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RESEARCH ARTICLE

Control and Management-tools of Reproductive Physiology in Dairy Cattle: Current Knowledge and the Future Strategies in Africa

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ABSTRACT

This study reviewed that several research discoveries have indicated for *ESP* to be a routine reproductive physiology control and management-tool for cattle producers is enable to: Shorten the breeding-and-calving-season, to create calf-crop uniformity, to enhance the efficiency of resources utilizations-possibilities, to eliminates the need to detect-estrus and allows herd-manager to schedule-breeding or artificial insemination (AI) activities in a predetermined period lasting from 1 to 12 days. AI permits to infuse superior-genetics into cattle-operations at costs far below that of purchasing a herd-sire of similar standards. These tools remain the most important reproductive biotechnologies available for cattle operations. The ESPs in cattle, especially the recent protocols involving the use of GnRH, from a series of studies using the Ovsynch protocol, averaged the conception and pregnancy-rates 34.9 and 37.9%, respectively. In general, it is concluded that a well-planned *ESPs* (are expected to have about 50–60% of cycling-cows pregnant at first service/breeding after synchronization, and 80–90% pregnant within a 30-day breeding-season) involves the application of hormones *GnRH, FSH, LH, PGF2α,* estradiols, progesterones, and prolactin as major-tools. Finally, for all *ESPs* to be effective and efficient, it is strongly-recommended that better-feeding and-management of healthy dairy-cows “having regular estrous cycle, and > body condition scores =4” is much more necessary.

Key words: Dairy-cattle, ethiopia, food-security, hormonal-tools, milk-production, reproductive-manipulation

INTRODUCTION

The projected growth in income, human population, and of the urbanization in developing countries suggests that the future milk and meat demand in these countries will increase substantially. By 2050, the global dairy and meat demand are projected to increase by 74% and 58%, respectively, a large part of this will originate from the developing countries.[1] The global cattle population in 2000 was 1.5 billion, which will be 2.9 billion by 2050.[2,3] However, cattle reproduction-efficiency (main limiting factor in cattle production-efficiency) is still traditional mainly due to: Animal reproduction control and feeds scarcity.[3-5] Accordingly, reproductive failure is a major source of economic loss in cattle industry that occurs due to cows do not become pregnant during a defined breeding season.[6,7] Likewise, huge loss of the potential calf-crop curses cows fail to become pregnant due to anoestrus and postpartum infertility.[8] This is to end; various reproductive – technologies could be applied.

Reproduction is one of most important considerations determining the profitability of cattle production, whether one is talking about dairy or beef animals.[9] If a breeding cow does not show regular cyclic breeding activity, become pregnant at the appropriate time and deliver a live, healthy calf

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each year, then her other excellent qualities may be to little avail. Although ample scope remains to increase reproductive efficiency by adjustments in the traditional methods of breeding, feeding, and management, there remains the possibility that valuable improvements in the biological and economic efficiency of dairy cattle can come from the appropriate application of controlled reproduction techniques.[10-13] The challenge of the years ahead in livestock agriculture will be to implement the more widely existing technologies, including controlled reproductive technology, while taking increasing account of the environmental and welfare aspects of cattle production systems.[2,6] For instance, *ESP* is the most useful and venerable techniques.

Estrous synchronization (*ES*) is a method that has been studied for 40 years to control cattle's reproductive efficiency.[14,15] Its purpose is to manipulate the estrous cycle (EC) of a herd to allow for increased production efficiency of a herd by achieving shorter breeding and calving seasons, which permits for the lower labor requirements throughout a year[16] and increased percentage of herd calves early in the season, along with possible control of anestrous cows.[17] *ES* also allows for disease control among herds and genetic improvements through the use of artificial insemination (AI)/ET. However, cattle producers are unaccustomed to apply such current and applicable products and protocols probably due to scarcity of reliable scientific-knowledge, particularly in countries like Ethiopia.[2,18] This review, therefore, is studied with the central-aim to:

- Transfer the scientific-knowledge and modern-technologies crucial to manage-reproduction in dairy cattle and boost their productivity
- Put-words in management-directions of dairy cow reproduction successfully
- Breeding higher-percentage of heifers/cows in short period of time, using either AI/natural-service
- Mach period of surplus feed-resources with prevailing markets accessibility
- Make embryo-transfer simple, manageable and increase dairy-cattle's productivity by applying reproductive technologies
- Promote the profitability of dairy cattle farmers and/or milk-producers
- Hamper malnutrition problem in human-being caused as a result of protein-intake.

THE COW REPRODUCTIVE-ANATOMY AND PHYSIOLOGY

Reproduction is the process of the replica or perpetuation of the cow's life and thus, it is the main limiting factor in production efficiency of cattle. It is very necessary to analyze reproductive anatomy and physiology of the cow for artificial insemination to practice properly, and for *ES* to be successful. Similarly, reproduction is a process for producing an offspring that comprises anatomy of reproductive tracts such as the vulva, vagina, uterus (cervix, uterine-body, and uterine-horn), oviducts and ovaries [Figure 1], and the cow's normal physiology [Figure 2][19] as descry-bed briefly hereunder.

Figure 1: Schematic diagram of the cow's reproductive life

Reproductive anatomy

The female reproductive system is made up of several organs [Figure 3] with specific functions; each will be discussed from the parts of most outside to inside.

Although this illustration was a simplified one, before someone starts to inseminate, to make rectal examination, or to treat the reproductive disorders, the anatomy of reproductive tract should be well understood.[20,21]

For example, when you pass some instrument through the vagina, you should direct the device upper-ward. If not, downwardly directed device could be inserted into the bladder or the blind pouch. The important-structures in the ovary are follicles and corpus luteum (CL). Both will change their conditions according to the EC. Especially there are many and variable developmental stages of the follicles coexist described more in the next section. The important thing to keep in mind is the ovary's features change due to the estrus cycle. The details will be discussed in the section "Reproductive-Physiology."[14]

However, the condition/size of these organs will dramatically change depending on the EC, gestation, parturition, nutrition, etc. Therefore, it is important not only to know the anatomy but also to know each cow's condition as well.

*Follicle-development: Primordial-follicle→Primary-follicle→Secondary-follicle→Tertiary-follicle→Graafian-follicle.

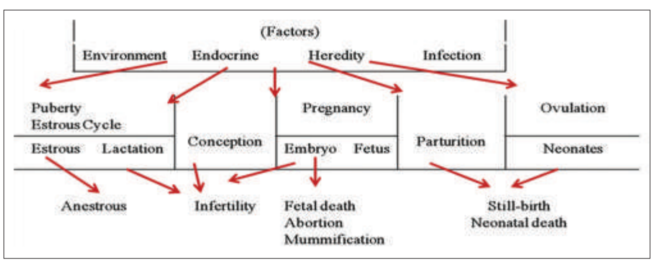


Figure 2: Reproductive process and factors having effect on the reproduction

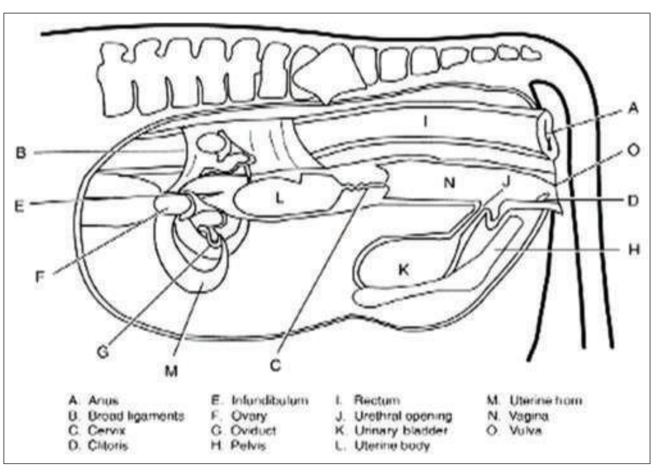


Figure 3: The cow's reproductive tracts or structure

Macro-reproductive structures in cow

Vulva

The external portion of the female reproductive tract serves to protect the internal system from infection [Figures 4 and 5], to initially receive the penis at copulation, and to act as a passageway for urine.

Clitoris

A sensory erectile organ the female reproductive system located just inside the vulva.

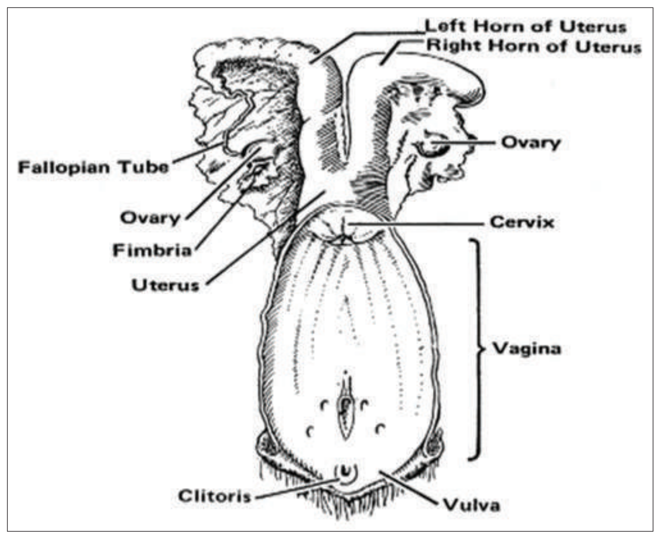


Figure 4: Cross-sectional view of cow's reproductive-tract

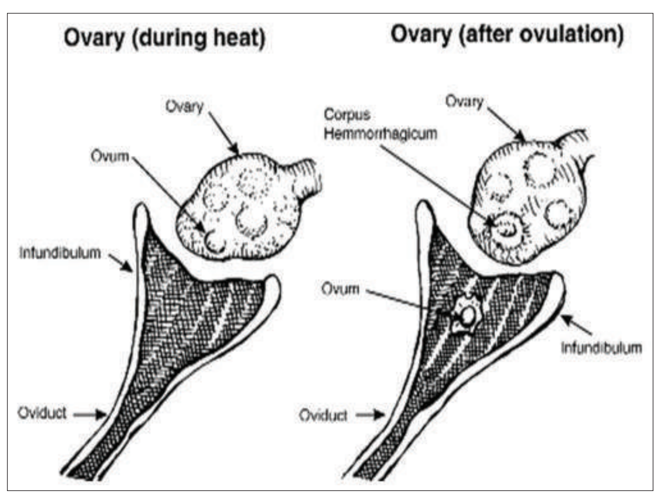


Figure 5: Structures of an ovary during EC

Vagina

This is referred to as a reproductive structure that serves as the receptacle for the penis during copulation and the birth canal at parturition; it also serves as a passageway for expelling liquid wastes, as the urethra joins the bladder to the vagina before the opening at the vulva.

Cervix

It is a thick-walled mass of connective tissue with a small tube-like opening that joins the uterus to the vagina; it serves as a passageway for semen during copulation. It also contains glands that secrete waxy-like substance that seals off the uterus during pregnancy and between heat periods to protect against infection, disease, or foreign matter.

Uterus

This is a major reproductive organ consists of the uterine body and two uterine horns. The embryo attaches to uterine body or uterine horn, depending on the species. Functions of the uterus include: Passageway for sperm during copulation and/or semen insemination, implantation and nourishment of the embryo during pregnancy and expulsion of fetus during parturition by contractions.[22-25]

Oviduct

It is also called fallopian-tubes – paired tubes that transport the eggs from the ovaries to the uterus and serve as the site where sperm and ova meet and fertilization occurs. Infundibulums – It is a pair of the funnel-like openings of the oviducts that pick up the eggs during the time of ovulation and direct them to the body of the oviducts.[15]

The ovaries

Paired structures produce eggs (ova) and the female reproductive hormones, estrogen, and progesterone.

Broad-ligaments

Ligaments support the female reproductive tract and arteries, veins, and nerves of the ovaries in the abdominal cavity.[26-30]

Microstructure and function

Oogenesis is the process of producing ova (eggs) in the ovarian follicles. Oogonia cells develop in the ovaries of the fetus and mature into oocytes by birth. Only a small proportion of oocytes develop into ova or reach ovulation.

Follicle – a blister-like mass on the surface of the ovary that contains a developing ovum and produces and stores estrogen.

The follicle secretes estrogen as a signal to the rest of the reproductive tract to prepare for ovulation (release of the ovum from a mature follicle).

Corpus hemorrhagicum – a small hemorrhage or blood-clotted area that develops at the site of a ruptured follicle and lasts 2–3 days.

CL – a yellow body of cells that develops in place of the corpus hemorrhagicum and produces progesterone.[31-35]

Progesterone – the female sex hormone that functions to prepare the female reproductive system for pregnancy; it is produced by the CL and lasts about 12 days, unless the ovum is fertilized.

Corpus-albicans – a white body of connective tissue that is the result of the degeneration and re-absorption of luteal-tissue. Before understanding the reproductive physiology, it is important to know that there are many steps and many affecting factors in the reproduction of course, the final objective of the reproduction is "to obtain a healthy calf."

Basic reproductive physiology

However, a series of studies indicated that the reproductive processes consist of many factors [Figure 6] such as environment, endocrine, heredity, and infection can affect the whole processes of reproduction.[27,33] Basic reproductive physiology comprises:

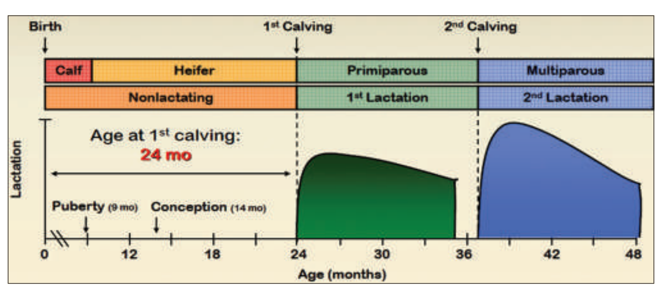


Figure 6: Stages of heifer development and age at 1st Calving=24 months[2]

Table 1: Summary of the four stages of EC in cow

Stage	Cycle day	Duration	Event
Estrous	0	10–12 h	Mature-follicle, high level estrogen *LH* surge
Metestrous	1–3	5–7 days	Ovulation (Within 12–18 h) Formation of CL no response to *PGF2α*
Diestrous	5–18	10–15 day	Mature CL high level progesterone
Proestrous	19–21	3-days	CL regressing Maturing follicle rising estrogen

Puberty

Puberty is defined as the process/time in which the young animals become sexually maturated and capable of reproduction. In case of cattle, the onset of the first ovulation is considered as the time of puberty. Well-grown Holstein heifer will show puberty at 10–12 months of age.

Calving heifers at 23–24 months of age are optimal for first lactation milk yields. Although heifers can calve at 19–21 months of age, they may experience dystocia and metabolic disorders.[16] However, the time for first insemination should be decided according to their body growth.

Too early pregnancy will cause distocia at the time of delivery, because of the narrowness of the birth canal.[19] Similarly, it have been indicated that reducing age at first calving reduces the non-lactating period but results in impaired mammary development and reduction in subsequent milk production.[17,19]

In Japan, the recommended standards for the first insemination are body weight 350kg in pure Holstein. If the heifer reached this body weight at 15-month age and was pregnant [Figure 1], we can respect the first delivery at 2-years (24 months) of age.[33,34]

EC and associated events in cow

Estrus, refers to a cow/heifer in standing heat or standing to be mounted, is the 21 day cycle from one estrus (heat) to the next. The average EC, from one standing heat to the next, is days 21 in the cow and 20 in heifers [Figure 1], with a normal range of 18–24 days.[6,8] The cycle begins on day 1 when the egg is ovulated from a follicle on the ovary. The egg moves into oviduct where, if viable sperm from the bull are present, it is fertilized and moves into the uterus. Regardless of whether an egg is fertilized by, approximately day 5 (Table 1), the site of ovulation on surface of ovary develops into CL (Corposlutium), which secretes the progesterone “hormone of pregnancy” into the cow’s blood during which, the cow does not come into estrus.[34]

Stages of EC

EC involves four stages: (i) Estrous – period when female is receptive to the male and will stand for mating; (ii) metestrous – follows estrus; when the CL (gland secreting hormone) forms where the egg was released from the ovary. Ovulation usually occurs now; (iii) diestrous – follows metestrous; period when the CL is functional.[27] Hormones released stimulate preparation of uterus for pregnancy; and (iv) *proestrus* – follows diestrous; rapid follicle growth to prepare for next ovulation.[21,25]

Estrous and detection techniques

It is probably true to say that the single most important problem faced the cattle AI industry since its inception is estrous detection; which is essential if there is to be successful application of AI in dairy and beef herds, but the methods commonly used in detection have remained largely unchanged throughout the 80 or more years that the breeding technique has been employed.[6]

Similarly, it is still possible to maintain good reproductive performance in cattle without *ES*, but it requires a sound heat detection program.[27] Unfortunately, maintaining an efficient heat detection program and quality heat detection personnel can be a never-ending challenge in today’s expanding herds.[29] As the accuracy and efficiency of estrous detection declines, the value of incorporating *ES* into the reproductive management program increases proportionately.[33] This is to evident for understanding characteristic of estrous is very important.[6]

Characteristics of estrous

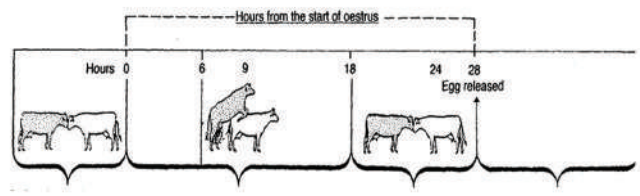
The cow that is in estrous will stand when mounted from the rear by bull or a companion cow. She indicates her willingness to stand by immobility when approached and a slight arching of the back.[15] An estrous cow will try and mount other cows but, unless they are themselves in estrus, they will move away. Exceptions to this could occur when the mounted cow is trapped by obstacles and cannot move freely.[7,35] Sometimes a cow will mount a companion animal from the front (head-mounting) and in this situation it is the riding cow that is in estrous and not the one underneath. Some workers report that the bull's interest in pro-estrous cows may begin some 4 days before estrus and is characterized by an increase in olfactory and gustatory behavior not displayed by herdmates. It is suggested that bulls can predict the impending onset of estrus from olfactory/gustatory signals produced by preposterous cows.[12,16] The relative importance of vision and olfaction for estrus-detection by bulls. They found that when physical contact is denied, bulls use visual observation of female homosexual behavior as the primary indicator of estrous and that olfaction alone provides insufficient stimuli for bulls to distinguish between estrous and diestrous-animals.[29]

Cows that are in heat can be expected to display a variety of signs, including: Discharge of clear mucus from the vulva; tail-raising and switching; licking, sniffing, and rubbing against other cattle; swelling and reddening of the vulva; frequent bawling; general restlessness and attentiveness to the activities of other cattle and humans; ruffling of rump hair and mild abrasion of rump skin as a consequence of having been mounted; and often a temporary decrease in milk-yield [Figure 7].

Many factors are known to influence estrous and mounting activity in cows. Cows show mounting activity [Figure 8] more in cold weather than in hot weather; in which cows interacted more by rubbing and licking than cows in cold weather.[21] Besides, several factors may result in failure of estrous in cattle.

Factors for failure of estrous-detection

Studies indicated for the presence of evidences that otherwise normal cow may fail to have its estrous symptoms [Figure 8] detected as a result of factors: Inclement-weather, domination by other cattle or lack of interest by other cows, especially if none of them are in the vicinity at, or near, the occurrence of estrous. Companion cows that are approaching estrous or are in estrous mount estrous cows at a much higher frequency than herdmates that have gone out of heat or those that are in the luteal-phase of the cycle.[19,20] Even the ground surface (e.g., concrete versus earth) may be a factor markedly shortening the heat period[17] and affecting the sexual behavior of cows.



Before heat (6–10 h)	**Standing heat (18 h)**	**After heat (10 h)**	**Life of egg (6–10 h)**
1. Smells other cows 2. Attempt to ride other cows 3. Vulva moist, red, slightly swollen	1. Stands to be ridden 2. Bawls frequently 3. Nervous and excitable 4. Rides other cows 5. Off feed and milk 6. First cow up 7. Vulva moist and red 8. Clear mucous discharge 9. Eye-pupil dilated	Will not stand Clear mucous discharge from vulva **Meteoestrous bleeding** 1. Not always notarized 2. May be the only heat period sign 3. Does not indicate cow conceived or will fail to coincide	Some studies indicate life of egg over 20 h)

Figure 7: Estrous and associated signs in cow[29]

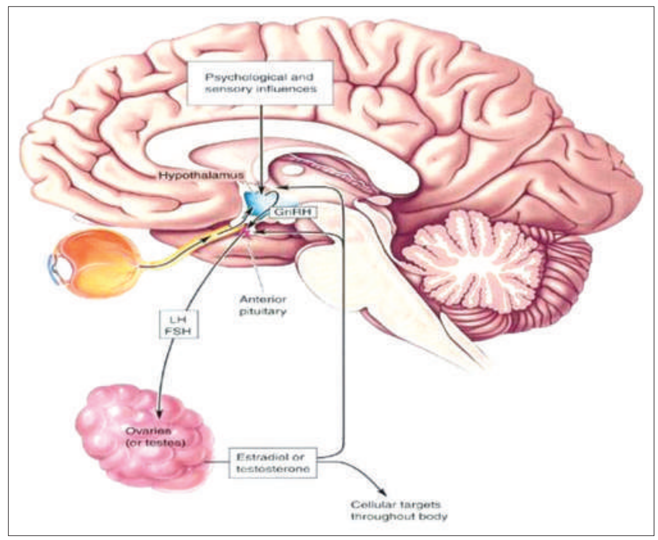


Figure 8: Hypothalamic release of *GnRH* for the release of *LH* and *FSH* from adenohypophysis[11]

Among dairy cattle, AI has been used to the least extent among replacement heifers because they are a group of females not generally under the close observation required for successful estrus detection.[6,9] Attention was drawn earlier to the fact that AI has not been applied in beef cattle to any great extent because of problems in heat detection; this is one reason for the slower rate of breeding improvement in such animals as compared with dairy cattle.[23] Although now there is a wealth of information published about estrus detection techniques, the fact remains that detection involves time and expense, no matter what approach is chosen.[6,7]

There are even reports from India suggesting a relationship between phases of the moon and estrous behavior in cattle;[30] this was on the basis of information showing a strong positive correlation between the new moon, full moon and the number of cows presented for AI (in estrous?). As mentioned earlier, the accurate detection of estrous, in order to achieve the optimal postpartum interval to rebreeding, remains a major problem in dairy farming.[19,23]

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Hormonal-regulation of reproductive cycle

An understanding of mechanisms involved in the control of the cow's EC has been influenced by a number of major discoveries made since 1950.[28] Similarly, it has been concluded in a number of studies that two of the most important of these were the discovery and development of the hormone-receptor concept, and the discovery of hypothalamus and brain regulate secretion of anterior pituitary hormones by way of a number of small peptides of neurosecretory origin [Figure 9].[2,3]

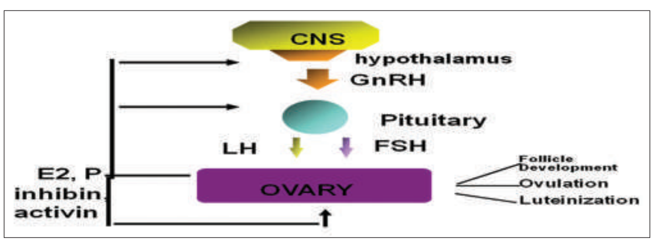

Figure 9: Neuron-regulation of follicular development and ovulation during EC. Where, CNS: Central nervous system, *GnRH*: Gonadotropic hormone, *LH*: Luteinizing hormone, *FSH*: Follicular stimulating hormone, *E2*: Estradiol hormone; *P*: Progesterone hormone

One of these hypothalamic peptides is *GnRH*,[29] which is now known to cause the release of both *LH* and *FSH* from the anterior pituitary [Figures 9 and 10]. It is indicated that the pituitary hormones responsible for the release and function of the steroid hormones regulating period of EC in cow.[29,31]

It is important to know the functions of the steroid hormones, estrogen, and progesterone, which are changed according to the EC and have direct effects to the female's reproductive organs and sexual behavior.[2,28] During EC, progesterone level shows dramatic decrease around the time of estrus, meanwhile estrogen level shows wavy changes [Figure 10][14,15] is because of the "Follicular Wave," explained in the section.

Major changes during EC

The major structures formed on the ovary [Figures 10 and 11] are: (i) The follicle (a blister-like structure containing the eggs) that produces high amount of hormone "estrogen" which causes "standing heat" and "ovulation." (ii) The CL looks like a hard yellow structure that produces progesterone hormone, which is responsible for pregnancy maintenance.[10,33]

During EC follicular development occurs as a wave-like pattern consisting of "Recruitment, Selection, Growth, Dominance, and Regression

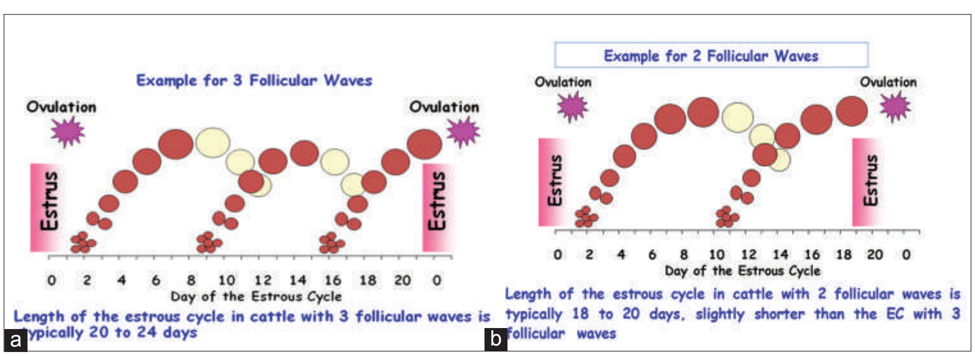

Figure 10: (a and b) Waves of follicular development during estrous-cycle

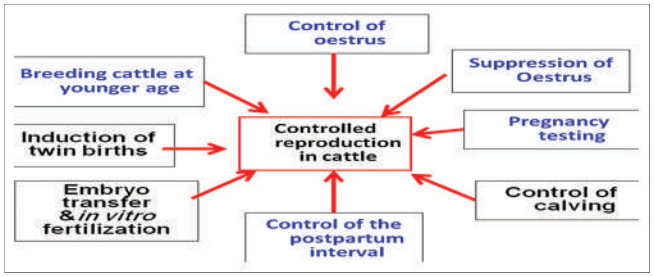

Figure 11: Areas of controlled reproduction in cattle[11]

phases [Figure 10]. Usually, 2–4 follicular waves occur during the EC in cattle [Figure 9].[5,7]

The different hormonal interactions and events occur during EC, involving *GnRH* (*FSH, LH,* and prolactin) [Figure 10], ovarian steroid peptide hormones (estradiol, progesterone, and inhibin) and *PGF2α*, of the uterine origin are shown diagrammatically in the section of endocrinology. Control of ovarian function has been reviewed[2,4] that in the period before estrous (proestrus) that gonadotrophins induce final maturation of the pre-ovulatory follicle, resulting in increased secretion of estradiol; this estrogen, in the relative absence of progesterone, acts on receptors in the brain to induce sexual receptivity and triggers the release of *LH*.[29] *FSH* precedes recruitment of follicles (causes follicles to start growing), and it is also used for super-ovulation and *ET* in cattle.[2,5] That circulatory levels of the thyroid-hormones triiodothyronine (*T3*) and thyroxin (*T4*) during the EC have also been examined.[22,27]

Endocrinology during estrus cycle (EC)

The knowledge of endocrinology during EC is crucial to control reproduction in cattle. Some of such phenomenon during EC is shown hereunder. CL develops from the ovulated follicle and takes approximately 10 days to reach mature size produces progesterone for the maintenance of pregnancy after conception occurs. Late in the EC, uterus produces *PG* which causes regression of *CL*. *PG* is the same or similar hormone in *Lutalyse®, Estrumate®*", *ProstaMate®*, and in Synch.[6,9]

Areas of controlled reproduction in cattle

The adoption of new reproductive technologies is likely to have far-reaching consequences on commercial dairy and beef herds [Figure 11]. In the

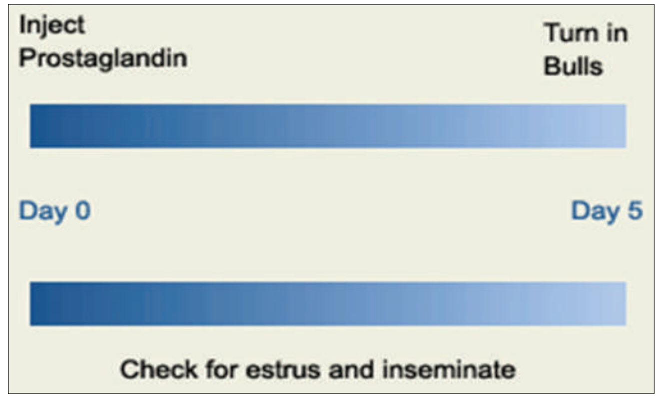

Figure 12: One injection *PGF2α* protocol with 5 days of AI

dairy herd, the cow's milk yield is influenced by its genotype, its environment and the interaction between the two.[21] Although environmental factors may be manipulated in several ways, the cow's genotype is determined solely by its parent's genetic make-up.[20] For that reason, reproduction plays a crucial role in determining the genetic progress that can be made within the dairy cattle enterprise [Figure 12].[6,8]

Reproductive technologies

According to Gordon (2009), reproductive technologies that are currently applicable to cattle have been broadly classified into those requiring a low, medium, or high technical input. A series of studies have suggested that the low-technology category includes options such as: Age at first joining, breed/cross or strain of cow, time of calving, and pregnancy diagnosis. Medium-technology includes options such as estrous synchronization. High technology options include twinning, controlling the sex of calves at birth, and cloning.[31,32]

Reproduction control

Control and manipulation of reproduction in cows cover several possibilities are summarized in Figure 10 and few of them currently most applicable are discussed at length in later parts of this book. Each of these possibilities has already been developed to the stage at which it can be applied to some extent in commercial practice; future developments and refinements in techniques should help to make all of them more valuable to the farmer.[5,27]

Control of reproductive-cycle facilitates breeding in two important ways: (i) By reducing and in some cases eliminating the labor of estrus (heat) detection, and (ii) allowing the producer to schedule breeding.[2,7] If the majority of a herd can be induced to exhibit estrus at about the same time, the producer can arrange for few days of intensive insemination. Although the total amount of labor involved with insemination may not be reduced, it is concentrated into a shorter period.[21,29] Other advantages of estrous synchronization were discussed in the following chapters

ESTROUS SYNCHRONIZATION AND PRODUCTS USED

ES

ES, as the name implies, is the manipulation of the EC to bring a group of females, at random stages of the EC, into estrus at a precise time. *ES* has a profound potential to: Shorten the calving season, increase calf-uniformity, match calving-period to the seasons with availability of surplus feeds (grains, fodders, and pastures), and enhance the possibilities to utilize all the resources required for production including labor.[32] It also makes AI efficient to allow producers the opportunity to infuse superior genetics into their operations at costs far below the cost of purchasing a herd sire of similar standard.[6] These tools remain the most important and widely applicable reproductive biotechnologies available for dairy operations. However, the producers have been slow to adopt and/or utilize these technologies into their production systems.[3,8]

Research has dramatically increased the number of synchronization options. A producer has many choices to pick from to tailor a synchronization protocol to his operation, his production goals, and his available labor. *ESP* use one or a combination of three hormones: Prostaglandins and Progesterone.[6,12] Progesterone released by the *CL* causes the tract to cease contractions; promotes and maintains pregnancy; blocks the releases of the new hormones from the brain; and decline in progesterone becomes signal to start new-cycle.[21]

Another way of creating estrous synchrony is using hormone *GnRH* or an analog, which causes ovulation of a large follicle. This product is sold under the trade name *Cystorelin®, Fertagyl®*, *OvaCyst®*, or *Factrel®*. Treatment with *GnRH* is combined with *PGF2α*, as these hormones have different functions. Synchrony of estrus and fertility with a combination of *GnRH* and *PGF2α* are good for cyclic females, and some research indicates that this combination may induce cyclicity in cows experiencing postpartum anestrous. However, protocols using only *GnRH* and *PGF2α* are not advised for use in yearling heifers due to extremely variable response.[29,31]

A third method for *ES* is to use a progestin, which will maintain high levels of progesterone in the female's system even after the regression of the *CL*. *ES* occurs 2–5 days following progestin removal. The commercial products that fall into this category are melengesterol-acetate (*MGA*) and controlled internal drug release (*CIDR*). All other products for synchronization are delivered as injections, but available progestin is administered differently.[4,10] *MGA*, added to the feed to maintain feed efficiency and feed intake of beef-cattle, is the only synchronization product that is administered orally. *MGA* is added to feed such that females receive 0.5 mg/head/day for 14 days. On removal of *MGA* from the feed, cyclic females will begin to show estrus. Estrus synchrony is good for cyclic females; however, fertility is poor immediately following *MGA* removal.[24,26]

The means to manipulate EC and synchronization in dairy cattle are discussed here-under.

The prostaglandins

Prostaglandins are lipids consisting of 20-carbon unsaturated hydroxy fatty acids derived from arachidonic acid. *PGF2α* is produced by the uterine endometrium and is responsible for luteolysis, or degradation of the CL, in cattle. The bovine EC can be divided into two phases, follicular-phase and the luteal-phase.[17] The follicular-phase is characterized by follicle growth culminating in selection of a dominant follicle and subsequent ovulation. The luteal-phase is the longest phase of the cycle (approximately 6–16 day of the EC). The luteal-phase is characterized by the functioning *CL* secreting progesterone. During the late luteal-phase (day 16–18 of the cycle), *PGF* is released from the uterus and binds to the *CL* causing luteal regression.[17,19]

Prostaglandin *F2α* (*PGF*) is the foundation hormone of any synchronization protocol. As in the naturally cycling cow, *PGF* brings cows into heat by removing the *CL* and the inhibitory effects of progesterone on *FSH* and *LH* secretion. However, *PGF* alone has several distinct limitations: First, *PGF* is not effective in animals that do not have a *CL*. This includes prepubertal heifers, anestrous cows, or cycling females in the first 5–6 days of the EC. Second, *PGF* has no effect on the follicular waves. Cow-to-cow variation in the size of the dominant follicle at the time of *PGF* injection results in considerable variation in the interval to estrus following *PGF* injection. During the 1970s, it was discovered that *PGF* was luteolytic in dairy-cattle and could be used to synchronize estrus.[30,32] It was later determined that *PGF* had limited utility in synchronizing estrus because it was only effective in cattle that were cycling and had a *CL* (day 5–17 of the cycle). Therefore, prepubertal heifers, anestrous females, females on day 0–4 of the EC, and females in the final days of the EC subsequent to luteolysis were not responsive. It was later determined that the interval from treatment with *PGF* to estrus was dependent on the stage of the follicular wave at treatment. Larger, more mature follicles ovulated sooner than their smaller, less mature counterparts.[14,18]

In cyclic females, estrus occurs within 2–6 days after they are given *IMI* of prostaglandin *PGF2α* (*-Lutalyse®*) or one of its analogues (*ProstaMate®, Estrumate®, estroPLAN®,* and *In-Synch-®).*[36] Remember: Anestrous females do not respond to prostaglandin injections. Estrous-cyclic females can respond to injections between days 7 and 16 of their cycles if they have a functional CL. The CL is a gland developed in the ovary and secretes the hormone progesterone into the cow's blood. EC females at days 0–6 and 17–21 of their cycles are without functional CL and do not respond to injection-ns. However, an estrous-cyclic female without a functional CL will respond to injections if they are given in a specific-sequence.

Several studies noted that there are four *PGF2α* -protocols being used to synchronize estrus in cow. Two of these programs require two injections of *PGF2α* and two require just one injection.[7,29]

One injection of prostaglandin with 5 days of breeding protocol

Inject all females with prostaglandin on Day 0 and check for estrus and breed 12 h after standing estrus [Figure 13]. With a single injection of prostaglandin about 75% of the cycling females would be expected to display estrus during the next 2–5 days. Anestrous cows, will not respond to this prostaglandin protocol because they do not have a CL present on the ovary

One injection of PGF2α within 10 days of breeding protocol

Check for estrus and breed all females in standing estrus for the first 5 days of the breeding season [Figure 14]. Inject all females with *PGF2α* not previously bred at the end of day 5 and breed these females 12 h after standing heat. By breeding for 5 days, none of the cows that receive the prostaglandin injection will be between day 1 and

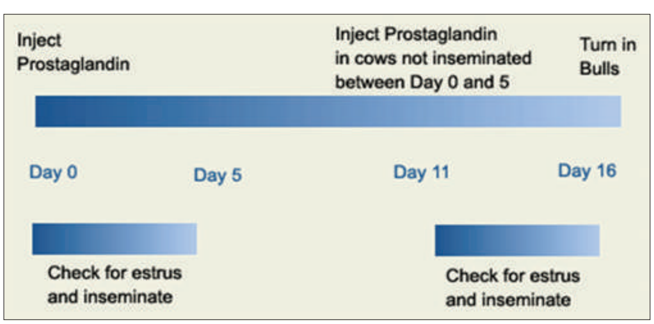

Figure 13: One injection

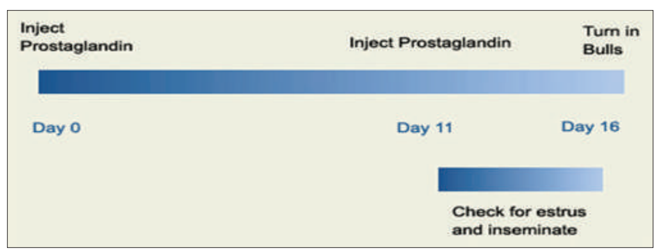

Figure 14: Two injection PGH2α protocol with AI after the second injection

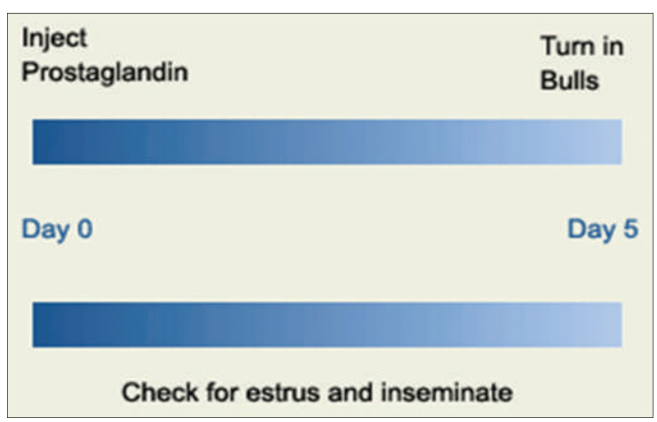

Figure 15: Two injection PGF2α protocol with 10 days of AI

5 of their EC. Cows that are cycling should display estrus within 2–5 days after the *PGF2α* injection. This protocol can result in greater than 90% of cyclic females being inseminated during the first 10 days of breeding season.[17,18,23]

Two injections with** PGF2α**-protocol with 10 days of breeding [Figure 15]

The two injection programs for synchronization with prostaglandin allow for females to be inseminated after each *PGF2α* injection or for insemination only after the second injection. In this protocol, an injection of prostaglandin is given to all cows [Figure 13]. After one injection, about 75% of the cycling females should be in heat during the next 5 days. Females that are detected in estrus should be inseminated 12 h later. The females that are not detected in heat and bred after the first injection should receive a second prostaglandin injection 11 or 14 days later and be bred 12 h after they display standing estrus. When breeding females after each injection, be sure not to inject *PGF2α* into females that were inseminated after the first injection.[19,20]

Two injections with PGF2α Protocol with 5 days of breeding

Conventionally, the injections of prostaglandin are administered 11 days apart with breeding after the second injection [Figure 14]. However, recent data suggest that administering the second injection 14 days after the first injection has resulted in more females exhibiting estrus. The two injection protocol should theoretically synchronize estrus in cyclic-females within 2–5 days after the second injection.[12,15]

Synchronization responses of 70–80% of females within a herd are common with this protocol, but can be highly variable depending on the number of anestrous females in the herd. Timed insemination with this protocol is not recommended.

Key Points

- Nutrition program so that mature cows calve in a body condition scores (*BCS*) of 5 and first calf-heifers in *BCS* of 6
- Nutrition program for replacement heifer such that they reach puberty and begin EC at least 3 weeks before the start of the breeding season
- Females must be exhibiting EC
- Cows at least 40–50 days post-calving
- Good facilities to restrain and handle cattle
- Trained people in detecting estrus (heat)
- Timed breeding is not recommended.

Progesterone hormone

Progesterone is the dominant ovarian hormone present in the circulation during the EC and is secreted from the *CL*. This period of the EC is also referred to as the luteal phase and lasts from the time of ovulation until regression/luteolysis of *CL* near the end of the cycle. Progestins suppress estrus in cow and used extensively to alter EC. Studies revealed that estrus could be delayed and therefore synchronized by administration of exogenous progesterone to cow/ewes.[31,33] This led to progestins administered by injection, released by an intra-vaginal sponge or fed for a period up to exceeding length of the EC to synchronize estrus following cessation of administration.[12]

Progesterone is a naturally occurring hormone in cow (female animals), which functions to maintain pregnancy. This hormone also "blocks" estrus and ovulation during diestrus phase of the EC.[32] There are two kinds of progesterone[30] products are used to synchronize estrus:

- A controlled intra-vaginal release device-*CIDR*®, which is an insert that contains progesterone. A special applicator tool is required to insert the device [Figure 16]. A string is attached for removal at the end of the treatment
- *MGA*® (melengestrol acetate), which is a progestin feed additive. It acts like progesterone in the body. Because both *CIDR*® and *MGA*® products "hold" animals out of estrus, their timed removal will synchronize estrus in responding females. When *CIDR*®s is used in

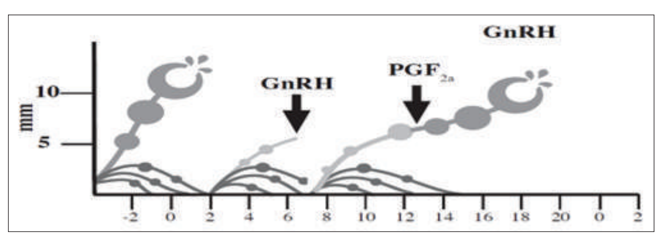

Figure 16: Synchronization of follicular growth and ovulation by *GnRH* and *Pgf2a*

combination with *GnRH* or prostaglandin, 20–40% of anestrous females may be induced into estrus.

One of the first methods used to synchronize estrus in cattle was the long-term feeding of *MGA* is a synthetic progestin that suppresses estrus when fed at the rate of 0.5 mg/head/day. *MGA* is still utilized extensively today by feedlots to suppress estrus in beef heifers that are being fed for harvest and used for estrous synchronization of heifers with a 14 days feeding program followed by a single injection of *PGF2α* 17 days after withdrawal of *MGA* feeding.[20] It is well established that administration of exogenous progesterone can hasten the attainment of puberty in heifers and cause postpartum anestrous cows to become estrous cycling.[4] The ability of exogenous progestins to induce estrus in anestrous cattle has been attributed to, in part, increased *LH* secretion both during and after treatment. It has been reported that progestin treatment increased *LH* secretion in postpartum beef[20] as well as seasonal dairy cows.[29] Besides, *LH* secretion following weaning was increased in cows with prior exposure to progestin. This induced increase in *LH* is important because it mimics the proestrus increase in *LH* leading to the preovulatory *LH* surge.[15,24]

GnRH based estrus synchronization systems

Gonadotropin Releasing-Hormone (*GnRH*), or (trade names *Cystorelin®, Fertagyl®, Factrel®* and *OvaCyst®*), is a naturally occurring hormone that causes the release of other hormones. One of these hormones affects the development of follicle on the ovary; another causes ovulation.[7] Several research outputs indicates that when *GnRH* is given with the prostaglandin hormone to and non-cyclic females, the patterns of follicular development are altered, inducing ovulation.[9] The same studies stated that this treatment may induce the estrus (heat) within 10–30% of the anestrous females. *GnRH* treatment is not recommended for pre-pubertal heifers because these young heifers have not yet established fertile EC and have no consistent response to the injection of this hormone.[6]

New systems of synchronizing estrus (heat) in cows for AI have been developed using commercially available *GnRH*. These systems allow producers to artificially inseminate cows with little or no heat-detection. For the first time, producers have a reliable system that results in acceptable pregnancy rates to timed AI.[7] Large numbers of cows are synchronized and artificially inseminated by a technician, are examples of effective use of AI in commercial cows. The resulting calf crops are grouped and sold in truckload lots at a considerable price advantage. A portion of this advantage is due to AI with the remainder from sorting, health programs, and numbers of calves. In addition, these groups are building a favorable reputation for uniform high-quality calves. Recent advances in estrous synchronization using *GnRH* are allowing these groups to take advantage of AI.[21]

What does GnRH do?

GnRH is a hormone naturally produced in cows that cause the cow to release another hormone – luteinizing hormone. *LH*, in conjunction with follicle-stimulating hormone (*FSH*), enhances the growth of ovarian follicles that contain the developing egg.[32] Large amounts of *LH* also cause ovulation (egg release). After ovulation, a CL forms on the ovary and produces progesterone which prepares the uterus for pregnancy and prevents return to heat.

During natural EC, *GnRH* through *FSH* and *LH* causes follicles to form and grow in small groups or waves on the ovary [Figure 14]. The largest (dominant) follicle (a) of the wave keeps new follicles (b) from growing. However, the dominant follicle must ovulate in a few-days or it will regress (d) and a new wave of follicles will start to grow. As long as the *CL* produces progesterone, the cow will not release enough GnRH and *LH* to cause ovulation.[32] The *CL* will regress and stop producing progesterone if the cow does not become pregnant. Once the *CL* regresses,[18] *GnRH* and *LH* release increase and the dominant follicle grows large and produces estrogen that causes the signs of heat. A surge of *LH* is then released and the cow ovulates.[14]

How are GnRH systems different from other ES systems?

Traditional estrus synchronization systems only synchronized heat, not ovulation.[17] For example, the two shot Lutalyse® system results in cows ovulating at various times over 5–7 days. To achieve acceptable pregnancy rates, producers had to check heat for 5–7 days and breed cows 12 h after heat.[15] That meant gathering cows 2–3 times to synchronize heats and then pulling groups of cows in heat out of the herd to be bred. As reported by[19] since cows did not all come in heat on 1 day, groups of cows had to be pulled, and bred over a 5-day period. This equals 10 round-ups, which involves considerable effort for a smaller operation (<75 cows) with limited labor and facilities. In addition, the AI technician's availability and expense becomes a factor with only a few cows to breed each trip.[32]

The new *GnRH* systems synchronize follicular growth and ovulation so all cows ovulate within a few hours of one another [Figure 17]. Another advantage of the *GnRH* systems is that they induce ovulation and EC in non-cycling cows.[19] If cows are given an injection of *GnRH*, then enough *LH* is released to cause the largest follicle on the ovary to ovulate and form a *CL*. A new wave of follicles will start to grow since *GnRH* "removed" the dominant follicle [Figure 18]. Now, the follicular growth of the cows is synchronized.

Seven days later an injection of an analog of prostaglandin *PGF2a* is given which regresses the *CL* to synchronize final follicular growth and heat. Two days after *PGF2a* injection, a second injection of *GnRH* is given to cause all cows to ovulate at approximately the same time.[16] Since ovulation is now synchronized, all the cows in the herd can be bred by timed-AI in one or two groups.[32]

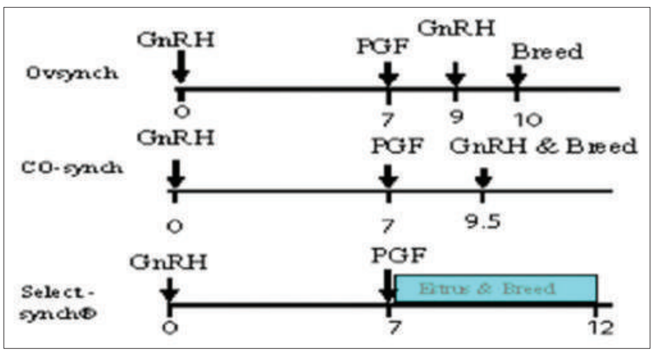

Figure 17: Timelines for *GnRH* based synchronization systems

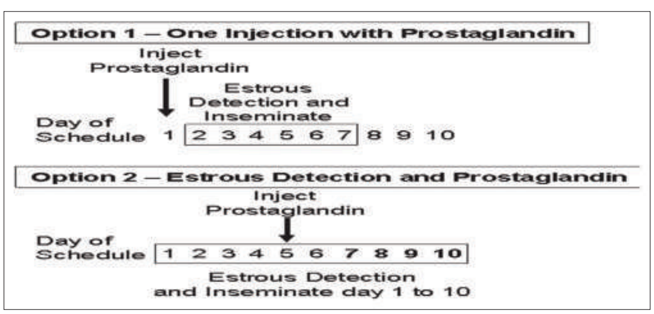

Figure 18: A single injection of prostaglandin

How the GnRH systems work?

The *GnRH* based synchronization systems, Ovsynch and CO-Synch® are timed AI systems whereas Select-Synch® requires heat checking.[6,18] All systems start with an injection of GnRH (100 μg) to synchronize follicular growth, followed 7 days later by an injection of a prostaglandin product (*PGF2α*) (i.e., Lutalyse®, Estrumate®, In-Synch®, or Prostamate®) to bring the cows into heat. Dosage of *PGF* varies with the product, so read and follow label directions carefully.[35]

With Ovsynch and CO-Synch, a second shot of *GnRH* causes ovulation. Many cows in these programs will never show heat. With *Select-Synch®,* cows will show heat and ovulate naturally, but over 2(3) days [Figures 19 and 20].[17]

It is suggested that pregnancy rates with the *GnRH* synchronization-systems can be maximized by incorporating additional strategies.[14] The first, cows on the Ovsynch program should be inseminated 16–18

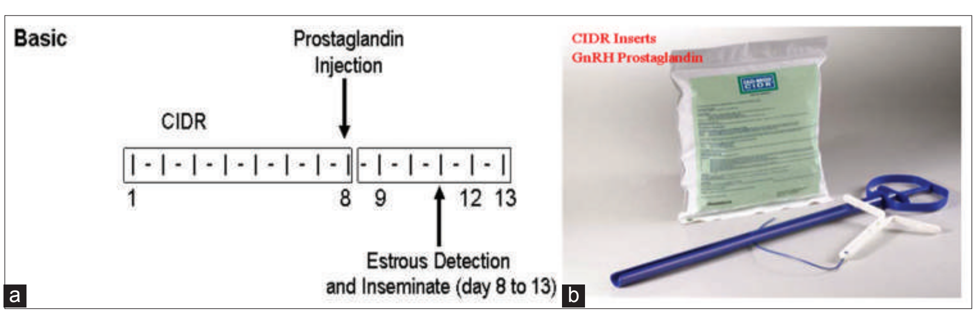

Figure 19: (a and b) Inputs for CIDR insert of estrous-synchronization

h after the second *GnRH*.[29] This means that the second *GnRH* injection should be given in the late afternoon with breeding occurring the next morning. Furthermore, 80–90% of the cows on Ovsynch or CO-Synch will not be observed in heat. The *GnRH* will actually cause ovulation before the cow begins to show heat.[29]

With all these systems, about 8–15% of the cows are in heat between the *PGF* injection and the second *GnRH* injection (or 48 h). These cows should be inseminated 12 h after the beginning of standing heat.[8,29] Therefore, some heat detection is necessary to insure maximum pregnancy rates.

CO-Synch works best when the second *GnRH* injection and breeding are delayed until 64 h after prostaglandin injection. Once again, any cows that come into heat early need to be bred in response to that heat. Often many of these "early" cows will be inseminated at the same time as the cows that are timed bred. Proper pre-breeding nutrition is essential to success of the systems. Cows must be in body condition score 5 or better to achieve maximum pregnancy rates.

GnRH eliminates the dominate follicle resulting in a new wave of follicles approximately 2 days later. Prostaglandin (PGF2a) lyses (kills) the corpus luteum which allows the new follicle to ovulate.

It is noted that separation of calves from cows for 48 h after PGF injection may improve reproductive response in cows of *BCS* 3 or 4.[24]

Finally, these systems do not work well in virgin heifers. The *GnRH* systems should only be used on mature cows. It appears that heifers have a different pattern of follicular waves which lowers the effectiveness of *GnRH* in young females.[17]

Results with GnRH systems

From 1999 to 2001, extension specialists, agents, and veterinarians conducted trials with the *GnRH* synchronization-systems in over 10,000 cows in virginia. Some of these cows were given older synchronization systems such as *Syncro-Mate-B*® or two shots of Lutalyse®.[7,29] A few of the non-*GnRH* systems are not shown because there were too few cows in the system or only one farm used the system, so the results were not meaningful. In all cases, the *GnRH* systems outperformed the older systems in cows nursing calves by increasing AI pregnancy rates to a single insemination.[24]

CO-Synch and Ovsynch observed as the most consistent-systems. Herds with low pregnancy rates, in the CO-Synch and Ovsynch groups, resulted from problems with body condition of cows or semen handling. However, these low pregnancy rate herds were included in the average and presented as a reminder of other factors that affect AI pregnancy rates.[6] In contrast, poor performance with Synchromate-B is a result of its ineffectiveness in cows late in the EC.

Another advantage of the *GnRH* systems is a reduction in the length of the calving season. Producers with cows in good body condition report that 75–90% of the cows calve in the first 30 days of the calving season after *GnRH* synchronization. Many of the cows that did not conceive to AI became pregnant to their first service by clean-up bull. Furthermore, producers report overall pregnancy rates of 85–98% in 60-day breeding season.

Research conducted recently demonstrated that reducing the dose of *GnRH* to 50 μg did not alter pregnancy rates [Table 2].[15,16] However, producers must be careful to accurately and completely deliver this small dose into the cow. Smaller gauge needles and reduced syringe size are required to accurately administer the 50 μg dose. Extreme care needs to be taken with the 50 μg dose so producers do not reduce pharmaceutical cost only to compromise pregnancy rates. This research also indicates that

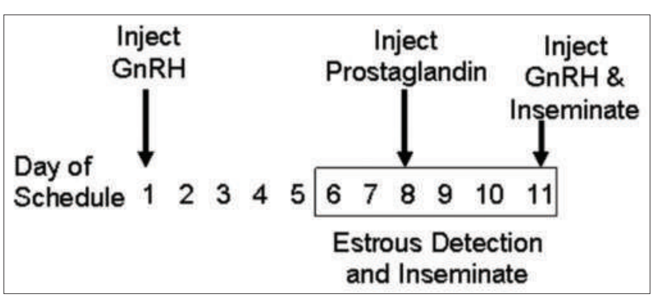

Figure 20: CO-synch protocol

Table 2: Results from on farm synchronization trials in beef cattle

System	Number of cows synchronized	Average % pregnant to single AI	Range (%) pregnant to single AI
Syncro-Mate-B	78	48.7	37.5–56.5
CO-Synch 64	299	49.8	43.6–58.8
Ovsynch	291	55.3	40.0–65.1
Select-Synch	97	62.9	52.9–71.0

using the 100 μg dose may compensate for injection errors.[13]

ESTROUS SYNCHRONIZATION PROGRAMS

Synchronization with *PGF2α*

One shot prostaglandin

Option-1 shows a single injection of prostaglandin is given to the cyclic females, and then these females are bred as they express estrus.[8,29] The disadvantage of this program is that one-third of the females will not respond to the injection, but the advantages are the lower cost of one injection and that females are only handled once other than for breeding.[15] A second one shot option requires detection of an estrus before any prostaglandin treatment is administered.[16]

The producer detects estrus for 5 days and breeds each cow as she exhibits estrus. The cows that have not exhibited estrus by the 5th day are given an injection of prostaglandin, which should induce them to come into estrus in about 3–5 days.[15,18] The same study indicated that a relatively large percentage (75–80%) of such type of animals will require this injection.

Option-2 represents the greatest savings in cost and labor associated with treatments because only one injection is given and not all the cows will need it. In addition, detecting estrus for 5 days gives the producer some idea of the total number of cows that are cycling. During this 5-day period, approximately 20–25% of the cows should show estrus (4–5%/day). If 4–5% of the cows are not exhibiting estrus each day, then the cows are probably not program. The disadvantage of this program is that it requires 5 days of accurate detection of estrus before prostaglandin treatment is administered. This program is recommended because of the opportunity to determine the reproductive status of the herd before animals are treated for synchronization.

Two shot-PGF2α in combination with GnRH

Option 1 uses two injections of prostaglandin spaced 14 days apart [Figure 21]. Estrous detection is not required before or between injections.[16,17]

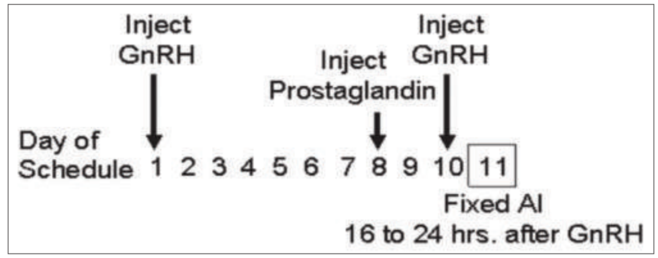

Figure 21: Select-synch

The Ovsynch program

The Ovsynch program [Figure 21] calls for an injection of *GnRH* on day 1, an injection of prostaglandin on day 8, a second injection of *GnRH* on day 10 and then *TAI* on day 11. This program's advantages are tight synchronization of estrus, most females respond to the program and it encourages estrus in non-cycling cows that are at least 30 days postpartum.[16,19]

The program's disadvantages are the relative expense and that females are handled three times before breeding short-term calf removal (48 h) following prostaglandin injection may improve the response in postpartum cows.

Co-synch program

The CO-Synch program [Figure 21] calls for an injection of *GnRH* on day 1, an injection of prostaglandin on day 8 and then a second injection of *GnRH* with breeding on day 10. This program's advantages are tight synchronization of estrus, most females respond to the program and it encourages estrus in non-cycling cows that are at least 30 days postpartum.[12,14]

The program's disadvantages are the relative expense and that females are handled twice before breeding, which is the only difference between CO-Synch and Ovsynch. Some females will show improved estrus response when 48 h calf removal is utilized after the prostaglandin injection.[13]

Melengestrol acetate and prostaglandin

Melengestrol acetate (*MGA*) is the only synchronization product that is administered orally.[6,12] It is added to feed such that females receive 0.5 mg/head/day for 14 days. On removal of *MGA* from the feed, cyclic females will begin to show estrus. This estrus is subfertile, and it is not recommended to

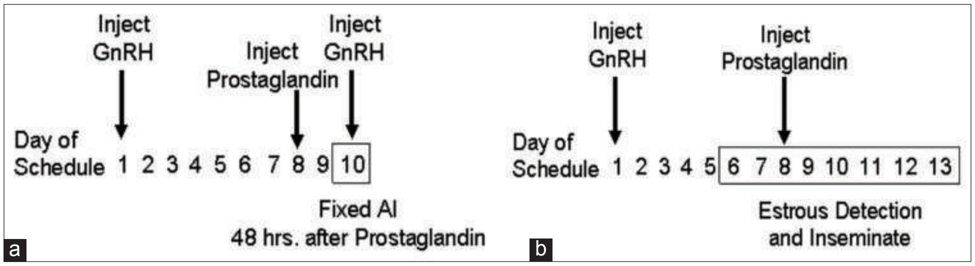

Figure 22: (a and b) Hybrid-synch

breed. Females should be bred on the second estrus following *MGA* removal [Figure 22].

A second *MGA* feeding option [Figure 22] would be to give an injection of prostaglandin 19 days after removal of *MGA* from the feed. This would increase synchrony of the females and shorten time spent in estrous detection and breeding. The third option [Figure 21] would be to give an injection of prostaglandin at the time of *MGA* removal from feed and 19 days following removal. This further reduces time spent in estrous detection and breeding.[11]

Synchronization with *MGA* alone is low cost and has minimal handling, but time spent in estrous detection and breeding may be several days. Addition of one or two injections of prostaglandin increases the cost and handling but provides more concentrated synchrony. All programs with *MGA* require that females be fed daily, which increases the level of management and equipment needed. Research showed that where calves were removed for 48 h starting on the 2nd day after completion of *MGA* feeding, conception rates were improved.[16,32]

Controlled internal drug release (CIDR®)

The *CIDR* (*CIDR®*) protocol consists of placing the insert into a cow's vagina for 7 days; then, 24 h before removal, injecting the cow with a regular dose of Lutalyse. Heat will generally occur very quickly (within 2–3 days) after the CIDR is removed on day 7.[5,7] *CIDR®* Cattle Insert is a progesterone vaginal insert used to synchronize estrus and hasten either puberty or postpartum cyclicity in the beef cow and heifer.

It is reported that the first product that we have had approved in beef and dairy for reproductive control for more than 20 years.

One of the most recent advances in estrous synchronization protocols has been the increased use of *CIDR* devices [Figure 22]. These progestin-impregnated plastic devices are placed into the vagina so hormones can be diffused into the female's system. Protocols using *CIDRs* can range from extremely simple to extremely involved [Figure 22].[26] The most basic protocol involves placing the *CIDR* into the female for 7 days and giving an injection of prostaglandin F2α at *CIDR* removal. Heat detection is implemented for approximately 3–4 days on the basic protocol.[24]

Conception rates from ES and AI

One of the greatest concerns that producers have when implementing an ES and AI program is the expected conception rate. Research reports for various synchronization programs report varied results.[15] Many research papers where cows and/or heifers were synchronized and bred once or bred once at a normal estrus, the average conception rate was 49% with a standard deviation of 11%. This means that two-thirds of these studies reported conception rates within a range of 38–60%.[23] With healthy, cyclic heifers in good body condition, first service conception rates with skilled AI technicians may approach 75%. However, this is usually not the case, and a more accurate estimate is 50–55%.[29] Conception rates are affected by the number of females that are cyclic, healthy, and in good body condition due to level of nutrition.[15] Skilled estrous detection and AI technicians also affect conception rates. Inadequacy in any of these areas can spell disaster for an *ES* program.[24] Table 1 ranks the cost and handling needs of each *ESP*. This information can be used as a guide to select the right program for each situation.[29]

Tips for a successful synchronization program

It have been stated that for the development of a high quality productive cow herd, many aspects pertaining to herd management as related to nutrition and other basic management concepts are some of the most important tools.[8] In this issue, I like to venture a little farther from center and look at a management tool that is being used with increased frequency and can significantly increase the value of the calf crop: Estrus synchronization.

It is recommended that *ES* may not be for every producer. Use of this technology generally requires skilled management and adequate facilities. Cows will respond poorly if not fed properly or if body condition is less than adequate. Level of herd health is also a factor, as many diseases cause reproductive failure.[8,10]

Reproductive management program

It is well accepted that there is a need for effective systems of management for high reproductive performance in cattle without it being a matter of concentrating attention only when there is a problem of herd fertility.[19]

There are many studies, mainly in dairy herds, which have measured the reproductive performance achieved in milking herds, so that it is well-known what can or cannot be achieved in terms of reproductive efficiency. Several reports have also shown that well supervised reproductive management programs can improve fertility. The value of comprehensive and accurate record-keeping should require no emphasis. In a survey of the reasons for culling cows, suggest that recording systems in use on many farms are far from adequate; if these farmers were to improve their recording systems and have cows accurately tested for pregnancy, especially before culling, incomes could be markedly increased.

Calving distribution

The greater the proportion of cows calving in the first 21 days of the calving season, the better the response expected from a synchronization and AI program.[2] Although some synchronization protocols can induce estrus and ovulation in some non-cycling cows, cows that calved during the 30 days just before the start of the breeding season are unlikely to respond.[14,24]

Using a synchronization protocol every year can gradually increase the proportion of cows that calve in the first 30 days of the calving season and subsequently increase the pregnancy rates to AI in a parallel fashion. With longer breeding seasons (more than 70 days) and less than 60% of the herd calving in the first 42 days of the calving season, expect much lower AI pregnancy rates. Timed AI of entire herd would not be recommended.[11]

Body condition

Body condition influences the length of postpartum-anestrous and thus the proportion of cows cycling at the start of the breeding season. Cows need to be in a positive energy balance to resume normal EC.[32] Over a range of *BCS* of 4–5.5 (1=thin to 9=fat), the proportion of cows cycling increased 18% for each unit increase in body condition score. This response would likely level-out for cows with *BCS* >6.5.[13,23] The cow's ability to conceive early in the breeding season also increases over this range of *BCS*. Use of the appropriate sizes of syringes and needles, follow label directions and products quality assurance guidelines is highly necessary. Accuracy is the goal, not speed. It is recommended that you do not inject in the top butt, and you should make sure you have the proper equipment in sufficient supplies (at least one needle per 10–15 cows).[30,31]

Mature cows

BCS ≥5: Good candidates for synchronization and AI; *BCS* 4-4.5: AI pregnancy rates will be lower. The risk of poor response may be reduced if plane of nutrition has been increasing 3–4 weeks before the onset of the breeding season. Timed AI is not recommended; and *BCS* <4 – Poor-candidates for synchronization.[18] Timed AI is not recommended.[23]

First-calf heifers

BCS ≥5.5: Good candidates if calved 3 weeks ahead of mature cows.[18] *BCS* 4.0-4.5: High risk. Response to induction of ovulation with *GnRH* is about half of that in mature cows at similar BCS. Consider using multiple methods to induce anestrus first-calf heifers to cycle (calf removal and a progestin).[39]

Choosing a synchrony method

The various approaches to estrous synchronization require different amounts of time to implement. Managers who have limited time and available labor should consider the methods that allow for time of mating.[14,23] The same studies indicated that before selecting any treatment, however, determine the number of females that can potentially respond to treatment. If the number is low, treatment may not be justified. Well-managed beef herds that calve in 80 days or less usually respond well, so the cost of treatment is justified.[14] In longer calving periods, the cows can be sorted into groups and treated according to their calves' ages. Any cow whose calf is at least 40 days old can be treated.[23] Beef cows with calves less than 40 days old may be anestrous and respond poorly to *ES*. Cows in poor to marginal body condition will likely be anestrous because of inadequate-nutrition. Thus, they will respond poorly to treatments. The response in replacement heifers depends on the proportions that have reached puberty.[8,35] The 15-month-old heifers weighing at least 65% of their expected mature weight will respond better than younger heifers at a lighter weight.[29]

All treatment methods result in pregnancy rates of about 50–60% among females that respond to treatment.[11] The overall pregnancy rate depends on the number of females that display estrus during the period.[1] That is, all females must respond to treatment and display estrus if a 50–60% pregnancy-rate is to be achieved in a single service. If only 50–60% of the females respond and display estrus, the pregnancy rate to single AI service would be only about 25–30%.[35] The use of high-quality semen and experienced technicians can help ensure conception in females that respond. Field trials indicate that, to recover the costs of the program, at least 60% of the females should be estrous cyclic before treatment.[35] If the number of responding females is unknown, detect estrus for 5–6 days before giving any treatments. If fewer than 15% of the females are in estrus during that time, the response to subsequent treatment will be low.[11] An alternative is to detect estrus after any treatment. Both approaches allow managers to see the degree of response and decide if the program should be continued.

CIDRs

Research findings revealed that following the package directions is necessary. Cleanliness is important during insertion of the drug. In confined situations or for heifers, you may wish to shorten the tail of the *CIDR*, leaving 2.5 inches exposed so pen mates do not play with the tail and remove *CIDR* early, reuse of *CIDRs* is not recommended.[6,11,24]

MGA

It is reported that uniform, consistent daily consumption is increased when adequate bunk space is available (18–24 inches for heifers and cows, respectively).[16] Make sure all animals are up to the bunk or gathered before feeding. Feed *MGA* mixed with a small amount of grain (3–5 lbs) that can be cleaned up in a relatively short time, yet allows for everyone to get their share.[11] When feeding *MGA* in a high volume total mixed ration, deliver half or less of the daily ration at first feeding with the entire *MGA* dose, delivering the remaining ration later in the day.[1,3] This increases the odds that those females with lower intakes will consume the entire daily dosage. Cows that are just getting new-growth grass in the spring at the time *MGA* feeding begins may ignore the *MGA* feed completely.[11] To improve consumption, remove free-choice salt from pasture before *MGA* feeding.[29]

Timing of synchronization

Do not combine administration of synchronization drugs with routine vaccination, especially with modified live vaccines.[8]

Most vaccinations should be completed several weeks before the breeding season begins. You should make sure to give the appropriate treatment on the appropriate day. Changes by even a day may seriously harm results.[24] If you intend to precisely identify AI versus natural service calves, wait at least 10 days after the synchronized period to turn out bulls and employ early pregnancy detection. Pregnancy detection at 30–50 days after AI will minimize errors in proper identification of AI pregnancies.[2]

Timing of artificial insemination

The highest conception rate to AI has been noted 4–12 h after the onset of standing activity. So for producers using intense visual observation, and thus having an accurate estimation of estrus began, insemination by the AM/PM rule should produce the highest conception rates.[11] If heat detection only occurs 2 times per day, an accurate estimate of the initiation of standing activity will not be achieved and insemination once a day may provide similar results to 2 times/day. If animals continue to exhibit standing estrus for long periods (12–14 h) after the initial insemination the conservative approach is to inseminate.[4,11]

Facilities

Well-designed facilities in good repair minimize stress on animals and people to optimize results.[18] If breeding on observed estrus, areas for easy sorting and holding animals are needed. Often cows bred on observed estrus are moved immediately after AI to make heat detection and sorting on the remaining group easier. If cows can be moved to an adjacent pasture, a creep gate may work to let calves sort themselves, saving considerable time, and effort.[11] Cows generally stand quietly in a breeding box without heads caught. Make sure to have a plan for rainy weather.[4] Semen handling and thawing should be done out of direct sunlight. As a synchronized group of females begins to show signs of estrus, even the best fence may not deter neighboring bulls.[35] If direct fence-line contact with bulls cannot be avoided, a hotwire set a reasonable distance from the permanent fence may prevent unplanned breeding.

First-time synchronization

- Make sure animals are in adequate *BCS*
- Start with smaller group; heifers or early calving cows
- Consider synchronizing and using bulls natural service in the 1st year
- Consult expert in selecting a synchronization system
- Trade help with an operation that has experience with AI and synchronization to learn how they do things and to have expertise on hand when it's your turn.[34]

Characteristics of successful ESP

- Good year-round nutrition program
- Mature-cows are in a minimum *BCS* of 5 at calving time and first-calf heifers a *BCS* of 6
- Total breeding-season is 60 days or less
- Functional-facilities for sorting, administration of treatments and AI is very important
- Skilled help
- Good record keeping
- Effective vaccination and health program
- Attention to details.

SPECIAL CONSIDERATIONS AND PREQUATIONS

Special considerations

There are special considerations when using MGA in combination with prostaglandins.[2] This method is typically the most cost-effective when a dry-lot or semi-confinement period is a normal part of management, such as in overwintering cow/heifer development programs. Ranchers should make sure each animal takes in an adequate amount of the *MGA* feed supplement so that each one gets the proper dosage and has an acceptable estrus response.[14] The dosage rate is designed to overcome some of the variation in intake among individual animals. Nevertheless, animals should be forced to consume the supplement, which can be accomplished in confined or semi-confined feedlot.[22]

Using *MGA* feed supplements to synchronize females grazing open range or pasture is not recommended because adequate intake cannot be ensured.[23] This is especially true in the south during springtime, when females may have enough good grazing and, consequently, no appetite for supplemental feeds. Intake cannot be ensured unless animals are confined for the required 14-day feeding period.[6] Females unaccustomed to eating daily, hand-fed supplements may require a 7–14 day "training" period in which they are fed the supplement without *MGA*.[32] This helps ensure adequate consumption. After this time, *MGA* can be added to the supplement to begin treatment.[14]

Precautions and planning

Herd managers should read and follow product labels or prescribed directions before beginning any treatment. If products are used incorrectly, there will be low treatment response and low pregnancy rates. Some products cannot be used in lactating dairy cows.[23]

Use prostaglandins with extreme caution because they cause abortions in animals and humans. They are readily absorbed through the skin and cause breathing difficulties[33] avoid any contact with the skin. Wash accidental spills from skin immediately. After selecting a synchronization product, enter on a calendar the work schedule associated with that protocol.[23] The 1st day or days of insemination should coincide with the usual start of the breeding season. Once the program has begun, does not alter the schedule. Timing of injections and insemination days is critical to success.

On injection and insemination days, additional people may be needed to move cattle through chute, give injections, read ear-tags, thaw-semen, and inseminate cattle.

Remember, estrus-detection in synchronization can be confusing because of the frequent mounting activity. At least two or three observers should be used during each detection period.[23] Detection periods should last about 1 hour and occur 2–3 times each day. Applying heat mount patches (Kmar® or Estrus Alert®) may make finding estrous cows more efficient.[25] To reduce the confusion from repetitive mounting, females confirmed in estrus should be sorted from the others about midway through each observation period[25] The remaining females should be observed for the latter half of the hour and other estrous females sorted out of the pen.

Whether using "time mating" or estrus detection followed by AI, it is possible to inseminate many females in a concentrated period of time. However, depending on the herd size and insemination schedules, as many as four technicians may be needed.[33] Use only experienced technicians and allow them to alternate after every 10–15 inseminations to avoid exhaustion. Tired technicians are less effective. If "time mating" is used, AI technicians should either thaw semen or perform inseminations and not be asked to perform other duties.[18]

Contact the AI technicians several weeks before the beginning of the program. Professional technicians usually have a full schedule during spring and autumn and will need to coordinate their work schedules.[23] Buy all the necessary products, semen and equipment at least 10 days before treatment. Make sure the working facilities are in good order. Most programs require that females be put through the chute at least 3 times.

Keep accurate records of all activities. Use ear tag numbers to identify which sire was used on each female and to record her date and time of observed estrus.[23] It also may be necessary to record which AI technician performed each insemination to assess the technicians' efficiency. On insemination days, do not ask the record keeper to perform other duties. The record keeper must be alert and free from distractions because of the speed at which experienced technicians perform inseminations.[18]

Series of studies recommended that Handling cattle in a manner that reduces stress.[23] Work them quietly, avoid excessive prodding, and refrain from using dogs near the chutes. Stress has been shown to produce certain hormones that can impair reproduction.[18] Reducing stress may also improve the efficiency and attitudes of AI technicians, because most technicians prefer to inseminate cattle that are calm rather than those that are overly exited, although these may seem to be insignificant details to the program's success.[26]

Effective estrus synchronization programs

1. Shorten the breeding-season of AI: Cows or heifers are in estrus during a predictable interval that facilitates AI; Reduce time and labor required to detect estrus
2. Result in more cows and heifers becoming pregnant early during the breeding-season: Progestin-based programs can induce estrous-cyclicity in anestrous cows and prepubertal-heifers(For example: *MGA* (*CIDR*); progestins are progesterone-like compounds that act like progesterone
3. Result in older and heavier calves at weaning
4. Will have beneficial effects on the next breeding season such as: More cows and heifers-calve early; more days postpartum at the next breeding season; and replacement heifers will be older.
5. Consider what happens during a restricted breeding season, based on the average 21-day EC: If cows or heifers are cycling when an *ES* treatment is implemented and they exhibit estrus during the synchronized period, they would have three opportunities to conceive during a 45-day period or four opportunities during a 65-day period; if cows or heifers are

cycling but no estrus synchronization treatment is implemented, then they have only 2 (45-day) or 3 (65-day) opportunities to conceive; and if cows or heifers are not cycling at the beginning of the breeding season, they have even less opportunity to conceive.

SUMMARY AND CONCLUSION

ES is manipulation of the bovine EC to result in the majority of animals exhibiting standing estrus in a short period of time. It is a very effective method to increase the proportion of animals that are bred at the beginning of the breeding season. *ES*, as the name implies, is the manipulation of the EC to bring a group of females, at random stages of the EC, into estrus at a precise time.

ES can be a useful tool in the reproductive-management of a cow herd. However, if proper levels of nutrition, body condition, and health are not maintained, the program is likely to fail. Improvements in facilities and management may be necessary before implementing *ESP*.

Any one of many estrous synchronization protocols can be used to achieve good synchrony of estrus in your herd. To determine which synchronization protocol will work the best in your operation contact your local livestock educator or state livestock specialist.

ES may not be for every producer that the use of this technology generally requires skilled-management and adequate-facilities. Cows will respond poorly if not fed properly or if body condition is less than adequate. Level of herd-health is also a factor, as many diseases cause reproductive failure.

REFERENCES

1. Folman Y, Kaim M, Herz Z, Rosenberg M. Comparison of methods for the synchronization of estrous cycles in dairy cows. 2. Effects of progesterone and parity on conception. J Dairy Sci 2004;73:2817-25.
2. Archbald LF, Tran T, Massey R, Klapstein E. Conception rates in dairy cows after timed-insemination and simultaneous treatment with gonadotropin releasing hormone and/or PGF2α. Theriogenology 2012;37:723-31.
3. Tegegne A, Haile A, Ayalew W, Kebede N, Dessie T. Breeding Strategy to Improve Ethiopian Boran Cattle for Meat and Milk Production. Nairobi, Kenya: IPMS Improving Productivity and Market Success of Ethiopian Farmers Project Working Paper 26, ILRI; 2011.
4. Barr HL. Influence of estrous detection on days open in dairy herds. J Dairy Sci 2005;58:246-7.
5. Britt JS, Gaska J. Comparison of two estrus synchronization programs in a large confinement-housed dairy herd. J Am Vet Med Assoc 1998;212:210-2.
6. Bülbül B. Super Ovulation in Synchronized Cows. Karatay, Konya: Bahri Dağdaş International Agricultural Research Institute, Animal Breeding and Biotechnology; 2013.
7. Burke JM, De La Sota RL, Risco CA, Staples CR, Schmitt EJ, Thatcher WW. Evaluation of timed insemination using a gonadotropin-releasing hormone agonist in lactating dairy cows. J Dairy Sci 1996;79:1385-93.
8. Burton LJ, McDougall S, Jolly PD. Treatment of noncyclic lactating dairy cows with progesterone and estradiol or with progesterone, GnRH, prostaglandin F2 alpha and estradiol. J Dairy Sci 2000;83:464-70.
9. Looney CR, Nelson JS, Riano EH, Forest DW. Estrus Synchronization Methods For Embryo Transfer in *Bos indicus* Cattle. Texas: Ovagenix, Bryan, TX and Department of Animal Science, Texas A&M University, College Station; 2005.
10. Chenault JR. Pharmaceutical control of estrous cycles. In: Van Horn HH, Wilcox CJ. Large Dairy Herd Management. Netherlands: Elsevier; 1992. p. 153-63.
11. Chenault JR, Boucher JF, Dame KJ, Meyer JA, Wood-Follis SL. Intra-vaginal progesterone insert to synchronize return to estrus of previously inseminated dairy cows. J Dairy Sci 2003;86:2039-49.
12. Deutscher GH. Beef Cattle Handbook. Estrous Synchronization for Beef Cattle. BCH-2320, University of Wisconsin-extension, Cooperative Extension Service; 1990. Available from: http://www.iowabeefcenter.org/pdfs/bch/02320.pdf.
13. Troxel TR. Synchronization of Estrus in Cattle. Little Rock: University of Arkansas Division of Agriculture; 2012.
14. El-Zarkouny SZ, Cartmill JA, Hensley BA, Stevenson JS. Pregnancy in dairy cows after synchronized ovulation regimens with or without presynchronization and progesterone. J Dairy Sci 2004;87:1024-37.
15. Fericke PM, Caraviello DZ, Weigel KA, Welle ML. Fertility of dairy cows after resynchronization of ovulation at 3 intervals following first timed insemination. J Dairy Sci 2008;86:3941-50.
16. Fricke PM. Ovsynch, Pre-synch, and the Kitchen-Synch: What's up with Synchronization Protocols? Madison: University of Wisconsin Extension; 2003.
17. Fricke PM, Guenther JN, Wiltbank MC. Efficacy of decreasing the dose of GnRH used in a protocol for synchronization of ovulation and timed AI in lactating dairy cows. Theriogenology 1998;50:1275-84.
18. Geary TW, Whittier JC. Modification of the Ovsynch estrous synchronization protocol for use in beef cows. J Anim Sci 1997;75:236.
19. Ginther OJ, Kot K, Kulick LJ, Wiltbank MC. Emergence

and deviation of follicles during the development of follicular waves in cattle. Theriogenology 1997;48:75-87.
20. Gyawu P, Ducker MJ, Pope GS, Saunders RW, Wilson GD. The value of progesterone, oestradiol benzoate and cloprostenol in controlling the timing of estrus and ovulation in dairy cows and allowing successful fixed time insemination. Br Vet J 1991;147:17182.
21. Heersche JG, Nebel RL. Measuring efficiency and accuracy of detection of etrusrus. J Dairy Sci 1994;77:2754-61.
22. Jobst SM, Nebel RL, McGilliard ML, Pelzer KD. Evaluation of reproductive performance in lactating dairy cows using three systematic breeding protocols: 14-d PGF, timed. J Dairy Sci 1999;83:2366-72.
23. Johnson S, Stevenson J. Tips for a Successful Synchronization Program. Kansas: Kansas State University Agriculture Experiment Station and Cooperative Extension Service; 2006.
24. Lamb GC, Stevenson JS, Kesler DJ, Garverick HA, Brown DR, Salfen BE. Inclusion of an intravaginal progesterone insert plus GnRH and prostaglandin F2α for ovulation control in postpartum suckled beef cows. J Anim Sci 2005;79:2253-9.
25. Lucy MC. Controlling the Estrous Cycle with Progesterone. Proceedings of the Society for Theriogenology. Nashville, TN: Society for Theriogenology; 2002. p. 211-9.
26. Lucy MC, Savio JD, Badinga L, De La Sota RL, Thatcher WW. Factors that affect ovarian follicular dynamics in cattle. J Anim Sci 1999;70:3615-26.
27. Meyer JL. Estrus and fertility rates to AI or ET after Estradiol or Estradiol and Progesterone Administration in Combination with a Controlled Internal Drug Release Insert. Texas: Texas A&M Thesis; 2002.
28. Meyer JA, Wideman D Jr., Looney CR, Anderson JC, Forrest DW. Embryo production rates of cattle superovulated with and without the presence of an intra-vaginal progesterone releasing device. Theriogenology 2000;53:504.
29. NADA. Progesterone EAZI-BREED™ CIDR® Cattle Insert, Supplemental New Animal Drug Application. Freedom of Information Summary, July 29, Package Insert, EAZI-Breed™ CIDR® Cattle Insert. New Delhi: NADA; 2006. p. 141-200.
30. NADA. Progesterone EAZI-BREED™ CIDR® Cattle Insert, Supplemental New Animal Drug Application. Freedom of Information Summary, July 29, Package Insert, EAZI-Breed™ CIDR® Cattle Insert. New Delhi: NADA; 2006. p. 141-200.
31. NDBQA. Producers Manual. North Dakota State University, Cooperative Extension Service; 1999. Available from: http://www.ag.ndsu.nodak.edu/bqa/manual/Bqa-pm.html.
32. Pursley JR, Garverick HA, Fricke PM, Kesler DJ, Ottobre JS, Wiltbank MC, *et al*. Improved fertility in an ovulatory lactating dairy cows treated with exogenous progesterone during Ovsynch. J Dairy Sci 2001;89:2567-78.
33. Rhodes FM, McDougall S, Burke CR, Verkerk GA, Macmillan KL. Review: Treatment of cows with an extended postpartum anestrous interval. J Dairy Sci 2003;86:1876-94.
34. Vasconcelos JL, Silcox RW, Rosa GJ, Pursley JR, Wiltbank MC. Synchronization rate, size of the ovulatory follicle, and pregnancy rate after synchronization of ovulation beginning on different days of the estrous cycle in lactating dairy cows. Theriogenology 1999;52:1067-78.
35. Wiltbank MC. Regulation of the Bovine Estrous Cycle. Nashville: Proceedings of the Society for Theriogenology; 2002. p. 185-198.