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A REVIEW OF ESTRUS SYNCHRONIZATION TECHNOLOGY IN CATTLE

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SUMMARY

Manipulation of the oestrous cycle by the use of synchronizing agents to enhance the function of the reproductive organs has proved beneficial to livestock production. Estrus synchronization has enabled a large number of cows to be bred at the same time with subsequent calving at a predictable time. Various estrous cycle synchronizing agents have been used with varying success. These synchronizing agents include progesterone compounds like PRID(R) (Sanofi, UK), CIDR-B(R) (Carter Holt, New Zealand) and Synchromate B(R) (Intervet, Holland) which extend the life span of the Corpus Luteum (CL) and luteolytic agents like Lutalyse(R) Upjohn, USA) and Estrumate(R) (ICI, UK) which shorten the life span of the corpus luteum. This paper discusses the various synchronizing agents and methods used to control the estrous cycle in order to increase reproductive efficiency in cattle.

KEY WORDS: Oestrus, Oestrous cycle, Oestrus synchronizing agents, Cattle.

INTRODUCTION

In many developing countries there is an acute and increasing shortage of carbohydrates and protein for human consumption. The average daily consumption of animal protein per head in these countries is sub optimal and insufficient to meet the minimum required for normal growth and development. Improved reproductive performance of our indigenous livestock is therefore essential in order to increase dairy and beef output to meet this ever-increasing demand. Poor reproduction in livestock enterprises is influenced by such factors as management, nutrition, climate and disease. In order to reverse this situation it is important to initiate sustainable strategic reproductive management of our livestock applicable at the farm level.

The possibility of inducing estrus and ovulation in anoestrus females and of synchronizing estrus and ovulation in a group of females offers an excellent opportunity to enhance the efficiency of animal production and facilitate the use of artificial insemination (AI). Reproductive efficiency of animals will increase as a result of early conception and reduced inter calving interval. Livestock in developing countries including Nigeria are generally raised under range conditions. In this situation the time of occurrence of estrus necessary for breeding female animals cannot be predicted with any certainty.

Running a male of the species with a group of females for heat detection and breeding has been the practice for many years. However, where supervised breeding or AI is to be used, it is important to know when a female will be in estrus. Oestrous detection requires time, labor, skill, and errors may usually occur. If domestic animals could be in estrus and ovulate within a given time period the problems mentioned above will be avoided. It is no longer in doubt that even in Nigeria the possibility of synchronizing estrus and ovulation in farm animals with use of exogenous hormones exist. The objectives of estrus synchronization programme are: (1) to be able to predict in advance the day and time a group of females is ready to be bred and (2) to obtain normal fertility at synchronized oestrous.

In normally cycling domestic female animals, CL produces P4, which prepares the endometrium for reception of fertilized ovum/ova; when there is no fertilization, the uterine muscle produces PGF 2 alpha, which stimulates luteolysis. This process triggers the hypothalamus to produce GnRH leading to production of FSH and LH that induce follicular development and maturation leading to oestrogen production, exhibition of oestrus and with the assistance of a sudden rise and fall in the level of (LH surge) that brings about ovulation. Thus the regulation of the oestrous cycle in animals implies controlling the life span of the corpus luteum. Oestrous synchronization can be achieved through two main methods namely: (1) the use of luteolytic agent to shorten the life span of the corpus luteum (luteolysis) and (2) the use of progestational compounds to extend the life of or substitute for the corpus luteum in order to suppress estrus and ovulation until removal of the progestogen.

The effectiveness of these two methods alone or in combination to synchronize the bovine estrous cycle will be the focus of this paper.

Progestins

Several studies have been conducted to determine the efficacy of different progestational agents alone or in combination with estrogens to synchronize estrus and ovulation in cattle. Different routes of administration have also been studied. 6-methyl-17-acetoxyprogesterone (MAP) has been shown to effectively inhibit oestrous and ovulation in cattle during feeding (Hansel et al., 1961). However, long-term MAP exposure resulted in reduced conception rates. (Hansel et al., 1966). In contrast Hansel et al. (1966) observed similar conception rates between untreated control beef cows and those fed MAP either as a liquid feed or pelleted form for 18 days. Cows fed 6-chloro-6-dehydro-17-acetoxyprogesterone (CAP) had lower synchronized pregnancy rates than contemporary cows fed MAP (Hansel et al., 1966). Oxytocin (Hansel et al., 1966), estradiol (Hansel et al., 1961), injected at the time of AI after MAP withdrawal and estradiol benzoate (Schechter et al., 1969) given 20 hrs after MAP withdrawal did not improve fertility at the synchronized estrus. Roche (1974) inserted silastic implants which contain 4g progesterone into the dewlap of beef heifers for 20 days. 93% exhibited oestrous within three days of implant removal but conception rates were low (57%) compared to a reduced treatment time of 10 days (82%). Melengesterol acetate (MGA) (6-methyl-17-alpha-acetoxy-16-methylene-pregn-4, 6-dinene-3, 2-Dione) and orally active progestational steroid was developed in 1962 for use in feedlot heifers to improve feed efficiency and weight gain (Patterson et al., 1989). MGA inhibited estrus and ovulation, while allowing follicular development (Adeyemo et al., 1979 and Anyam et al., 1995). MGA is an analog of MAP but several times more potent than MAP (DeBois and Bierschwa, (1979). The interval to oestrous after MGA fed at 0.2-0. 6mg/day/animal were similar to that for MAP fed at a dosage of 150-500mg/animal/day (Hardin et al., 1979). The interval to estrus following MGA withdrawal varies with the dosage fed (Hardin et al., 1980). The route of administration either orally or intravenously did not influence potency.

The early studies using MGA as a method of synchronizing estrous in beef cattle took place in the mid-1960's. Cycling cattle were fed MGA for 10-20 days at levels of 0.5-1mg (Hardin et al., 1980). Most studies reported a high estrus response rate within the synchronized period; even though conception rates were lower than untreated control females (Henriks et al., 1973). However, (Roussel et al., 1969) reported normal fertility. Research scientists also attempted to more precisely control the timing of ovulation in cattle by combining MGA with gonadotropins, estrogens and oxytocin (Smith and Zimberman, 1968a, 1968b, 1968c) and prostaglandin F2 alpha treated heifers than those given a single injection of prostaglandin F2 alpha. They suggested an extended inter ovulatory period as being responsible for the low conception rate. Physiological changes, which occurred due to increased oestrogen levels from progesterone treatment, are the subject of a review by Patterson et al. (1989).

The synchro-mate-B (SMB), estrus synchronization system consists of the synthetic Progestogen, Norgestomet (Hafs et al., 1974) (alpha-acetoxy 1-11 beta-methyl-19 nor-pregn-4-ene-3, 20-dione) and oestradiol valerate. A 6mg norgestomet ear implant is inserted for 6-9 days with or without a 5mg Oestradiol valerate and 3mg Norgestomet administered at implant insertion. The Norgestomet implant acts as a corpus luteum while the Norgestomet and Oestradiol valerate injection either regress the natural corpus luteum or inhibits a new corpus luteum from forming (Pratt et al., 1991). SMB is approved for use in dairy and beef heifers and postpartum beef cows (Odde, 1990). A high percentage of SMB treated cows and heifers exhibited oestrous following implant removal (Pratt et al., 1991). However, fertility of the synchronized estrus was variable (Brink and Kiracofe, 1988). Most studies seem to indicate that the conception rate depends on the day of the estrous cycle when the study was initiated. Mikeska and Williams (1988) found no significant difference in conception rate regardless of whether the study was initiated before or after day-11 of the oestrous cycle. The mean interval to estrus following implant withdrawal was found to be 30-40 hrs and high estrus synchrony, which will be advantageous for, timed insemination. These studies show the effectiveness of SMB for inducing estrus in treated cattle. However, the variability in conception rates following treatment seems to be the major disadvantage of the SMB system. In addition, adequate facilities for handling are required for implant insertion and removal.

Intra-vaginal progesterone

Progesterone releasing intra-vaginal devices (PRID) (McPhee et al., 1983) and controlled internal drug release-bovine (CIDR-B) devices (Macmillan et al., 1991) have been shown to successfully release progesterone at a fairly predictable rate. These two devices have been studied as methods for oestrous synchronization as well as for studying follicular dynamics (Macmillan et al., 1991). The PRID is a stainless steel coil coated with a silicone rubber containing 6.75% progesterone (Smith et al., 1984). Insertion of PRID for 7 days with a prostaglandin F2 alpha injection 24 hrs prior to device removal resulted in similar or higher conception rate than the prostaglandin F2 alpha injection method (Smith et al., 1984). Smith et al. (1984), Voh Jr. et al. (1987a), Brink and Kiracofe (1988) have studied the use of prostaglandin F2 alpha either on the day of PRID removal or one day prior to PRID removal. Although similar conception rates were observed between the two treatment groups, the 24 hours delay in PRID removal improved the synchrony of the estrus and resulted in a lower variance for the interval to oestrous. Folman et al. (1983) inserted PRID with estradiol benzoate capsule attached in lactating dairy cows. He found longer interval to estrus in PRID-estradiol treated cows but no difference in conception rates between this treatment group and cows treated with PRID-Prostaglandin F2 alpha or untreated controls.

The CIDR-B device is a nylon spine coated with a silicone based elastomer-containing 1.9g of progesterone (Macmillan and Peterson, 1990). Short and long-term treatments with the CIDR have been studied for oestrous synchronization. Longer treatment periods (14-21 days) resulted in a high degree of estrus synchrony but reduced fertility at the synchronized estrus (Macmillan and Peterson, 1990). Like the PRID, prostaglandin F2 alpha have been used in combination with the CIDR to more precisely control estrus synchrony (Macmillan and Peterson, 1990, Broadbent et al., 1993, Anyam, 1995). Macmillan and Peterson (1990) found a conception rate of 58% in heifers treated with CIDR devices for 7 days and the prostaglandin F2 alpha injected at device removal. While Anyam et al. (1995) found no signs of vaginitis. Broadbent et al. (1993) indicated less discomfort than the PRID. Many research workers have found similar progesterone levels in PRID and CIDR treated animals (Munro, 1987, Macmillan et al., 1991). Results from PRID and CIDR studies suggest that short-term treatment combined with a luteolytic agent appear to be the most effective method for synchronizing oestrous and ovulation as well as obtaining acceptable conception rates.

Prostaglandin F2 alpha and Analogs

Manipulating the estrous cycle of the cow is dependent on being able to control the lifespan of the corpus luteum. Various factors are known to affect the lifespan of the corpus luteum of domestic animals. These include injections of oxytocin, estrogens, foreign bodies in uterus, irrigation of uterus with irritants such as iodine solutions or benzyl alcohol, LH antibodies and prostaglandins. Out of these, the most widely used is prostaglandin F2 alpha (Hafs et al., 1974). A luteolytic agent such as prostaglandin F2 alpha or one of its analogs used to regress the corpus luteum and induce estrus in the female.

Prostaglandin F2 alpha is an unsaturated 20-carbon fatty acid (Inkeep, 1973) that has two double bonds and a hydroxyl group at the 9-and 11 alpha positions (Bergstorm et al., 1968). It has been shown that the uterus is responsible for regressing the corpus luteum in cattle, sheep, dogs and horses (Inkeep, 1973). Prostaglandin F2 alpha is present in high concentrations in the uterus (Inkeep, 1973).

Prostaglandin F2 alpha has been shown to inhibit progesterone production by the rabbit corpus luteum when cultured in vitro (Grady et al., 1972). Prostaglandin F2 alpha (LutalyseR), cloprosterol (EstrumateR), and ferporstalene (BovileneR) are three prostaglandin products currently approved by FAO (Odde, 1990).

Prostaglandin F2 alpha is ineffective for inducing luteal regression before day 5 of the estrous cycle (Roche, 1974). It was ineffective when injected on day 1 to 4 of the cycle. King et al. (1988) and Chenault et al. (1990) showed a decrease in estrus response and conception rates when beef and dairy heifers were injected with prostaglandin F2 alpha before day 10 of the oestrous cycle. The effectiveness of prostaglandin F2 alpha therefore depends on the age of the corpus luteum (Beal and Peterson, 1984), with treatment being more effective after day 10 because of increased concentration of prostaglandin F2 alpha receptors on the corpus luteum (Shipley et. al., 1988)

Different methods for synchronization that utilize prostaglandin products are available to cattle producers. One method consists of two-25mg prostaglandin F2 alpha injection given intramuscularly 10-12 days (Graves and Dziuk, 1968, Adeyemo et al., 1979) or 10-14 days (Voh Jr et al., 2001) apart and all females are bred after the second injection. At the time of the second injection the majority of cattle should have a functional CL that is susceptible to luteolysis. Various conception rates have been obtained when cows and heifers are inseminated 72 hrs or 80hrs (Hansel et al., 1961), 72hrs and 96hrs (Adeyemo et al., 1979) after second injection. Interval to oestrous after second injection has been reported to be shorter in heifers (54hrs) than in cows (62hrs) (King et al., 1982). King et al. (1982) also reported decrease in intervals to estrus when injections are before day 10 of the estrous cycle.

A second method to regulate oetrus in cattle is to inject all females and inseminate those that exhibit estrus (Burfening et al., 1978). Females that do not exhibit oestrous are then given a second injection 11 days after the first injection and insemination at a fixed time after the second injection. Here less prostaglandin is required than the two-injection method.

A third method is to inject once those females carrying a corpus luteum and inseminate at observed estrus or twice at 72hrs and 96hrs (NAPRI, Unpublished data).

Different prostaglandin analogs have been used in estrus synchronization of cattle with varying success. These include cloprostenol (Roche, 1976, Hardin et al., 1980), fenprostalene (Herchler, 1983) Alfaprostol (Kiracofe, 1985) and Estrumate (Roche, 1976).

Researchers have attempted to improve estrous response and fertility following prostaglandin treatment by combining this drug with HCG (Shipley et al., 1988), estradiol benzoate (Figueroa et al., 1988) and GnRH (Burfening et al., 1978). In all these reports response either increase, remained the same or reduced but the conception rates were generally not affected. The use of a prostaglandin agent to regulate the bovine oestrous cycle is fairly inexpensive and easy to administer if proper handling facilities are available as in developed countries. However, for less developed countries the method may be regarded expensive since the drug is imported coupled with a general absence of adequate facilities for the programme.

Progesterone-prostaglandin Combinations

This has already been discussed earlier. Important research works include norgestomet-prostaglandin F2 alpha (Heersche et al., 1979, Deletang, 1975), SMB or norgestomet and prostaglandin F2 alpha (Beal and Peterson, 1984), PRID-prostaglandin F2 alpha (Voh Jr. et al., 1994, Voh Jr. et al., 2001, Voh Jr. et al., 2004a/b) and CIDR-prostaglandin F2 alpha (Anyam et al., 1995). In a study by Voh Jr et al., (2004a), 184 non-suckled cycling Bunaji cows were randomly allotted to four treatment groups of 46 animals each: group 1 {PRID-12}, PRID inserted for 12days; group 2 (PRID + 7 + PGF 2 alpha),PRID was inserted for 7 days and PGF 2 alpha administered intramuscularly 1 day prior to PRID withdrawal, group 3 (PRID-7 + PGF 2 alpha-7), PRID was inserted for 7 days and PGF 2 alpha on the day of PRIOD withdrawal and group 4 (2 X PGF 23 alpha-13), two intramuscular injections of PGF 2 alpha 13 days apart. At the end of each treatment period the cows were observed for 7 days for behavioral oestrus and were inseminated 12hrs following detection of oestrous. Fertility rate determined by rectal palpation 30-40 days post AI were 37.1%, 41.3%, 52.2% and 52.2%, and conception rates were 50.0%, 54.3%, 60.3% and 58.6% for groups 1-4. The results of the study confirmed effectiveness of the four regimes in synchronizing and controlling oestrus and ovulation in Bunaji cows. The results of this study provide options for synchronizing oestrous for herd health fertility programmes.

Most of these studies have reported better response and higher conception rates over other methods of estrus synchronization already described. Short-term Progestogen administration (6-9 days) with prostaglandin F2 alpha injections either 24hrs before or on the day of Progestogen withdrawal have also been studied (Anyam et al., 1995, Voh Jr. et al., 2004a). Long-term (13-14 days) Progestogen administration and prostaglandin F2 alpha injection 16 days after Progestogen withdrawal has been reported (King et al., 1988, Voh Jr. et al., 2001, Voh Jr. et al., 2004a/b). Although the method is very expensive since it requires the use of more drugs compared to other systems particularly for third world countries, development of progesterone-prostaglandin F2 alpha combination appears to show the most promise for future estrus synchronization programme.

CONCLUSION AND RECOMMENDATIONS

In all these, variability result due to such factors as season, level of management, level of nutrition, synchronization regimen selected, and available time for heat detection and necessary facilities for handling animals. The producer must properly evaluate his preparedness before embarking on estrus synchronization programme. In order to obtain good results the drug should also be properly administered.

If the livestock industry is willing to increase production producers will need to utilize new technologies that have become available to them such as estrus synchronization. Despite remarkable advances in oestrous cycle regulation, variability, low first service conception rates after treatment still exist for long-term and medium-term treatments which have been compounded by a high incidence of early embryonic death and abnormalities of the ovum. It is therefore recommended that further studies should be conducted into those factors controlling artificial oestrous cycle regulation.

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