpation options, injection schemes and breeding methods, seven systems were selected for evaluation in the simulation model (Table 1).

System 1a was a single injection system. Under this system all cows were injected and then bred by detection or by a combination of detection and appointment.

System 1b was similar to system 1a except for the addition of ovary palpation. Cows were palpated on the day of injection and only those cows identified as having a CL were injected and bred by detection or a combination of detection and appointment.

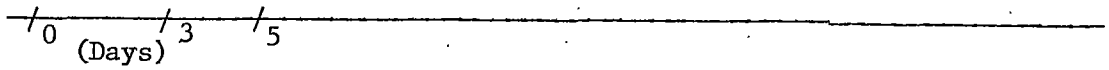
In system 1c, cows were bred by detection for five days prior to injection. On the fifth day all cows not previously bred were

Table 1

Synchronization Systems

1a Single Injection

Inject all cows	Breed by detection until day 5	
	or	
	Breed by detection and appointment at 80 hrs	

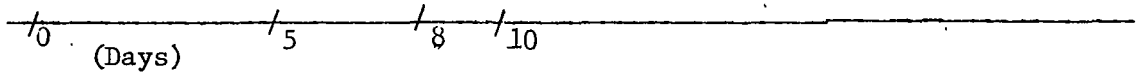


1b Palpate; Single Injection

Palpate and inject	Breed by detection until day 5	
	or	
	Breed by detection and appointment at 80 hrs	

1c Five-day Prebreeding

Detect heat and AI	Inject remaining cows	Breed by detection until day 10	
		or	
		Breed by detection and appointment at 80 hrs	



1d Five-day Prebreeding; Palpate

Detect heat and AI	Palpate and inject remaining cows	Breed by detection until day 10	
		or	
		Breed by detection and appointment at 80 hrs