SYNCHRONIZATION OF OESTRUS IN INDIGENOUS GOATS: THE USE OF DIFFERENT PROGESTAGEN TREATMENTS

by

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DEDICATION TO MY FAMILY AND FRIEND

- *My parents, Masehloho and Letele, for their love, inspiration and guidance in life. I could not have a better education.*

- *My friend Mike, for the support, encouragement and help throughout this study. Above all, thank you for loving me and being my friend in these hard times.*

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DECLARATION

I hereby declare that this dissertation submitted by me to the University of the Orange Free State for the degree, **Magister Scientiae Agriculturae**, has not previously been submitted for a degree to any university. I further cede copyright of the dissertation in favour of the University of the Orange Free State.

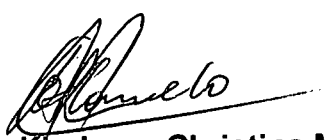

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER 1

GENERAL INTRODUCTION

Due to the rapid population growth and limited available resources, poverty is escalating in developing countries and rural communities cannot afford sufficient animal protein to satisfy their minimum nutritional needs. As a result, malnutrition in humans and its related diseases (kwashiorkor and marasmus) are common in rural areas. Similarly, protein deficiency in growing children result in impaired immune responses, causing a higher susceptibility to diseases. One of the main factors contributing to this protein shortage is low animal production in these areas, due to poor management practices, resulting in low productive performances.

There is an urgent need to improve livestock production in general and particularly ruminant production in developing countries. Ruminant production in cattle, sheep and goats has the advantage of not competing with humans in terms of nutrients. These animals have the unique capacity to be able to convert grasses and plant material with no nutritional value for humans into high quality animal protein (milk and meat) and other animal byproducts (skins, wool, hair and dung).

Goats have the advantage of being hardier, less selective to diets than other ruminants, less labor intensive and can more readily tolerate poor nutritional environments and even certain toxic plants. Besides these advantages, goats generally have a high fecundity and lower nutritional maintenance requirements due to their smaller frame size. Goats are essentially browsers and therefore can additionally utilize bushes in their diet (Mackenzie, 1980; Devendra & Burns, 1983). These small ruminants are often incorporated into an integrated mixed farming system (with cattle or sheep), as they minimally compete for grasses and thus a more efficient utilization of the available nutritional resources is made. The role of goats in controlling bush encroachment is well recognized and extensively practiced (Orodho *et. Al,* 1999).

Goats are also more affordable and available to the resource poor farmer in the rural areas. This is the main reason why small-scale farmers for meat and milk production maintain the majority of goats in South Africa. This is one of the reasons why goat production and research has been neglected in the past and very little attention has been given to optimize the productive potential of this unique specie. In these areas, goats are generally exploited under traditional farming systems, where poor management practices and low productivity prevail. That is why goats are often referred to as the poor man's cow. The fact that goats have a considerable contribution to make in the social upliftment of the rural African communities is a reality that can not be denied and its socio-economic importance in this regard must not be underestimated.

Reproduction is one of the main factors influencing the animal production in general. Any attempt to improve animal production should take into consideration the optimization of the reproductive potential of the animals or its genetic merit. Environmental factors, such as nutrition and management determine to what extent this potential is expressed and utilized.

One of the tools available to the farmer for improving the productive potential of goats is the use of genetically superior animals by means of controlled breeding techniques, for example synchronization of oestrus and artificial insemination (AI.).

Oestrous synchronization or control of ovulation is the basis of controlled breeding techniques or methods used to manipulate the reproductive performance in farm animals. According to Van Der Nest (1997), synchronization of oestrus is a prerequisite for artificial insemination (AI); superovulation and embryo transfer programmes, which are used to achieve, accelerated genetic progress. Control of oestrus in farm animals offers the opportunity to increase the efficiency of animal production and is accompanied by an increase in the use of artificial insemination (Ahmed *et al.*, 1998; Greyling & van Niekerk, 1991). Oestrous synchronization also allows

the farmer the opportunity to concentrate births at a favourable time of the year, thus optimizing the nutritional management and allowing better supervision at birth. Out of season breeding is also made possible by controlled breeding and oestrous synchronization (Gordon 1983). The end result of these breeding programmes will be an increased number of offspring with surplus animals to supply meat and milk for human consumption.

Most AI programmes in goats incorporate oestrous synchronization using different progestagens, with or without follicle stimulating agents. Most of these breeding techniques have been developed in Europe for European breeds under temperate climates, where efficient synchronization is achieved, with acceptable ovulation rates both during the breeding season and during the seasonal anoestrous period (Haresign, 1978; Thimonier, 1979). However, these programmes are not always compatible and do not always produce the same results in indigenous goat breeds under varying South African conditions. Greyling and Van Niekerk (1991) reported conception rates of 73.3% in Boer goats following oestrous synchronization and AI, while Greyling and Van Der Nest (2000) obtained conception rates ranging between 65 and 80% in indigenous feral goats. Environmental factors could affect and play a major role in limiting the use of controlled breeding techniques such as synchronization and AI, thus delaying genetic improvement and more efficient goat production. Lack of data on controlled breeding in South African goats calls for the need to evaluate the efficiency of different synchronization treatments in all goat breeds, in order to increase production and develop a more efficient oestrous synchronization programme for goats in South Africa. This study was therefore, aimed at comparing the use of different progestagen treatments for oestrous synchronization in indigenous South African goat breeds, in an effort to increase reproductive efficiency.

CHAPTER 2

LITERATURE REVIEW

2.1 SYNCHRONIZATION OF OESTRUS

2.1.1 Introduction

Goats are considered to be unique in their ability to adapt to harsh conditions as it is experienced in rural small-scale farming communities. To exploit this positive trait and improve goat production in the rural areas, it is necessary to focus on aspects such as, the low reproductive efficiency experienced in these herds. This can be achieved by the adoption of acceptable nutritional and reproductive managerial practices. By the use of controlled breeding (for example, the use of oestrous synchronization and AI) and improved nutritional management, goat production can be increased through reproductive performance and lower perinatal losses. This improved production obtained, could increase the availability of animal protein (meat and milk) to the rural communities and lead to a decrease in the occurrence of under or malnutrition, as well as improving the financial status of the people.

Recent advances at improving the reproductive performance of farm animals have resulted in extensive research in the field of endocrinology, where researchers have realized that certain natural reproductive processes can be manipulated to the advantage of better reproductive performances. Oestrous synchronization is an example of such physiological manipulation of the female reproductive processes.

2.1.2 Endocrinology of the oestrous cycle

The oestrous cycle can be defined as the period between two consecutive oestrous periods. These cycles start at puberty. At puberty the ability of very low concentrations of steroids (oestrogens) secreted by the prepuberal gonad to inhibit neurosecretion of gonadotrophins releasing factors by the hypothalamus is gradually removed as the sensitivity to this negative

feedback diminishes towards the end of the prepuberal period (Hunter, 1980). Eventually, the gonadotrophins produced by the anterior pituitary are in concentrations high enough to initiate follicle growth and ovulation (Bearden & Fuquay, 1980; Rhind, 1992). In female goats, the onset of puberty depends on age, body size (weight) and at higher latitudes, where the breeding activity is seasonal, short day photoperiod is a triggering factor. Goats which fail to have the necessary minimum body weight before the end of the first natural breeding season after birth, have a delay in the onset of puberty until at least the following breeding season when the animals attain a critical live weight (Riera, 1982; McCall *et al.,* 1989; Wolde-Michael *et al.,* 1989).

The duration of the oestrous cycle in goats is 18 to 21 days and it varies depending on season, latitude and breed (Devendra & Burns, 1983). According to Gordon (1997), 77% of the cycle is normal (17 to 25 days), 14% are classified as short (<17 days) and 9% as long oestrous cycles (>25 days). In a study carried out by Llewelyn *et al.* (1993), in Zimbabwe, the distribution of normal and extended cycles was significantly influenced by season. The proportion of normal cycles was highest in the cool dry months (June to August) and was lowest during the hot, rainy months (September to February). According to Ott (1986), short oestrous cycles should be regarded as a natural phenomenon, especially early or late in the breeding season. For goats in the tropics, short oestrous cycles are associated with short oestrous periods, which is in agreement with earlier studies in temperate zones (Cerbito *et al.*, 1995).

The oestrous cycle can be divided into four periods namely, the oestrous, met-oestrous, di-oestrous and pro-oestrous periods (Table 2.1). These periods occur in a cyclic and sequential manner, except for the period of anoestrus (absence of cyclic activity) in between breeding season in goats (Bearden & Fuquay, 1980).

Table 2.1 Stages of the oestrous cycle (Greyling, 1999)

Periods	Days	Duration	Principal features
Oestrus	1	34-38 hours	Behavioral signs of oestrus
Met-oestrus	2-4	2-3 days	Ovulation and corpus luteum formation
Di-oestrus	5-16	10-14 days	Corpus luteum function
Pro-oestrus	17-21	3-4 days	Rapid follicle growth

The most important period of the oestrous cycle, is oestrus, especially for artificial insemination and mating programmes. Oestrus is the period of time when a female is receptive to the male and will stand to be mated (Bearden & Fuquay, 1980). During this period progesterone concentrations in the goat doe are extremely low (Greyling & Van Niekerk, 1990a). For example, in native and crossbred goats of Venezuela, serum progesterone concentrations were found to be lower than 1ng/ml during the oestrus period (Leyva-Ocariz *et al.,* 1995). According to Evans and Maxwell (1987), the duration of the oestrous period varies between 16 and 50 hours in goat does. This period also varies with breed, age, geographical location and contact with males. In the humid tropics, Chibooka et al (1988) reported the duration of oestrus in West African dwarf goats to be 33 hours. In the Boer goats the oestrous period appears to be variable in length. A duration of 37.4 ±8.6 hours, with a variation of 24 to 56 hours between animals has been reported (Greyling, 1988). In the studies of Romano (1993; 1994a; 1994b), Romano and Fernandez Abella (1997) and Akusu and Egbunike (1990), working on Nubian and West African dwarf goats, respectively, significant reduction in the duration of oestrous period was shown by the presence of the buck. The duration of oestrus is shorter in young does (18 to 30 hours), compared to mature does (20 to 40 hours) (Evans & Maxwell, 1987).

In most tropical goat breeds, oestrus occurs all year round, whilst in the temperate regions, goats undergo a period of reproductive inactivity called anoestrus. Anoestrus is the period of sexual rest, during which ovarian activity is low. Sexual activity in temperate goat breeds is governed by photoperiod, with oestrus activity commencing during the period of decreasing day light length (autumn) (Evans & Maxwell, 1987; Jainudeen & Hafez, 1987).

Knowledge of the basic endocrinology of the oestrous cycle in farm animals is necessary to understand the techniques used to manipulate the reproductive activities. This knowledge would allow such techniques as synchronization or induction of oestrus to be performed at the most appropriate time in order to achieve effective manipulation of the female reproductive cycle and, hence, achieve maximum fertility or conception.

A reciprocal balance between the steroid hormones of the ovary and the gonadotrophins of the anterior pituitary principally regulates the oestrous cycle. In all livestock species the oestrous cycle is divided into two phases, namely, a luteal and follicular phase (Figure 2.1). The duration of the cycle and time of ovulation varies between females (Hafez, 1987).

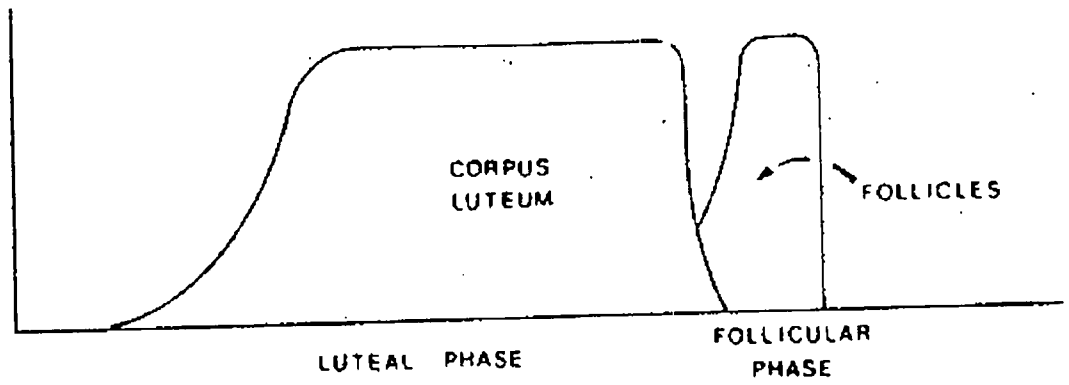


Figure 2.1 The two phases of oestrous cycle (Hunter, 1980)

The follicular phase of the oestrous cycle is characterized by the growth and development of ovarian follicles and by a decline in progesterone

concentration associated with the regression of the CL (Gordon, 1997). It is well known that the neural control of the oestrous cycle is exerted primarily by the secretion of gonadotrophin-releasing hormone (GnRH) from the hypothalamus into the hypophyseal portal vessels. During the follicular phase, the action of GnRH stimulates the release of luteinizing hormone (LH), which is necessary to maintain the gonadal function (Clarke & Cummins, 1982). The rise in serum LH will stimulate the secretion of oestradiol from the ovarian-follicles and oestradiol, in turn, will lead to a preovulatory LH surge, which causes ovulation and initiates luteinization (Karsch *et al.,* 1977).

During the luteal phase of the oestrous cycle, when the corpus luteum is secreting progesterone, tonic gonadotrophin secretion prevails. Progesterone concentrations are high at this time and can be as high as 10ng/ml and 12ng/ml on days 12 and 15 of the oestrous cycle, respectively (Leyva-Ocariz *et al.*, 1995). In Boer goats, serum progesterone concentrations are reported to be lower than 1ng/ml (Greyling & Van Niekerk, 1990a). Progesterone plays an important role in preventing the LH peak discharge (Thimonier, 1979; Baird *et al.,* 1976). At this stage the LH frequency is reported to occur as low as once every 3 to 10 hours (Baird & McNelly, 1981; Karsch *et al.,* 1983). Oestradiol secretion on the other hand is maintained at low level and appears to synergise with progesterone to limit LH secretion (Karsch *et al.,* 1980).

At the end of the di-oestrous period, the concentration of venous prostaglandin-F2α (PGF2α), as described by Thimonier (1979) and Bearden and Fuquay (1980), increases and causes regression of the corpus luteum (CL) and an eventual drop in plasma progesterone levels. The frequency of LH pulses increase gradually throughout the follicular phase (Baird, 1978; Wallace *et al.,* 1988; Picton *et al.*, 1990), until oestrus is exhibited. During this phase there is also a gradual increase in the secretion of oestradiol from the ovarian follicles (Baird, 1978; Karsch *et al.,* 1977; Baird & McNelly, 1981), which triggers oestrus and the LH surge (Clarke *et al.,* 1987).

2.1.3 Techniques used for oestrous synchronization and the principles underlying these techniques

There are several advantages for implementing oestrous synchronization. It will, for example, permit the farmer to schedule livestock handling and breeding times to fit in with the work schedule and other required activities (Gordon, 1983). In goats, it also allows scheduling of the kidding season to a time when forage growth and nutritive content of the pastures are good for the animals. This will result in improved milk production and consequently a higher kid survival and growth rate (Baril & Saumande, 2000). By having a number of females in oestrus during a very short period of time insemination/mating and parturition activities can be restricted to a very short time (Van Rensburg, 1973; Gordon, 1983), thus facilitating the management. Furthermore, oestrous synchronization creates the opportunity for artificial insemination (AI) to be performed at a fixed time and to ensure that adequate numbers of animals are in oestrus at AI (McDonald, 1976; Bearden & Fuquay, 1980; Hunter, 1980; Waldron, *et al.,* 1999). Due to the fact that oestrous detection is prone to human error, controlled oestrous practices (synchronization) will allow the farmer to predict the time of oestrus with reasonable accuracy and also reduce the time consuming exercise of oestrous detection and make AI more acceptable (Ahmed, *et al.,* 1998). Synchronization of oestrus can also help mature animals that do not visually show intrinsic reproductive rhythms and other animals in the flock, to impose their reproductive rhythms within the desired timetable of breeding (Hunter, 1980). The overall aim of oestrous synchronization will be to have parturition at a favorable time with respect to climate and marketing patterns (Bearden & Fuquay, 1980). The ability to control and manipulate oestrus would benefit the small stock industry, in that seasonal breeding is limited and hence a continuous supply of offspring is possible. According to Carlson et al. (1989), oestrous synchronization enhances a continuous supply of young animals, which is important to the meat industry where year-round availability of offspring would make better use of labour and capital outlay.

Oestrous synchronization techniques as such fall into two categories, namely, natural and hormonal methods and can be achieved in several ways (Evans & Maxwell, 1987).

2.1.3.1 Natural methods of synchronization

Natural methods has been achieved by the utilization of teaser bucks, the so-called "male effect". With extended research, oestrous induction had also been achieved by artificial photoperiod treatment, in combination with the male effect. The male effect has been used to synchronize oestrus effectively in goats. This synchrony is based on the fact that the male or buck acts as the stimulus to initiate ovarian activity (Bowen, 1988; Rajamahendran *et al.,* 1993; Mellado & Hemandez, 1996; Romano, 1998). In essence, the introduction of the male induces a rapid increase in LH pulse frequency leading to a LH surge, similar to that observed during the follicular phase of the oestrous cycle (Oldham *et al.,* 1980; Ungerfeld & Rubianes, 1999). For best synchronization responses, physical separation of the males and the females for some 6 to 8 weeks before mating is necessary. The distance of isolation is difficult to determine but, for a buck, the minimum recommended distance is 500m downwind of the does (Bowen, 1988). The use of the male effect for synchronization is cheaper, but does not always result in a close synchronization of oestrus (Evans & Maxwell, 1987; Rajamahendran *et al.,* 1993). According to Walkden-Brown et al (1993), 59% of does exhibited oestrus during the first 10 days following the introduction of bucks. The incidence of oestrus peaked at days 2 to 3 (25% of does) and on days 7 and 8 (33% of does). The male effect also works effectively during the seasonal anoestrus period. Attempting just to introduce a ram to the flock during the breeding season has proven unsuccessful, perhaps due to the fact that the male effect is more potent in anoestrus females (Godfrey *et al.,* 1997). The ovulatory response of anoestrus females to the male stimulation varies with several factors inherent to males (Edgar & Bilkey, 1963). According to Delgadillo et al (2000), the male behavioural and physiological activities decrease during the period of female anoestrus, in both sheep and goats.

The use of artificial photoperiod is an alternative natural method of synchronizing oestrus in small stock. The method is based on the principle that in females the photoperiod may be modified by the association of long days (16L: 8D, 20L: 4D) and a melatonin implant (Chemineau *et al.*, 1986; Devenson *et al.*, 1992). This modification can be achieved with a treatment of long days for 2 or more months, in order to allow the animal to interpret a spring-like condition. This in turn will make the animals unresponsive to the short days of autumn and winter. The situation is due to the fact that by the end of the long day treatment the animals interpret the prevailing photoperiod as short days, because the natural light of shorter duration than that imposed by the photoperiod treatment. This will result in elevated melatonin secretion during the nights at the end of winter and beginning of spring, to initiate sexual activity in females (Traldi *et al.*, 2000).

In a study by Traldi et al (2000), the photoperiod treatment was shown to give a better response to the male effect, and induce a series of ovulatory oestrous cycles during spring, resulting in good fertility. In this study 92.2% of does subjected to artificial photoperiod responded to treatment and manifested oestrus in an interval between 10 to 30 days after the introduction of males, while the kidding rates recorded were 70.1%.

Recently, the focus of using non-hormonal methods for controlling the breeding periods of farm animals has increased, as health conscious consumers prefer "hormone free" animal products. In goats, effective induction of oestrus has been achieved with a combination of the male effect and photoperiodic treatments. However, the variability in the onset of oestrus that is inherent to the natural method requires the goats to be inseminated at the observed oestrus. Based on these variations in response, it has become apparent that oestrous synchronization in small ruminants would be more efficient with the use of hormones especially where AI is performed at a predetermined time is needed (Godfrey *et al.*, 1997; Baril & Saumande, 2000).

2.1.3.2 Hormonal methods of synchronization

Synchronization of oestrus implies the application of hormonal treatment to a large number of females with the aim of manipulating their oestrous cycles. The animals should all demonstrate oestrus more or less simultaneously, or in such a way that the time of onset of oestrus can be predicted in the majority of animals receiving treatment (Van Rensburg, 1973; Hunter, 1980). Hormones were extensively implemented for oestrous synchronization following the development of hormonal assay procedures, especially the use of radioimmunoassay for hypophyseal and steroid hormone measurements.

Two hormones that are most frequently used to synchronize oestrus in small stock are firstly luteolytic drugs and secondly progesterone and its analogue progestagens. The first synchronizing agent is based on the administration of PGF2α or its analogues to remove or shorten the life of corpus luteum (CL). All animals in the appropriate responding groups enter the follicular phase of the cycle at the same time (Figure 2.2). The second synchronizing agent is based on the administration of progesterone or synthetic progestagens to suppress follicular development during an artificially extended luteal phase (Figure 2.3). Upon removal of the progestagen blockage following an adequate period of treatment, all animals should enter the follicular phase approximately synchronized (Hunter, 1980; Evans & Maxwell, 1987; Carlson *et al.*, 1989; Romano *et al.*, 1996).

a) The use of Prostaglandins:

The use of PGF2α in oestrous synchronization became popular after it was confirmed that prostaglandins are synthesized and released by the endometrium of the non-pregnant female (Goding, 1974; Baird & Scaramuzzi, 1975). This was justified by the observation of a complex series of peaks of short duration in PGF2α in the utero-ovarian venous concentration, the frequency of which increases as oestrus approaches, reaching a maximum level of 20ng/ml. These peaks of PGF2α are associated with a fall in the secretion of progesterone (Thimonier, 1979). After this discovery, many researchers used prostaglandins to synchronize oestrus in small stock and

achieved acceptable synchronization rates (Britt & Roche, 1980; Gordon, 1983; Godfrey *et al.,* 1997; Ahmed *et al.,* 1998). When PGF2α is administered to ewes or does that are in the mid to late-luteal phase of the oestrous cycle, prostaglandin is able to cause regression of the CL. According to Thimonier (1979), a 16-aryloxyprostaglandin injection to ewes in the mid oestrous cycles induces luteolysis and complete luteal regression is effective after 15 to 20 hours, depending on the breed, and followed by oestrus 36 to 44 hours after PGF2α injection. The inhibitory effect of progesterone, produced by the CL on the pituitary gland, is thereby removed with the pituitary releasing increasing amounts of gonadotrophins, which stimulate follicular growth. Oestrus eventually occurs within 2 to 3 days after treatment of the females (Bearden & Fuquay, 1980; Evans & Maxwell, 1987).

Luteal regression with the aid of PGF2α can only be induced between days 5 to 14 of the oestrous cycle in sheep and days 6 to 17 in goats. This means that the CL will not be responsive to PGF2α administered, during the refractory period (the period when the CL does not react to prostaglandin). Thus the use of PGF2α requires multiple injections (Evans & Maxwell, 1987; Carlson *et al.,* 1989; Greyling & Van Niekerk, 1991). When 2 injections of PGF2α are given 11 days apart, synchronization of oestrus is successful and all the treated animals show oestrus within 3 to 5 days after the second injection (Hearnshaw *et al.,* 1974). As mentioned, this technique only works in the presence of a CL, which limits its application to cycling animals (Britt & Roche, 1980; Gordon, 1983). Due to the fact that the PGF2α method of synchronization has many limitations, the progesterone method of synchronization is normally favoured to synchronize oestrus in small stock. Besides the many limitations that prostaglandins may have, it also does not really improve fertility over that of progestagens (Carlson *et al.,* 1989).

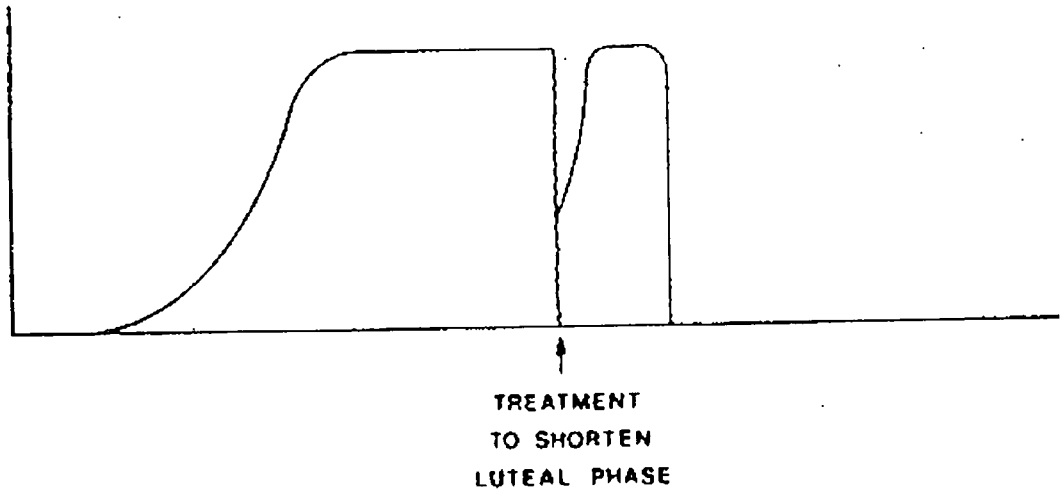


Figure 2.2 **The use of prostaglandin to shorten the luteal phase (Hunter, 1980)**

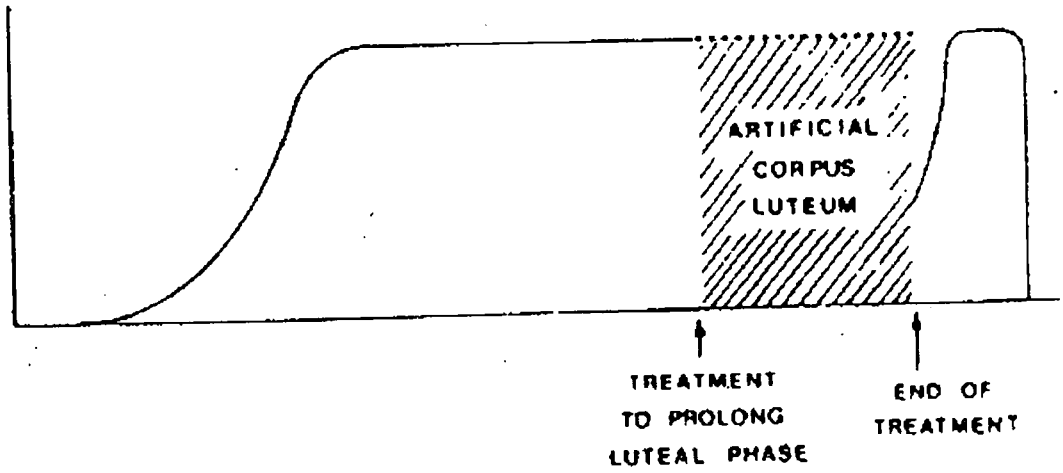


Figure 2.3 **The use of progesterone to extend the luteal phase (Hunter, 1980)**

b) The use of exogenous progesterone or progestagens:

Progesterone had been extensively used to control oestrus in sheep, goats and cattle following the development of the intravaginal route of administration for long term treatment (Gordon, 1983). In the female animal, progesterone exerts a negative feedback on LH secretion so that the endocrine events that lead to maturation of preovulatory follicles and their subsequent ovulation are inhibited until progesterone declines with CL regression. Thus, exogenous

progestagens are used to imitate this natural process, but in a way of extending the luteal phase. In oestrous synchronization, the use of progesterone or its analogues involves administration of a progestagen so that the CL regresses naturally during the period when progestagen is administered. With this approach the exogenous progestagen continues to exert a negative feedback on LH secretion even after CL regression has occurred. When the progestagen is then withdrawn, follicular growth, oestrus and ovulation occur within 2-8 days (Evans & Maxwell, 1987).

Progestagen treatments have been extensively used for oestrous synchronization in small ruminants (Mellado *et al.,* 1998). There are several routes in which progesterone treatments can be administered, all aimed at obtaining efficient synchronization. Progestagen can be fed daily for a specific period to obtain synchronization and it may be implanted or administered by means of intravaginal pessaries. In all incidences the main goal of inhibiting the endocrine events that lead to maturation of ovarian preovulatory follicles and subsequent ovulation must be achieved in treated animals (Quispe *et al.,* 1994; Romano *et al.,* 1996; Godfrey *et al.,* 1997; Mellado & Valdez, 1997).

The technique of progesterone being fed daily for a required period of time has been commonly used to synchronize oestrus in small stock (Lindsay *et al.,* 1967; Evans *et al.,* 1962; Gordon, 1983). Quispe et al (1994) reported efficient synchronization rates in ewes treated with medroxyprosterone acetate (MAP) or clormadinone administered orally. An alternative approach of administering progesterone to small stock is by the use of subcutaneous implants. Several trials have obtained effective synchronization rates in sheep and goats, using progesterone ear implants in conjunction with gonadotrophins (Carpenter & Spinzer, 1981; East & Rowe; 1989; Mellado & Valdez 1997). Intravaginal progestagen impregnated sponges are however presently the most common method of progesterone administration (Freitas *et al.*, 1997; Freitas & Salles, 2000; Greyling & Van Der Nest, 2000). Researchers have reported from 87 to 100% efficiency of synchronization with intravaginal progesterone impregnated sponges (Gordon, 1983). The use of subcutaneous implants, when compared to intravaginal progestagen devices

used in anoestrus or transitional goats shows no significant difference in the efficiency of synchronization (Waldron *et al.,* 1999). On the other hand, intravaginal progestagens are favoured because of the speed and simplicity of administration (Gordon 1983).

The development of the intravaginal progestagen impregnated sponges has provided a practical technique for oestrous synchronization. These sponges continuously supply progesterone, with an abrupt termination upon treatment (sponge) withdrawal. This technique results in the most commercial feasible synchronization of oestrus in goats (Gordon, 1983; Carlson *et al.,* 1989).

The progestagen intravaginal sponges are normally left inserted for a period of 12 to 18 days in does. According to Baril and Saumade (2000), when the duration of progestagen treatment is shorter than that of the luteal phase, the administration of prostaglandin is necessary. During the treatment period, progesterone is released continuously, increasing the concentration of the hormone in the blood, until removal of the exogenous source of progestagen. Progesterone will exert a negative feedback in the pituitary gland, inhibiting the release of gonadotrophins. After the withdrawal of progestagens the decreasing level of progesterone results in serum FSH levels increasing and eventually, the majority of females demonstrating oestrus within 2 to 3 days after sponge withdrawal (Evans & Maxwell, 1987).

The most frequently commercially used progesterone sponges are medroxyprogesterone acetate (MAP) and flurogestone acetate (FGA). Both sponges are highly efficient in controlling oestrus and ovulation in small stock (Gordon; 1997; Romano *et al.,* 1996). Essentially, there is not much difference in the effectiveness of the two progestagen types of sponges (Smith *et al.,* 1981; Evans & Maxwell, 1987; Romano *et al.,* 1996), although some authors have found small advantages in favour of FGA compared to MAP sponges with regard to the fertility rates (Gordon, 1983; Smith *et al.,* 1981). Such advantages are based on fact that MAP sponges are more prone to loss during treatment than FGA sponges (Boland *et al.,* 1979; Ainsworth & Shrestha, 1983).

In the early 1980's, a controlled internal drug release (CIDR) device was developed in New Zealand as an alternative means of delivering exogenous progesterone for oestrous synchronization. These CIDR's are basically intravaginal devices constructed of a progesterone-impregnated medical silicon elastomer, molded over a nylon core (Wheaton *et al.,* 1993; Godfrey *et al.,* 1999). Initially a type S device (CIDR-S) was developed for sheep but, currently a CIDR-G is used for sheep and goats, after modification to facilitate treatment in goats (Welch & Tervit, 1984; Welch, 1984; McMillan, 1986; Carlson *et al.,* 1989). Unlike the intravaginal sponges, the CIDR does not absorb nor impede drainage of vaginal secretions, with the result that it is more pleasant to handle than sponges at cessation of treatment (Carlson *et al.,* 1989; Van Der Nest, 1997). These devices are also less prone to loss during treatment and tend to have a higher oestrous response after removal, compared to the intravaginal sponges (Welch, 1984; Lynch 1985; Greyling & Brink, 1987; Van Der Nest, 1997). Regarding fertility, higher kidding rates have been reported in goats synchronized with CIDR's, compared to goats treated with MAP and FGA sponges (Selvaraju & Katheresan, 1997).

c) The use of progestagens plus pregnant mare serum gonadotrophin (PMSG)

Oestrous synchronization during the breeding and anoestrus seasons can be achieved by the administration of progestagen and PMSG to induce preovulatory follicular development (Gordon, 1983; Carlson *et al.,* 1989). Stimulation and synchronization of oestrus during seasonal anoestrus period in small stock requires progesterone priming prior to artificial induction of a fertile oestrus and ovulation (Amoah & Gelaye 1990a). Progesterone priming is important to avoid premature ovarian antrial follicle development (Bartlenski *et al.*, 1999). After progesterone priming, followed by induction of a LH surge, full-length luteal phases were observed in 100% of experimental anoestrous ewes (Legan *et al.,* 1985).

The use of a progestestagen/PMSG treatment can lead to high ovulation rates resulting in high conception rates following artificial insemination (Colas, 1979;

Thimonier, 1979). PMSG is used in conjunction with progestagen in small stock to induce a mild ovulation, depending on the dose of PMSG used. Hence PMSG can increase the occurrence and rate of ovulation (Greyling & Van Niekerk, 1990b; Ahmed *et al.*, 1998; Waldron *et al.*, 1999). A higher number of does kidding and higher prolificacy following oestrous synchronization with progestagen/PMSG treatment has been reported by Waldron et al (1999). PMSG given at progestagen withdrawal is also reported to result in a more precise and reliable synchronization of oestrus. The precise synchronization is important in the application of fixed-time AI (Smith *et al.*, 1981). The use of PMSG in conjunction with progestagen treatment has been shown to eliminate partly the variability in ovulatory response and ensure that the majority of goats ovulate, whether treated in the breeding season or during the anoestrus season (Boland *et al.*,1979; Ritar et al 1989; Greyling & Van Niekerk, 1990b).

2.2 FACTORS AFFECTING THE RESPONSE TO OESTROUS SYNCHRONIZATION

The oestrous response of a group of females following synchronization is influenced by several factors. Firstly, external factors such as nutrition, season, breed, insemination/mating techniques. stress and age of the animal can have an influence. Secondly, internal factors including type of progesterone/dose and duration of treatment could also play a role. Therefore, the possibility of improving the efficiency of oestrous synchronization by controlling these factors needs to be considered.

2.2.1 Dose of progestagen

Several researchers have documented the induction of oestrus in females treated with intravaginal progestagen impregnated pessaries, resulting in low fertility rates (Allison & Robinson, 1970; Hawk, 1971; Hawk & Conley, 1971; Gordon, 1983; Quispe *et al.*, 1994). Amongst other factors leading to the depression in fertility rate following the use of synthetic progestagens, are dose level of the progestagen used and the method of drug preparation (Haresign, 1978; Greyling *et al.*, 1994; Van Der Nest, 1997). It has been noted that a high level of progestagen followed by the rapid withdrawal and

adequate ovarian stimulation are prerequisites for acceptable fertility (Colas, 1975; Gordon, 1983). Allison and Robinson (1970) found an increase in the incidence of oestrus and ovarian response when the dose of progestagen was increased. This, however, is contrary to the work of other researchers who found low fertility in animals after oestrous synchronization with high progestagen doses (Freitas *et al.,* 1996). Thus, Faure *et al* (1983) found optimal fertility to be obtained in sheep treated with minimal doses of progestagen. Greyling *et al* (1994) found no significant differences in the occurrence of oestrus or kidding rates with different doses of progestagen outside the normal breeding season.

Low reproductive performances have been mostly associated with low dosages of progestagen (Allison & Robinson, 1970; Freitas *et al.,* 1997). Previously, it was noticed that many of the progestagen dosages employed to control oestrus in sheep and goats were too low to simulate the action of CL. As a result, the depression in fertility occurs due to a progestagen dose which inhibits ovulation and is lower than that which is required for the condition for oestrus, as well as complete fertility (Robinson, 1968). Low doses of progestagen is believed to result in inadequate suppression of the release of the pituitary gonadotrophins, which affects the ovarian production of oestrogens during the period following treatment with exogenous progestagens (Smith & Robinson, 1970). It was also found that ewes treated with low doses of progestagen show oestradiol production patterns different to those of untreated ewes or ewes treated with an optimum dose of progestagen. Here, only one oestradiol peak was observed, compared to two peaks in the control ewes. This is suggested to be a result of inadequate suppression of the release of pituitary gonadotrophins, particularly FSH, during treatment (Robinson, 1968).

The variability in oestrous response is not only associated with decreasing progestagen doses, but also with the disturbed temporal relationship between the onset of oestrus and the preovulatory LH surge (Greyling & Van Niekerk, 1990a; 1991; Freitas *et al.,* 1997). These authors found that the preovulatory

LH peak was more variable in goats treated with lower progestagen doses, compared to higher doses.

Poor synchronization and low fertility rates following the use of too low doses of progestagen treatment is also associated with the pattern of absorption of progestagen in the vagina (Allison & Robinson, 1970; Haresign, 1978; Gordon, 1983). In sheep significantly higher mating responses and lambing rates have resulted from a more even distribution of the 30mg dose of FGA in the sponge, and such distribution is believed to ensure a higher uptake of the synchronizing agent (Gordon, 1983). It has also been found that there is a rapid absorption of the progestagen during the first few days of treatment (Allison & Robinson, 1970). This is followed by a tendency of slowing down in the rate of absorption of progestagen towards the end of treatment (Greyling *et al.,* 1994), regardless of the initial dose. This rate of absorption demonstrates that at the beginning of the treatment period, absorption of progestagen is important and thereafter becomes a function of the amount of hormone present. Treatment with low doses of progestagen caused a marked drop in fertility, while there was also no improvement with excessive intravaginal progestagen doses used (Allison & Robinson, 1970).

Failure of fertilization is also a major cause of sub-fertility in females treated with progestagen pessaries to induce oestrus. This depression in fertility is related to the detrimental effect of exogenous progestagen on sperm transport and survival (Hawk, 1971; Robertson, 1977; Quispe *et al.,* 1994; Greyling *et al.,* 1994). It has been documented that this impeded sperm transport and survival in the female genital tract is related more to the endocrine response rather than the physical effect of the pessaries (Hawk & Conley, 1971). The balance of ovarian steroids at or just prior to the onset of oestrus is important for the sperm transport and survival (Allison & Robinson, 1970; Croker *et al.,* 1975). The progesterone released by the impregnated intravaginal sponge fails to maintain the endometrium in a normal state due to high levels of oestrogen produced immediately following progestagen withdrawal (Smith & Robinson, 1970). This in turn, leads to abnormal patterns of cervical mucus

secretion and abnormal uterus contractions, resulting in impeded sperm transport (Croker *et al.*, 1975).

2.2.2 Duration of progestagen treatment

The duration for which intravaginal progestagen pessaries are left *in situ* does seem to have an inconsistent effect on the response to synchronization (Corteel *et al.*, 1988; Greyling *et al.*, 1985; Amoah & Gelaye, 1990a; Pintato *et al.*, 1996). In the work done by Corteel et al (1988), fertility was low in either of two hormonal treatments (11 days or 21 days progestagen treatment), but much lower when goats were synchronized for 21 days rather than 11 days. No significant differences have been found when intravaginal progestagens have been left *in situ* for 11 or 21 days with regard to oestrus, follicular activity or ovulation rate (Amoah & Gelaye, 1990a; Pintato *et al.*, 1996). Moreover, Pintato et al (1996) reported that both the standard synchronization regimes, long and short treatment periods are equally efficient in synchronizing oestrus in goats. This is, also, in agreement with the work of Ritar et al (1987) who found no effect on the length of the CIDR insertion (15 to 20 days) on non-return rates after cervical inseminations. These results are contradictory to the study of Moore et al (1988) who reported that a progressive decline in fertility and prolificacy was observed after the insertion of intravaginal progestagen pessaries for 18 or 19 days. This observation is associated with sperm breakdown during the period of progestagen treatment.

In goats treated with intravaginal progestagen for 11 days, fertility was better out of the breeding season. This is related to the effect of prolactin as, it has been shown that the preovulatory discharge of prolactin after synchronization for 11 days is more rapid and more marked than after synchronization for 21 days. The inhibition of prolactin did not seem to prevent ovulation, but provoked premature regression of all subsequent CL's. As a result it was not clear whether or not an increase in the preovulatory discharge of prolactin resulting from progestagen administration for 11 days, could improve luteogenesis and hence fertility (Corteel *et al.*, 1988).

It was found that when reducing the duration of progestagen treatment to a period shorter than the luteal phase, it is necessary to administer an injection of prostaglandin or an analogue 48 hours before the end of the progestagen treatment. This in turn helps to regress any CL's present. When a short term (11 days) progestagen treatment with PMSG was combined with a prostaglandin injection 48 hours before sponge removal, the response to oestrus was satisfactorily high (98%). The fertility rate following AI was higher for a short progestagen than for a long progestagen treatment period (61.1% vs 56.7% for 11 and 21 days, respectively) (Baril & Saumande, 2000). However, the addition of prostaglandin injection to short (11 days) progestagen/PMSG treatment does not reflect the potential of the technique (60.9 and 61% conception rates). In South Africa higher fertility rates of 73.3 to 74.35% have been obtained with long term (14 to 16 days) progestagen/PMSG treatment in indigenous goats (Greyling & Van Niekerk, 1991; Greyling & Van Der Nest, 2000).

2.2.3 Nutrition

Prolificacy in small stock is determined mainly by genetic cues and is reflected by the number of ova released at ovulation and the number of fertile and viable embryos that implant in the endometrium. The degree by which animals can express their genetic potential is greatly influenced by environmental factors. One of the factors being the nutritional status of the animal before and at breeding (Downing & Scaramuzzi, 1991). According to Ferrell (1991), nutrition can determine whether an animal ovulates or exhibits oestrus.

The mechanism by which nutrition affects reproduction is not fully understood. There is evidence that body condition may have a direct effect on the hypothalamus and pituitary interaction (Rhind *et al.*, 1989). Both body condition and level of feed intake affect the gonadotrophin profiles and reproductive activity by a direct effect on the hypothalamic/pituitary sensitivity to the steroid feedback or inhibin (Rhind *et al.*, 1991). It is postulated that nutritional effects on ovarian activity in ewes are related to the concentration of gonadotrophins present in the blood serving the ovary. Greater hormone production was observed in high energy fed (grain) ewes, compared to ewes

fed a lower energy diet (hay) (Downing & Scaramuzzi, 1991). During the follicular phase, ewes with a high nutrient intake had a significantly elevated LH frequency and a non-significant increase in FSH concentrations. This suggests that the level of pre-mating feed intake could influence ovulation rate, by acting on the final stages of follicle development (Rhind *et al.*, 1985). In order to realize the efficiency and potential of the techniques used to improve the reproductive performance in animals, knowledge of the impact of nutrition on reproduction is essential.

The effect of nutritional flushing in small stock, especially sheep has been recorded as early as in the 19th century (Gordon, 1983; Greyling & Venter, 1994). It is generally considered as the practice by which the reproductive potential of small stock (in terms of ovulation rate and kidding rate) is increased, by improving body condition at the time of mating with the aid of a pre-mating nutritional supplement (Gordon, 1983; Henninawati & Fletcher, 1986; Wentzel, 1987; Chamiago, 1988; Downing & Scaramuzzi, 1991; Rhind, 1992; Greyling & Venter, 1994). Generally, flush feeding entails giving female animals which are in poor condition a high energy diet for a few weeks before mating, so that animals are in a rapidly rising body condition and in a positive energy balance when being mated (Robinson, 1984). According to Downing and Scaramuzzi (1991), flushing includes two processes. Firstly, an increase in nutrient intake, both by an increase in the level and/or intake of better quality feed particularly of high-energy value and secondly, resultant improvements in body condition (body reserves).

However, the response to flushing can vary, depending on the environment and season (Gordon, 1983), difference in initial body condition (Downing & Scaramuzzi, 1991), duration of the flushing period, intensity of flushing and type of nutrient used for flushing (Greyling & Venter, 1994). There is evidence that short term energy intake appears to be sufficient to increase ovulation rate and hence, an increase in the number of kids per litter (Steel, 1996; Downing & Scaramuzzi, 1991). Earlier research found no significant difference in the ovulation rate between groups of ewes of similar body weights that were either gaining or losing weight (Rattray, 1977). Increasing the level of intake or

feeding concentrates prior to mating tends to increase ovulation rate, while the level of oestrous response appears to be influenced by the duration of increased nutritional practice (Rattray, 1977). Greyling and Venter (1994) reported difficulty in determining the optimum duration of the flushing period in grazing ewes, as responses were not predictable. However, a period of 2 to 3 weeks prior to mating has been generally agreed upon as ideal for flush feeding (Greyling & Venter, 1994; Van Niekerk & Schoeman, 1994).

The effect of body condition and level of feed intake in sheep and goats with respect to ovulation rate, appears confusing and contradictory (Rhind, 1992). The uncertainty is as to whether the increased ovulation rate is due to pre-mating nutrition (flushing) or body condition as such. In goats, as in sheep, body condition affects the occurrence of oestrus (Mellado *et al.,* 1994), ovulation rate (Mellado et. al, 1996) and consequently a higher litter size (Newton *et al.,* 1980). Mani et al (1992) reported that poor body condition in sheep was associated with a delay or suppression of oestrus and a high rate of return to oestrus. This study indicated a low level of nutrition to be associated with a drop in body condition in goats, and to be accompanied by an accompanying significant reduction in mean ovulation rate. Other findings observed include a lower kidding rate in does on a low energy diet and a higher kidding rate and larger percentage of multiple births in does on high levels of nutrition (Sachdeva *et al.,* 1973).

Lindsay (1976) reported that, ewes do not have to show a change in body weight when supplemented, to exhibit a significant change in ovulation rate. It was also observed that the ovarian response was sudden and dramatic once the female settled into the new nutritional regime and it ceased soon after nutritional supplementation ended. On the other hand, there is strong evidence showing that the differences in response to flushing may be due to the body condition score at mating (Rattray, 1977). This is not significantly related to the level of pre-mating nutrition, when females are in a good or in a moderately good condition (Gunn & Doney, 1975). Recently, it has been speculated that ovulation rate increases with an increase in liveweight and body condition, as well as an increase in the level of pre-mating feed intake

(Rhind, 1992). In addition, Downing and Scaramuzzi (1991), working with females in poor body condition at mating, reported that ovulation rate may be related to the level of pre-mating nutrition. However, reported responses are not consistent, probably due to the fact that the effect of body condition and feed intake are confounded (Rhind, 1992). Gunn et al (1983), suggested that ovulation rate is dependent on the short-term effect of nutritional flushing, only in females within a certain intermediate range of the optimal body condition. Above or below this critical range, energy or feed intake has no effect. When considering other aspects of reproduction such as conception rate, body condition seems to have a marked influence. In goats a positive correlation between body condition score and conception rate has been recorded. Cissé *et al.* (1994) found that pregnant does had a significantly higher body condition score (2.9) than non-pregnant does (2.3).

Due to the uncertain and varying responses obtained by nutritional flushing, firstly, it was suggested that ovulation rate in small stock may be related to what is called the "net nutritional status". This is taken to be the sum of nutrients available from the body reserves and those nutrients taken in daily from the digestive tract (Lindsay, 1976). According to this postulation, females with a higher body condition score, given poor quality nutrition may still have an acceptable ovulation rate because of a reasonable endogenous source of energy and protein. On the other hand, females with a poor body condition, temporarily well fed, will also ovulate well because of the contribution of exogenous source of nutrition. In females with too poor body condition, short term nutritional flushing would probably have no effect on ovulation rate (Gordon, 1983).

The response to nutritional flushing may also be influenced by the age of the animal (Rattray, 1977; Gordon, 1983; Parry et. al, 1990), as the lower ovulation rates recorded in maiden does (compared to older does) are difficult to overcome by nutritional flushing (Parry *et al.,* 1990). The evidence that flushing prior to mating has no effect on ovulation in young females (Rattray, 1977) was not realized in the results of Downing and Lees (1977). These authors reported a definite positive response in this category of animals.

Pre-mating nutrition does not only have influence on ovulation rate alone, but also on the survival of the embryos at an early stage of gestation. Due to very low nutrient requirements of the embryos at an early stage of gestation, only extreme nutritional regimes are believed to affect their survival. In sheep, significant embryo losses have been reported when feed is restricted from 2 weeks prior to mating (Mani *et al.,* 1992). Strategic feeding during pregnancy is necessary, as uncontrolled nutritional practices may lead to reproductive wastage in the form of abortions and neonatal deaths due to too low birth weights resulting from malnutrition or undernutrition. Uncontrolled nutritional practices (over-feeding) may also lead to dystocia due to a high feeding level throughout gestation (Osuagwuh *et al.,* 1980; Osuaggwuh & Akpokodje, 1981, 1986; Osuagwuh, 1992). About 80% of foetal growth in goats occurs during the final trimester of pregnancy. Therefore, nutritional requirements of the dam follows a similar trend to foetal growth, being very low in early pregnancy, and increasing markedly in the last trimester (Robinson, 1984). It has been documented that goats are very sensitive to nutritional stress during the period of between 90 and 120 days of gestation and at this time most nutritionally induced abortions occur (Osuagwuh & Aire, 1990). It has been observed that there is a linear relationship between crude protein intake of pregnant does and foetal weight gain (Osuagwuh, 1992). Based on these observations, undernutrition in terms of energy and protein level intake, in late pregnancy can lead to a substantial depression in birth weight. This is associated with increased perinatal kid losses and hence, reduced reproductive efficiency (Rattray, 1977).

2.2.4 Seasonality

The seasonal nature of breeding in sheep and goats in temperate latitudes has been accepted for many years (Hulet & Shelton, 1980; Kennaway *et al.,* 1987; Mellado & Hermandez, 1996). In temperate regions the goat can be regarded as an autumnal breeder, with sexual activity occurring in northern latitudes between September and January. Season can place a major constraint on goat farmers wishing to maximize their farm inputs, as it limits the output to only one kidding crop per year (Kennaway *et al.,* 1987). In Egypt,

it was recorded that in Egyptian-Nubian goats the non-breeding season starts in late January and has a duration of no more than 4 months (Gordon, 1997). In the southern hemisphere, Rita and Salomon (1991), recorded a breeding season of goats in Australia extending from March to August. There are breeds of goats in which the breeding activity never ceases completely, when kept in suitable environments. This is true for breeds in tropical and sub-tropical regions, but may also be evident in other breeds located further from the equator. In South Africa, Greyling and Van Niekerk (1987) observed that the Boer goat showed peak breeding activity during autumn, and lowest activity in the late spring to mid summer. However, periods of complete anoestrus were never observed. In Japan, Shiba goats are considered as continuous breeders and do not show seasonal variations in fertility throughout the year (Sawada *et al.*, 1995).

In sheep there is evidence of low conception rates in induced oestrous periods outside the breeding season. This suggests that the uterine environment of the anoestrus female animal is not conducive to sperm transport (Wallace, 1992). It further, restricts the periods of milk yield and extends kidding intervals which reduce the number of kids born and, hence, a lower goat output (Kennaway *et al.*, 1987).

The season of sexual activity in goats is governed by photoperiod, with oestrous activity commencing during the period of decreasing daylength. Thus, the breeding activity in goats begins in autumn. The length of the sexual season varies with breed and nutrition (Evans & Maxwell, 1987; Jainudeen & Hafez, 1987). The question of how seasonal changes in daylength result in the onset and offset of the breeding activity has been addressed in many different ways (Walton *et al.*, 1977). During the seasonal anoestrous period, oestradiol exerts a strong negative feedback to the hypothalamus and anterior pituitary gland to reduce the secretion of gonadotrophins. As a result LH pulses occur infrequently, despite the absence of a CL and the virtual absence of circulating progesterone. Between pulses, circulating LH decreases to an undetectable low level. Thus, there is an insufficient gonadotrophin stimulus for the final stages of follicular maturation and for the

preovulatory oestradiol rise. This precludes the LH surge and ovulation (Karsch *et al.,* 1984).

Prolactin has been seen as the most striking seasonal hormone, with the highest concentrations occurring in the blood during the long daylight length and low concentrations during the short daylength periods. The importance of prolactin is, however, controversial. Many studies have demonstrated low prolactin concentrations coincide with the onset of ovarian activity (Thimonier et. al, 1978; Kennaway *et al.,* 1983). There are however also reports of ovarian activity in the presence of high prolactin levels induced by photoperiod manipulation (Worthy *et al.,* 1985).

The pineal gland has also been shown to control reproductive activity in small stock (Kennaway *et al.,* 1984). The hormone melatonin, secreted by the pineal gland, appears to mediate the suppressive effect of long days as well as the inductive effect of short days (Karsch *et al.,* 1984), by altering the daily photoperiod to the neuroendocrine systems regulating these activities (Bassett, 1992). There is evidence of high melatonin levels during dark periods and low levels during light periods (Kennaway *et al.,* 1987). It has been reported that exogenous melatonin administered to goats exposed to long days (16h light: 8h dark) treatment, maintained maximum sexual activity in seasonal anoestrus goats (Chemineau *et al.*, 1986; Amoah & Gelaye, 1990a).

Oestrous synchronization (with hormonal and natural methods) of seasonally anoestrus does to induce does to breed is also possible (Chemineau, 1983; 1985; Devenson *et al.,* 1992; Romano, 1993). The degree of success in inducing oestrus and of rate of fertility, however, has been inconsistent and is frequently poor during early and the mid-anoestrous period (Robertson, 1977; Senn & Richardson, 1992). In ewes, the mean incidence of oestrus and conception rates tend to be low (77±2.3% and 53±10.1%, respectively) during seasonal anoestrous period compared to during the breeding season (97±3.5% and 79±5.3%, respectively), following progestagen/PMSG treatment (Rajamahendran *et al.,* 1993). When using the male effect to synchronize and

induce reproductive activity during seasonal anoestrus, it was found to be ineffective, especially in sheep and goats that were extremely seasonal. So, for example, in breeds exhibiting only moderate seasonality such as Merino sheep and Creole goats, the introduction of the male can synchronize and induce an ovulatory response anytime throughout the anoestrous season (Chemineau, 1983). However, in more seasonal breeds the male effect is limited to about one month before the onset and one month after the end of the normal breeding season (Delgadillo *et al.*, 2000).

2.2.5 Fertility following synchronization and artificial insemination (AI)

2.2.5.1 Type of mating (Natural vs AI)

The success of goats bred naturally or artificially depends on several factors (Amoah & Gelaye, 1990a). When the comparison is made between fertility of goats after natural or artificial insemination (AI), it is possible that a biased conclusion can be reached. In natural mating, females are mated more than once and often by different males within the same oestrous period (Evans & Maxwell, 1987). In sheep, the mean conception rate in flocks mated naturally was observed to be higher (68.4%) when compared to AI (55%) (Laliotis *et al.*, 1993). In general, natural service obtains better fertility results. It is well documented that an increase in the number of motile spermatozoa and experience of the inseminator can compensate for the decrease in fertility following AI (Amoah & Gelaye, 1990a). In small stock, it has been seen that both natural mating and AI have a significant effect on the conception rates, but not in the number of females exhibiting oestrus (Lewis & Inskeep, 1971).

The interest in the AI of goats has increased, especially in dairy goats, for economic reasons (Blokhuis, 1962; Baril *et al.*, 1993). However, the kidding rate is normally low, and sometimes even below 50%. This is the primary factor limiting the adoption of AI programmes by goat farmers (Baril *et al.*, 1993). In small stock, AI needs to be performed following oestrous synchronization. It has been shown that it is possible to obtain acceptable conception rates when females are artificially inseminated following the

induction and synchronization of oestrus with progestagen/PMSG treatments (Gordon, 1983; Baril *et al.,* 1993). In a study of Corteel et al (1988), a higher proportion of females ovulating was observed in goats treated with hormones for the synchronization of oestrus. In the same study, goats inseminated had a higher kidding rate than does bred naturally. On the other hand, the conception rate after the use of intravaginal progestagen pessaries and PMSG following AI is also known to be variable and influenced by several factors such as semen quality, time of the insemination, ability of inseminators, technique of AI used as well as general managerial practices (Parker & Pope, 1983).

2.2.5.2 Place of semen deposition plus Fresh semen vs Frozen semen

Conception rates in goats after progestagen/PMSG treatment followed by cervical insemination with frozen-thawed semen is low (Evans & Maxwell, 1987; Moore *et al.,* 1988). Moore et al (1989) reported a kidding rate of below 30%, while Bowen (1988) obtained a kidding rate of 56% after progestagen treatment followed by a cervical insemination with frozen semen. Fertility following cervical AI with frozen-thawed semen is higher in goats than in sheep. This is mainly due to the structural differences in the cervix of the two species. In a number of does semen can be deposited deep into the cervix canal or into the uterus through the cervix contrary to that of sheep (Evans & Maxwell, 1987). Thus, intra-uterine insemination with undiluted fresh semen is possible in goats (Lindsay, 1991).

Acceptable conception rates with frozen-thawed semen can be achieved by intra-uterine insemination in sheep and goats (Evans & Maxwell, 1987). According to Moore et al (1989), laparoscopic (intra-uterine) AI is markedly more successful than cervical AI in terms of doe fertility. It has been documented that the laparoscopic technique of AI produces twice the kidding rate compared to the cervical technique (Moore *et al.,* 1988). However, intra-uterine AI by laparoscopy in goats is only recommended when there is a shortage of semen available in relation to the number of females to be inseminated or when only frozen semen is available and when the penetration of the cervix with the insemination pipette is impossible. Laparoscopic AI in

goats does not produce consistently high conception rates. Kidding rates vary markedly between 37% and 69% following laparoscopic AI, with fresh diluted semen in feral goats (McKelvey, 1990).

2.2.5.3 Time of insemination

For acceptable fertility results following AI, knowledge of the length of the oestrous period and the time of ovulation is essential, so that the time of insemination can be adjusted accordingly (Evans & Maxwell, 1987; Ritar *et al.,* 1989; McKelvey, 1990; Baril *et al.,* 1993). Therefore, proper synchronization of the onset of oestrus and time of ovulation is necessary. These two aspects are important to avoid the aging of gametes which contributes to low fertility following AI (Amoah & Gelaye, 1990a). Ovulation in Boer goats has been shown to occur approximately 31h after the onset of oestrus, following withdrawal of exogenous hormone treatment (Greyling *et al.,* 1985). Oestrous detection and the timing of breeding is very important to the success of AI and fertilization (Gordon, 1983; Evans & Maxwell, 1987; Amoah & Gelaye, 1990a; Baril *et al.,* 1993).

AI can be performed with acceptable success at a fixed time in relation to synchronization treatment (Evans & Maxwell, 1987; Ritar *et al.,* 1989). According to Evans and Maxwell (1987), the optimum time for cervical AI in sheep is 48 to 58 hours after cessation of treatment, while for intra-uterine inseminations (laparoscopy) with frozen-thawed semen, the optimum time is 60 to 66h after progestagen withdrawal. In synchronized goat does, 98.1% exhibited oestrus within 24 to 72 hours after progestagen removal. Fertility in goats that came into oestrus later than 30hours after sponge withdrawal was however lower (Baril *et al.,* 1993). As AI was conducted 43 to 45 hours after pessary removal, this lower fertility was associated with the time of the LH peak, which occurred concurrently with oestrus. Synchronization generally has no effect on prolificacy, suggesting that the low fertility achieved in goats, which exhibited oestrus more than 30 hours following progestagen removal, was not related to abnormal ovarian response but to the inappropriate time of insemination. It was also reported that animals inseminated less than 5 hours

after the LH peak have a low conception rate. This has been confirmed by several researchers who found higher fertility in a group of animals inseminated 60 hours after sponge removal, compared to those inseminated 48 hours after cessation of treatment (Maxwell *et al.,* 1984; Eppleston & Roberts, 1986). In other trials these differences were not observed (Smith *et al.,* 1981). One of the factors that may be the cause of this phenomenon could be that insemination was performed closer to ovulation in the 60 hour inseminated group (Romano *et al.,* 1996).

The effect of the number of inseminations within one oestrous period on fertility following progestagen treatment results in different pregnancy rates (Evans & Maxwell, 1987; Amoah & Gelaye, 1990a). It is known that fertility can be increased by two inseminations performed within the same oestrous period. The effect of a double insemination varies, depending on the time of insemination in relation to ovulation or time of pessary removal (Evans & Maxwell, 1987). Two inseminations 12 and 24 hours after the onset of standing oestrus resulted in better conception rates than a single insemination at 12 hours after onset of standing oestrus. However, the difference is so small that it is not worth the effort, especially when fresh diluted or undiluted semen is used (Evans & Maxwell, 1987; Amoah & Gelaye, 1990a). Does induced to ovulate during the breeding season recorded better conception rates following one insemination (at 42 to 43 hours after pessary removal) than after two inseminations (Amoah & Gelaye, 1990a). Two inseminations in a single oestrous period is, however, recommended when liquid refrigerated stored and frozen-thawed semen is used for cervical insemination, but is not recommended for laparoscopy (Evans & Maxwell, 1987).

2.2.6 The effect of breed on synchronization efficiency

The effect of breed on oestrous synchronization is not clear as it is also confounded by environmental factors such as nutrition and season (Devendra & Burns, 1983; Gordon, 1983). However, fertility in goats is said to be influenced by differences that exist between breeds (Devendra & Burns, 1983; Gordon, 1983; 1997; Steel, 1996). The incidence of multiple births is common in goats, but differences between breeds exist with crossbreds tending to

show better performances, presumably due to heterosis (Devendra & Burns, 1983). With one insemination following oestrous synchronization, Saanen goats were recorded to obtain a lower conception rate than Alpine goats in France (Corteel *et al.,* 1988). These results contradict those of Vosniskou *et al.* (1996), who found no significant difference in the overall mean conception rate between Saanen goats and Greek goats. This is in agreement with the work of Van Der Nest (1997), who found no significant differences in the duration of the oestrous period and conception rate in South Africa indigenous feral and Boer goat does. The same results were obtained by Laliotis et al (1993) where the breed of sheep had no significant effect on the conception rate obtained.

2.2.7 The effect of age of the dam on the efficiency of synchronization

Amongst the factors known to have a definite effect on ovulation rate, is age of the female (Devendra & Burns, 1983; Gordon, 1983; Laliotis et al 1993; Pintato *et al.,* 1996). There is ample evidence to show that young females tend to have a lower ovulatory response and smaller litter sizes than mature females (Armstrong & Evans, 1983; Mahmood *et al.,* 1991; Pintato *et al.,* 1996). Moreover, it has been found that in goats not only the birth rate but also the occurrence of multiple births (fecundity) increases with an increase in age of the dam (Devendra & Burns 1983; Fourie & Heydenrych, 1983).

In progesterone/PMSG treated sheep and goats, there is uncertainty as to whether reduced fertility is due to age or the number of synchronization treatments previously administered to the females. No age effect on the time from progestagen removal to oestrus has been observed in goats (Baril *et al.,* 1993). The fertility rate of goats older than 3.5 years that had previously received 0 to 2 progestagen treatments tended to be higher, compared to the fertility of goats in the same age group that had previously received 3 to 5 synchronization treatments. However, the conception rate at the first induced oestrus following treatment was found to be lower than at the subsequent oestrus following treatment. The possible reason may be due to a modification in the pattern of uterine contractions (Hawk *et al.,* 1981), thereby reducing the

survival of the spermatozoa in the progesterone treated animals (Laliotis *et al.*, 1993).

2.2.8 The effect of stress on synchronization efficiency

Under stress conditions, irrespective of its cause it is known that adreno-coticortrophic hormone (ACTH) from the anterior pituitary is released. This in turn will stimulate the release of cortisol and other glucocorticoids (Bearden & Fuquay, 1980; Jainudeen & Hafez, 1987). The glucocorticoids released inhibit the release of the hypothalamus-pituitary-gonadal axis hormones (Jainudeen & Hafez, 1987). Therefore, in the animal under stress during the critical period of the oestrous cycle (late pro-oestrus and oestrus), glucocorticoids will induce suppression of LH release which will either delay or prevent ovulation (Bearden & Fuquay, 1980). It is well known that stress can delay or block the demonstration of oestrus and even reduce fertility by impairing the cervical transport of sperm (Ehnert & Moberg, 1991; Romano *et al.*, 1996; Gordon, 1997).

Goats are thought to be less susceptible to environmental stress than other domesticated ruminants. This is due to the fact that goats possess certain characteristics such as water retention capacity, a higher sweating rate, lower basal heat metabolism and a relative constant heart rate and constant cardiac output (Shkolnik *et al.*, 1980). These properties enable goats to survive heat stress better than sheep or cattle (Lu, 1989). However, various forms of environmental stress such as climate or physical stress like excessive handling during mating may have an adverse effect on fertility in goats (Bearden & Fuquay, 1980; Jainudeen & Hafez, 1987; Corteel *et al.*, 1988; Lu, 1989; Romano *et al.*, 1996).

Heat stress depresses voluntary feed intake (appetite) and reduces thyroid activity, with a resulting lower basal metabolic rate (Bearden & Fuquay, 1980; Lu, 1989). The reduced feed intake and lower thyroid output will in turn contribute to shorter and quieter overt oestrus demonstrations as well as the birth of smaller offspring (Bearden & Fuquay, 1980). In sheep, heat stress can

result in the reduced duration of the oestrous period and extension of the length of the oestrous cycle (Jainudeen & Hafez, 1987).

The stress factor induced by the handling of females at the time of AI could also affect the fertility rates obtained, especially if the animals are not accustomed to being handled (Romano *et al.*, 1996). Two inseminations within one oestrous period are believed to increase the secretion of cortisol, which will inhibit the secretion of hormones responsible for the fertility processes (Corteel *et al.*, 1988). In a study where the effect of the duration of progestagen treatment in goats was compared to the frequency and amplitude of the preovulatory LH discharge, the overwhelming factor associated with the variation of time of onset of the LH preovulatory peak was the frequency of blood sampling. The higher the frequency of blood sampling the earlier the time elapsing from sponge removal to the onset or to the maximum LH preovulatory peak (Corteel *et al.*, 1988).

2.3 Summary

The primary goal in any reproductive programme and in particular controlled breeding is to improve the reproductive efficiency. There are several ways that can be utilized to achieve this goal, such as the use of AI, superovulation and embryo transfer. The induction of oestrus and ovulation is prerequisite to all of these breeding techniques. A progestagen/PMSG combination is the most commonly used treatment to synchronize oestrus in small ruminants. The treatment holds the advantage of being able to induce oestrus and ovulation either during or outside the normal breeding season. However, fertility seems to be low during the early anoestrous period. The use of PMSG in the treatment also holds the advantage of reducing the interval from progestagen treatment withdrawal to oestrus and improves the success of synchronization of oestrus, ovulation and the subsequent kidding rate.

The most important parameter in goat reproduction is the number of kids born, which is directly related to the number of ova released and fertilized. In this regard good nutritional management becomes an important factor to improve this parameter. Both medium (liveweight and body condition) and short-term

(flush feeding/pre-mating nutrition) nutritional effects are important for the female to produce multiple ovulations and produce higher litter size. Strategic nutritional management is also important during the gestation period, particularly during the last trimester of pregnancy, as about 80% of the foetal growth occurs during this period.

The time of the onset and the duration of oestrus as well as the time of breeding (mating or AI) are also important factors determining conception rates and therefore, need attention in controlled breeding programme. After oestrous synchronization, oestrous detection may not be necessary, as fixed time insemination is possible and acceptable results can be achieved. A timely insemination is needed so that the semen is deposited as close as possible to the time of ovulation. This enhances the fertilization rate. From an economical point of view, cervical insemination with fresh diluted or undiluted semen in goats holds an advantage while also avoiding laparoscopic stress and the use of frozen-thawed semen with reduced number of spermatozoa and hence a possible lower fertilization rate. Excessive handling of the does must be avoided around the oestrous period, as this can exert stress to the animal resulting in inhibition of the hypothalamus-pituitary-ovarian axis and secretion of gonadotrophins with a resultant lower reproduction performance in the does.

CHAPTER 3

MATERIALS AND METHODS

3.1 LOCATION

This study was conducted between February and September 2000 at the Paradys Experimental Farm of the University of the Orange Free State. The farm is situated approximately 20km South of Bloemfontein in the Free State province at 28.57° south latitude, 25.89° east longitude and an altitude of 1304m above sea level. The vegetation is semi-arid, with a temperate climate and a temperature range from a maximum of 35.8°C in summer to a minimum of –7.4°C in winter. The mean annual rainfall varies between 400 to 600mm and occurs predominantly during the summer months (December to February). The mean daylight length varies from 13.2 hours in mid-summer to 9.8 hours in mid-winter.

3.2 ANIMALS

Forty-eight Indigenous feral goat does and 42 Boer goat does were used in this experiment performed during the natural breeding season. The numbers of permanent incisor teeth were recorded for each doe (which varied between 2 and 8 teeth) to estimate the age of the animals. At the beginning of the experiment the mean body weight of Boer and Indigenous feral goats ranged from 27 to 63kg and 25 to 53kg, respectively. Breeds were evenly allocated and distributed between the progestagen treatment groups.

3.3 NUTRITIONAL MANAGEMENT

All the animals were maintained on natural pasture. This pasture was initially improved by hand sowing smutts finger grass (*Digitaria eriantha*) and controlled grazing over the years. Due to good rainfall during this particular summer when the trial was executed, the pasture was in a good condition. In general the pasture composition included red grass (*Themeda triandra*) as dominant specie, smutts finger grass (*Digitaria eriantha*), weeping grass (*Eragrostis lehmanniana*), drop seed grass (*Sporobolas fimbriatus*) and other minor species such as prickle grass (*Aristida congesta*). For the entire

summer the animals were allowed to graze for about 12 hours on the pastures before being housed in pens at night. During the experimental period clean, fresh water was always available ad lib.

During winter all the animals were supplemented with a mixed winter supplement given for about 1½ hours/day in addition to grazing on the natural pastures. Winter supplement was provided from the end of May to the end of the experiment (September). The feed was composed of a mixture of chopped finger grass, lucerne and LS33 (in a ratio of 10 bales: 4 bales: 10 litrers, respectively).

3.4 MEASUREMENTS AND METHODOLOGY

3.4.1 Treatments

At the onset of the experiment the animals were divided into 6 groups of 15 animals each. These groups were determined homogeneously in order to have an equal number of animals from the two breeds, similar age composition and similar mean body weight (±44kg) in each group. The animals were allocated at random to 6 treatments as set out in Table 3.1.

Treatment 1: Nutritional treatment

Flush feeding: One week before the beginning of the progestagen treatment, half of the experimental animals (groups A1, B1 and C1) were subjected to flush feeding for a period of 3 weeks. The animals were group fed and each animal was given an average of 300g of crushed yellow maize per day.

Late pregnancy supplementation: During the last 6 weeks of pregnancy, all the does certified pregnant were once again divided into two groups irrespective of their previous treatments. The animals were allocated into the two groups according to body weight and the number of foetuses that each individual doe was carrying. The two groups had an average mean body weight of ±46kg. One group was selected randomly and supplemented with 300g of whole maize grain per day until kidding. The other group served as a control and therefore received no supplementary feed.

Table 3.1 Experimental group

Type of progestagen	Nutritional flushing	Without Nutritional flushing
Repromap (MAP) sponges 60mg (Group A)	15 animals (A1)	15 animals (A2)
Chronogest (FGA) sponges 40mg (Group B)	15 animals (B1)	15 animals (B2)
Controlled Internal Drug Release dispenser (CIDR)	15 animals (C1)	15 animals (C2)

Treatment 2: Progestagen treatment

The oestrous cycle of all the experimental animals was synchronized with three different progestagen agents for a period of 16 days (mid-March to early-April). The progestagen treatments (Table 3.1) were administered intravaginally with the respective applicators (Plate 3.1). During administration of the progestagen treatment, a small amount of antiseptic cream was applied to the devices and applicators to prevent infection and also act as a lubricant. The applicators were rinsed with clean water after each insertion. At progestagen withdrawal (Plate 3.2), all the animals were injected intramuscularly (im) with 300IU Pregnant Mare Serum Gonadotrophin (PMSG) (Fostim; Upjohn). Does were randomly allocated to the following treatment groups:

- Group A: 30 does synchronized with 60mg Medroxyprogesterone acetate (MAP) sponges for 16 days+300IU PMSG im administered at sponge withdrawal
- Group B: 30 does synchronized with 40mg Fluoregestone acetate (FGA) sponges for 16 days + 300IU PMSG im administered at sponge withdrawal.
- Group C: 30 does synchronized with controlled internal drug release dispenser (CIDR) for 16 days + 300IU PMSG im administered at device withdrawal.

3.4.2 Oestrous observations

Oestrous detection with the aid of two vasectomized bucks was performed for 30 minutes per group, twice daily (early in the morning (7:00) and late in the afternoon (17:00). The does were teased for a period of 22 days prior to administration of synchronization treatment, to determine the cyclicity and the stage of the oestrous cycle at the commencement of progestagen treatment. Following progestagen treatment cessation, all the animals were tested for oestrus at 8 hours intervals for a period of four days (96 hours) to determine the time to oestrus and duration of the induced oestrous period. Animals were also teased from 14 days to 23 days after AI for two weeks twice daily for 30 minutes (in the morning (7:00) and in the afternoon (17:00)) to determine the non-return rate.

3.4.3 AI procedure

Cervical inseminations were performed on all the does using fresh diluted semen (0.1ml). The semen was collected by artificial vagina from two fertile Boer goat bucks and tested for viability prior to use. The rate of dilution was 1:2 using sterilized skimmed cow milk. All does received two artificial inseminations with a dose of 0.1ml per doe at fixed times of 48 and 60 hours after progestagen treatment withdrawal.

3.4.4 Blood sampling

Blood samples were collected from 5 animals per group for serum progesterone concentration determinations. These samples were collected via the jugular vein by jugular veni puncture into 10ml plain vacutainer tubes (Plate 3.3). Blood samples were taken during treatment at 4 days intervals from the day of progestagen insertion, until progestagen withdrawal. From progestagen withdrawal blood was sampled at 8 hours interval for a 72-hour period. Blood samples were also taken at day 14 and 21 following AI, for pregnancy diagnosis.

After collection the samples were centrifuged at 1500 r.p.m for 15 minutes. The serum was recovered and stored at –20°C, until assayed for serum progesterone concentration.

3.4.4.1 Serum progesterone assay

The serum progesterone concentrations were determined using the Automated Chemiluminescence System (Chiron Diagnostics ACS: 180, USA). The Chiron Diagnostics ACS: 180 progesterone assay is based on a competitive immunoassay using direct chemiluminescent technology. Progesterone in the sample binds to an acridinium ester-labeled mouse monoclonal anti-progesterone antibody in the lite reagent. Unbound antibody binds to a progesterone derivative convalently coupled to paramagnetic particles in the solid phase. The amount of progesterone present in the sample is inversely related to the amount of relative light units detected by the system. The ACS: 180 progesterone assay sensitivity was 0.11ng/ml. The analytical sensitivity is defined as the concentration of serum progesterone that corresponds to the relative light units (RLUs) of 20 replicate determinations of the progesterone zero standards. The inter and intra-assay coefficients of variation was 9.1% and 14.6% respectively.

3.4.5 Body weight

All the animals were weighed weekly at the same day of the week and same time of the day, using an oil pressured scale (Plate 3.4) throughout the observation period to monitor body weight changes in the does.

3.4.6 Pregnancy diagnosis and kidding performance

Fertile bucks were introduced twice daily (7: 00 and 17:00) to all does for two weeks, from day 14 to 23 after AI, to check for returns to service (not conceiving) and to mate these animals. Forty days following AI, all the animals were tested for pregnancy with the aid of an ultrasonic scanning apparatus using an intra-rectal probe. Pregnancy status and the number of foetuses were recorded. Kidding data were collected throughout the kidding period which lasted about 2 weeks (Plate 3.5 & Plate 3.6). The data recorded included date and time of birth, sex, type of birth (litter size), and birth weight. The number of kids dead during the first 48 hours and the cause of death were also recorded.

3.5 DATA ANALYSIS

The analysis of variance (ANOVA) procedure (SAS, 1991) was used to test the effect of flush feeding and progestagen treatments on body weight and serum progesterone concentrations. The same procedure was used to test the differences on duration and onset of oestrus between does which gained or lost weight prior to AI.

The categorical modeling (CATMOD) procedure (SAS, 1991) was used to test the effect of flush feeding and progestagen treatment on oestrous response following oestrous synchronization and on the fertility (conception rates). The percentages for the same parameters were ordered from the general linear model (GLM) procedure (SAS, 1991). The effect of the treatments on the onset and duration of oestrus was tested by the GLM procedure (SAS, 1991). The GLM procedure was also used to test the effect of treatments on gestation length, litter size, total litter weight and birth weight. For perinatal mortality analysis, the CADMOD procedure was used. The percentages were obtained by the GLM procedure for comparison within the variables (SAS, 1991).

Plate 3.1 Insertion of intravaginal progestagen device

Plate 3.2 Withdrawal of intravaginal progestagen device

Plate 3.3 Blood sampling method used in does

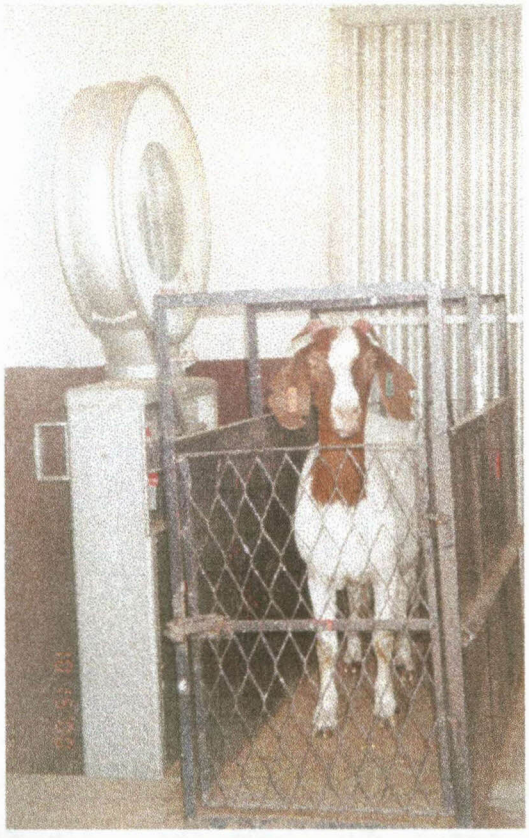


Plate 3.4 Measuring body weight of a doe

Plate 3.5 Indigenous feral goat shortly after kidding

Plate 3.6 Boer goat shortly after kidding

CHAPTER 4

RESULTS

4.1 BODY WEIGHT

The body weight of does from the three progestagen treatment groups as well as from the two supplementary feeding treatment groups showed a similar trend without any significant differences. Figure 4.1 sets out the mean body weight of flush fed and control does from the beginning of the experiment to AI. There were no significant differences in body weights between flush fed and control does. The mean body weights of pregnant and non-pregnant does throughout the experimental period are set out in Figure 4.2. The body weight had a similar trend throughout the observation period. The mean body weights for the pregnant does were always significantly ($P<0.01$) higher when compared to the non-pregnant ones. As it can be seen, all does lost weight from the beginning of the trial until the time of AI (from week 1 to week 6) regardless of flush feeding. From breeding until 5 weeks after AI does in general gained weight irrespective of the treatments applied. The pregnant does at this time gained about ±4kg while the non-pregnant does gained about ±3kg on average.

The mean body weight of pregnant animals during the last six weeks of pregnancy is set out in Figure 4.3. Mean body weights of pregnant supplemented and the control does did not differ significantly. All does tended to increase their body weight (by 1.5kg to 1.8kg) rapidly during the last week of pregnancy irrespective of late pregnancy supplementation. Weight at breeding had a significant ($P<0.05$) effect on conception rate. Heavier does (46.2±7.9kg) had a significantly ($P<0.05$) higher pregnancy rate, when compared to lighter does (41.5±8.6kg) (Figure 4.4). However, there was no significant difference between animals, that gained or lost weight before insemination with respect to conception rate following oestrous synchronization and AI (46.8% vs 59.5%, respectively) and litter size (2.2±1.2 vs 1.9±0.9 respectively).

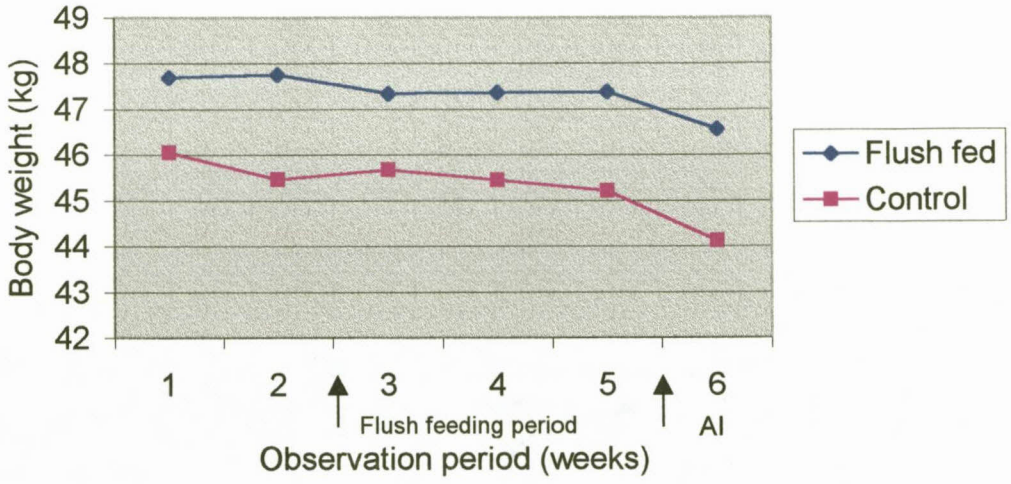
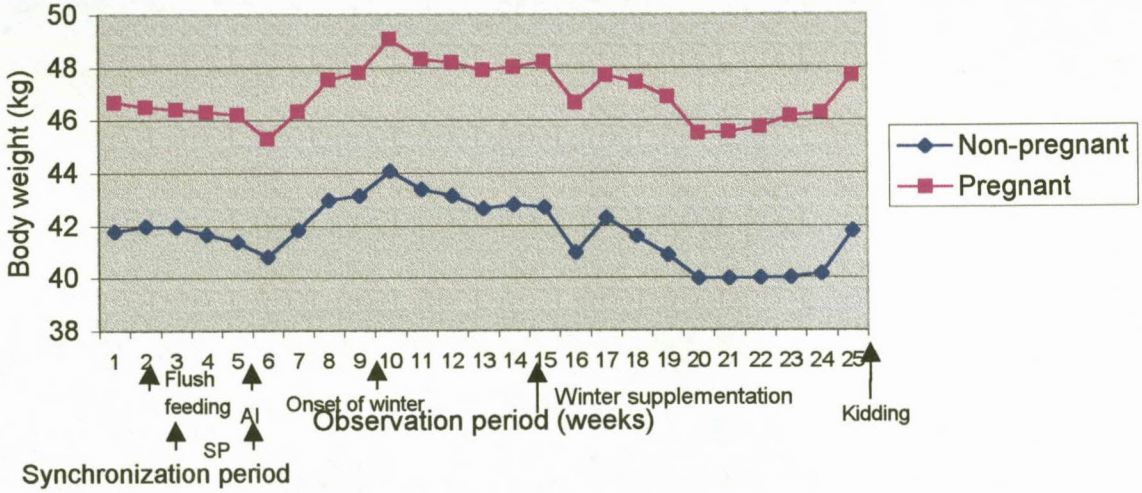


Figure 4.1 **Mean body weight of flush fed and control does from the beginning of the experiment to AI**



SP Synchronization period

Figure 4.2 **Mean body weight of pregnant and non-pregnant does throughout the experimental period.**

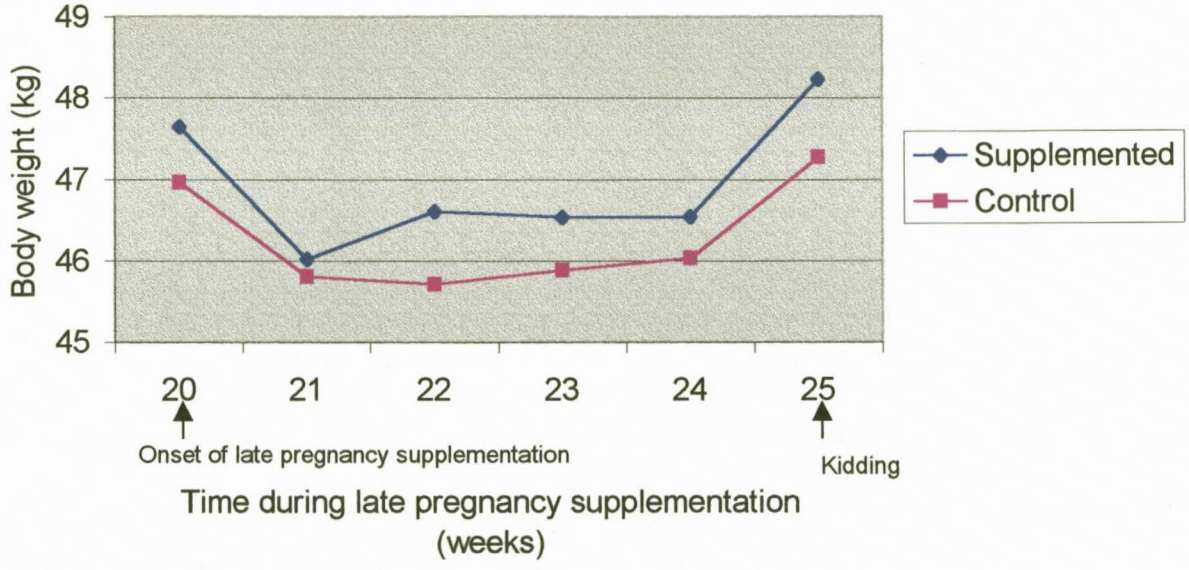


Figure 4.3 **Body weight of pregnant does during the last six weeks of pregnancy**

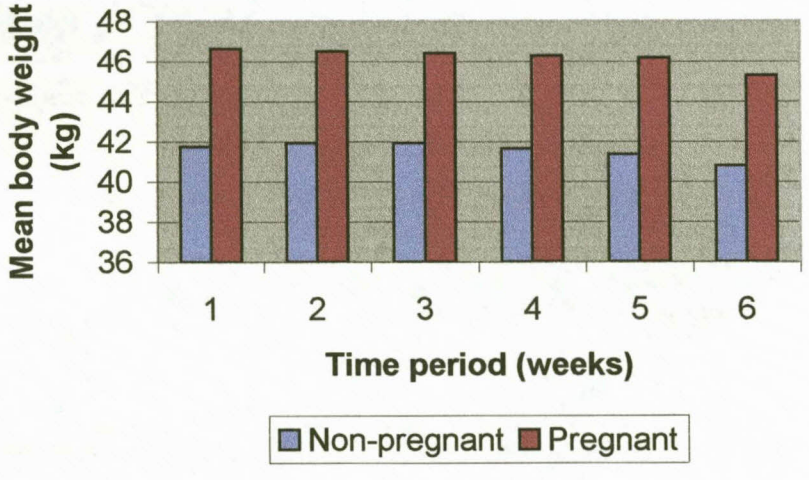


Figure 4.4 **Relationship between body weight and pregnancy rate of does from the beginning of the experiment to AI**

4.2 OESTROUS RESPONSE

4.2.1 Pre-synchronization oestrous activity

During the 22 day period prior to oestrous synchronization, animals were observed twice daily for oestrous signs with the aid of teaser bucks. Only 17.8% (16 does) of the does were found to be cyclic prior to progestagen treatment.

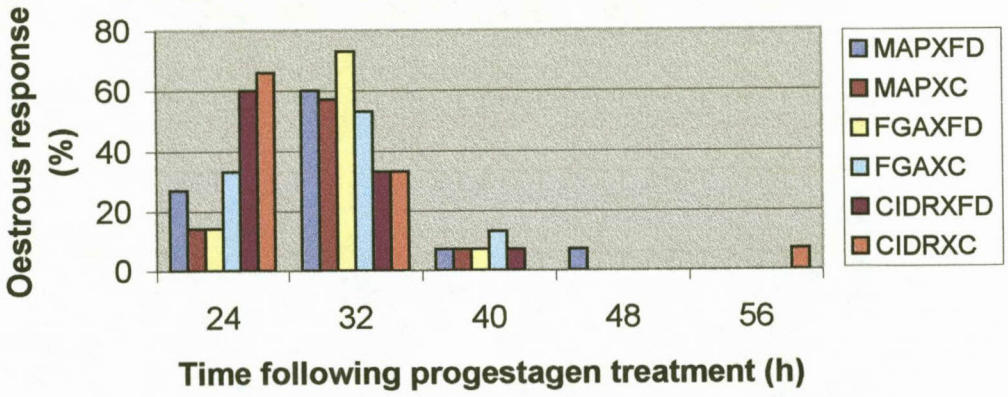
4.2.2 Response to oestrous synchronization

Analysis of oestrous response before and after synchronization failed to show any significant relationship. In fact, only 3.4% of the does failed to show signs of oestrus after synchronization. None of these does were in oestrus during the 22 day observation period prior to synchronization. Five does (5.6%) lost their intravaginal progesterone agents during the synchronization period and these devices were replaced immediately when such incidences were observed. Out of these 5 animals 3 did not show signs of oestrus following progestagen treatment withdrawal. This represents all the does (3.4%) that failed to show signs of oestrus following synchronization.

Following oestrous synchronization, the overall oestrous response for all treatment groups was 96.6%. When comparing the three progestagen treatments, bo significant differences were observed in regard to oestrous response. However, CIDR had the highest (100.0%) oestrous response, compared to MAP (93.1%) and FGA (96.7%). Regarding the interaction between synchronization and the flush feeding treatments, the CIDR treated animals whether flush fed or not, showed a 100.0% oestrous response rate. In the FGA group, the animals flush fed had a slightly lower oestrous response (93.3%), compared to the control (100.0%) animals. In the MAP treatment group, the flush fed animals had a higher oestrous response rate than the MAP control animals (100.0% vs 85.7%, respectively). The percentage of animals showing oestrus at different times following progestagen withdrawal for the different groups, are presented in Figure 4.5.

The effects of progestagen treatment and flush feeding on the response, time to onset and duration of oestrus are illustrated in Table 4.1. The mean time to onset of oestrus following progestagen treatment withdrawal was 30.1±5.5h. The CIDR treated animals exhibited oestrus significantly ($P<0.01$) earlier (27.2±4.5h) when compared to FGA groups (30.9±4.6h) and MAP groups (32.2±7.1h). There was, however, no significant difference between FGA and MAP treated groups with respect to the time from progestagen withdrawal to the onset of oestrus. Flush feeding had no effect on the time to onset of oestrus.

The overall mean duration of the induced oestrus was 33.3±13.4h for all the treated groups. Neither progestagen treatment, flush feeding or the interaction between hormonal treatment and flush feeding had a significant effect on the duration of the induced oestrous period. The CIDR treated animals had a tendency of a longer oestrous period (35.2±13.7h), compared to MAP (32.6±13.8h) and FGA (32.0±13.7) treated does, however the differences were not significant.



MAPXFD: MAP X Flush feeding FGAXFD: FGA X Flush feeding CIDRXFD: CIDR X Flush feeding
MAPXC: MAP X Control FGAXC: FGA X Control CIDRXC: CIDR X Control

Figure 4.5 Distribution of oestrous response following different progestagen treatments in does

Table 4.1 **Effect of progestagen treatment and flush feeding on the oestrous response, mean time to onset of oestrus and duration of the induced oestrus period.**

Variables	N	Cyclic response (%)	Oestrus response (%)	Onset of oestrus (h)	Duration of oestrus (h)
				Mean±SD	Mean±SD
Progestagen				**	ns
1 MAP	27	23.3	93.1	32.2±7.1a	32.6±13.8
2 FGA	29	10.0	96.7	30.9±4.6a	32.0±13.7
3 CIDR	30	20.0	100.0	27.2±4.5b	35.2±13.7
Flush feeding				ns	ns
1 Fed	44	17.8	97.8	30.2±5.4	33.3±13.9
2 Control	42	17.8	95.5	29.9±6.4	33.3±13.5
Progestagen and Flush feeding interaction				ns	ns
1X1	15	20.0	100.0	31.5±6.4	35.7±13.1
1X2	12	26.7	85.7	33.3±8.2	28.7±14.3
2X1	14	13.3	93.3	31.4±3.8	30.9±14.7
2X2	15	6.7	100.0	30.4±5.4	33.1±13.1
3X1	15	20.0	100.0	27.7±5.1	33.1±14.5
3X2	15	20.0	100.0	26.7±3.9	37.3±13.1

** Significant (P<0.01)
ab Values in the same column with different subscripts differ significantly (P<0.01)

4.3 SERUM PROGESTERONE CONCENTRATIONS FOLLOWING OESTROUS SYNCHRONIZATION.

One animal from the MAP group from which blood was sampled was removed from the experiment for health reasons. From the FGA group, one animal from which the blood was sampled lost its sponge, but the sponge was replaced as soon as it was detected. This animal was removed and replaced by another animal from which blood was sampled. The serum progesterone levels throughout the observation period are set out in Figure 4.6. The mean serum progesterone concentrations in the CIDR treated animals were significantly (P<0.05) higher between days 4 and 16 after the onset of progestagen treatment, when compared to both the MAP and FGA treatment groups. There was no significant difference in serum progesterone levels between the two latter synchronizing agents. The serum progesterone levels increased rapidly from 4.7±4.1ng/ml in CIDR treated animals from the day of intravaginal device

insertion, to 9.4±5.8ng/ml on day 4 following device insertion. Similarly, the levels of serum progesterone decreased from the day of sponge insertion from a level of 2.5±5.5ng/ml and 1.1±2.7 ng/ml to 0.1±0.9ng/ml and 0.2±0.1ng/ml on day 4 of sponge treatment in the MAP and FGA groups, respectively. From day 4 to day 16 of progestagen treatment the serum progesterone levels decreased in all 3 progestagen treatment groups. The mean serum progesterone concentration at 8 hours after progestagen removal were significantly ($P<0.01$) higher in the CIDR treated group compared to the MAP and FGA treated groups. When the majority of animals were in oestrus (32h) following progestagen treatment, the mean serum progesterone concentrations did not differ significantly between the three progestagen treatments (0.3±0.2ng/ml, 0.2±0.5/ml and 0.3±0.1ng/ml for the MAP, FGA and CIDR treatment groups respectively). At the time of AI there was no significant difference in mean serum progesterone levels between the three progestagen treatments (MAP 0.49±0.4ng/ml; FGA 0.30±0.1ng/ml; CIDR 0.53±0.3ng/ml). Flush feeding as well as the combination of flush feeding and progestagen treatment did not have any significant effect on the level of serum progesterone at any time of the observation period. In addition there were no significant differences between pregnant and non-pregnant does with respect to serum progesterone concentrations during the 72 hours period following progestagen withdrawal (Figure 4.7).

No significant relationship was observed between the serum progesterone concentrations and pregnancy status on day 14 after insemination in all the groups. There was however a significant ($P<0.01$) relationship between serum progesterone concentration and pregnancy status on day 21 after AI (Table 4.2). Pregnant does had significantly ($P<0.01$) higher mean serum progesterone concentrations (17.3±6.9ng/ml), compared to non-pregnant does (3.03±5.4ng/ml).

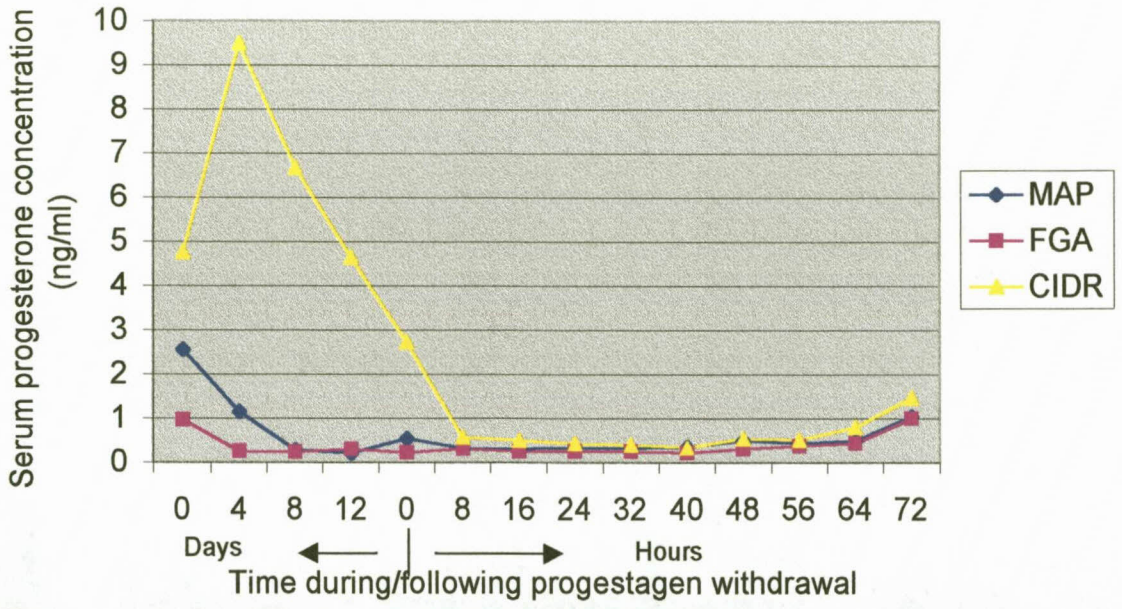


Figure 4.6 **Mean serum progesterone concentration (ng/ml) during and after cessation of different progestagen treatments in does.**

Table 4.2 **The mean (±SD) serum progesterone levels at 14 and 21 days after AI in pregnant and non-pregnant does**

	Day 14	**Day 21**
Pregnant does	18.9±10.5ns	17.3±6.9a
Non pregnant does	14.8±11.2ns	3.6±5.4b

ns Non significant

ab Figures with different subscripts within the same column differ significantly (P<0.01)

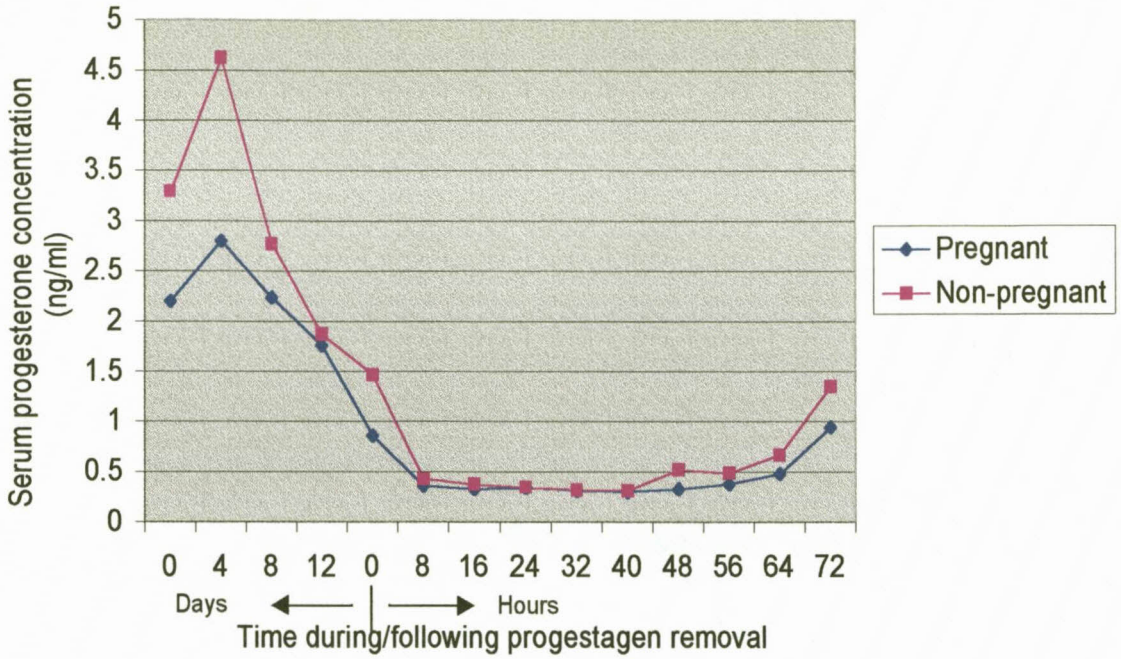


Figure 4.7 **Mean serum progesterone concentration of pregnant and non-pregnant does following synchronization and AI**

4.4 CONCEPTION RATES

The overall non-return rate recorded between 14 and 23 days after AI was 91.0%. In Table 4.3 the effect of progesterone treatment, flush feeding and cyclic activity prior to synchronization on conception rates after fixed time AI are set out. From Table 4.3 it is evident that the different treatments had no significant effect on conception rate. The overall mean conception rate achieved following AI and oestrous synchronization in all the does was 52%. There was a tendency for a higher conception rate in the FGA treated animals, followed by the MAP treated group and then the CIDR group (60.0%, 51.7% and 46.6%, respectively). These differences were however not significant. There was also a tendency for a higher conception rates in flush fed animals, compared to the control animals (60.0% vs 45.5%). However, this difference was also not significant. The mean interval between cessation of progestagen treatment and the onset of oestrus for the pregnant and non-pregnant animals was 29.9±4.9h and 30.1±6.9h respectively, while the average duration of oestrus was 45.9±6.9h and 45.7±6.9h for these 2 groups, respectively. Neither the difference in time to the onset of oestrus, nor the duration of the induced oestrus period had a significant effect on conception

rates. There was no significant difference in respect to conception rate between animals from which blood was sampled and the rest of the does.

Table 4.3 Conception rate (%) following oestrous synchronization and artificial insemination in indigenous goats

Variables	N	Non return rate (%)	Conception rate
Progestagen		ns	ns
1 MAP	29	89.8	51.7
2 FGA	30	100.0	60.0
3 CIDR	30	83.4	46.7
Flush feeding		ns	ns
1 Fed	45	88.9	60.0
2 Control	44	93.2	45.5
Cyclic before treatment		ns	ns
1 Cyclic	15	75.0	60.0
2 Non-cyclic	74	93.2	51.4
Progestagen and Flush feeding interaction		ns	ns
1X1	15	86.7	66.7
1X2	14	92.9	35.7
2X1	15	100.0	53.3
2X2	15	100.0	66.7
3X1	15	80.7	60.0
3X2	15	86.7	33.3

ns not significant

4.5 GESTATION LENGTH, LITTER SIZE AND TOTAL LITTER WEIGHT

Two animals did not complete their gestation period. The first doe died 2½ months into pregnancy due to kidney infection while carrying 3 foetuses (two females and one male). The second animal aborted a male foetus after 3½ months of pregnancy and died the following day. The mean gestation lengths and total litter weights are set out in Table 4.4. The mean recorded gestation

period for all the does was 149.1±4.1days, with a range of 141 to 157 days. The gestation length for singles, twins, and triplets was not significantly different (150.0±2.8d, 148.8±4.3d and 150.0±4.1 respectively). Does with quadruplets, however, had a significantly (P<0.01) shorter gestation length (142.7±2.8d). The gestation length was not affected by type of progestagen agent used during oestrous synchronization, flush feeding prior to synchronization and AI or strategic supplementation during the last 6 weeks of pregnancy. The mean total litter weight was 5.3±1.8kg for all does that kidded. No significant beneficial effect of late pregnancy supplementation or progesterone agent used were observed on total litter weight. The total litter weight for kids born as singles was significantly (P<0.01) lower than those born as multiple births (3.6±0.4kg, 6.1±0.9kg, 6.7±1.5kg and 6.4±0.5kg for singles, twins, triplets and quadruplets, respectively). The total litter weight for twins, triplets and quadruplets were not significantly different.

Table 4.4 Effects of litter size on gestation length, total litter weight and kid birth weights

Variables	N	Gestation length (days)	Total litter weight (kg)	Birth weight (kg)
		Mean SD	Mean± SD	Mean± SD
Litter size		*	**	**
1	17	150.0±2.8a	3.6±0.4a	3.6±0.4a
2	14	148.8±4.3a	6.0±0.9b	3.1±0.6b
3	11	150.0±4.1a	6.7±1.5b	2.3±0.6c
4	3	142.7±2.8b	6.4±0.5b	1.6±0.3d

** Significant (P<0.01)

* Significant (P<0.05)

abcd Figures with different subscripts within the same column differ significantly

The mean litter sizes for the different groups are set out in Table 4.5. The overall mean litter size was 2.0±0.9. The type of progestagen used in synchronization did not have any significant effect on litter size. Animals that

were flush fed prior to breeding had a significant (P<0.05) lower litter size than the control animals (1.8±1.5 vs 2.3±1.0, respectively). The body weight of the dam at breeding (AI) had a significant (P<0.05) effect on the litter size produced and a positive correlation was recorded between these two parameters (r=0.3595). Does that weighed less than 41kg at breeding had significantly (P<0.01) lower litter sizes (1.8±0.9), compared to the heavier does (>41kg), where litter size varied between 2.5±0.9 and 2.9±0.8 kids/doe

Table 4.5 Effects of progestagen, flush feeding and breeding liveweight of the dam on litter size in goats following oestrus synchronization and AI

Variables	N	Litter size (Mean±SD)
Progestagen treatment		ns
1 MAP	14	1.9±0.9
2 FGA	17	1.8±0.8
3 CIDR	14	2.4±1.0
Flush feeding		*
1 Fed	26	1.8±0.9
2 Control	19	2.3±0.9
Breeding weight (kg)		**
1 x<41.0	21	1.8±0.9a
2 41.0<x≤46.0	22	2.6±0.9b
3 46.0<x≤51.0	24	2.5±0.9b
4 x>51.0	23	2.9±0.8b

* Significant (P<0 05)
** Significant (P<0.01)
ab Figures with different subscripts are significantly different

4.6 KID BIRTH WEIGHTS AND PERINATAL MORTALITY RATES

Kid birth weights are set out in Table 4.6. Type of progestagen and late pregnancy supplementation had no significant effect on kid birth weight. The average birth weight of all kids was recorded as 2.7±0.5kg. Crossbred and male kids were significantly (P<0.05) heavier than pure Boer and female kids, respectively. The mean birth weights were 3.6±0.4kg; 3.1±0.5kg; 2.3±0.6kg and 1.6±0.3kg, for singles, twins, triplets and quadruplets, respectively and were significantly different (P<0.01). A significant (P<0.01) negative correlation (r=-0.7729) was recorded between kid birth weight and litter size.

Table 4.6 Effects of late pregnancy supplementation, sex of the kids and litter size on kid birth weight

Variables	N	Birth weight (kg)
		Mean±SD
Overall	90	2.7±0.5
Pregnancy supplementation of dam		ns
1. Supplemented		2.6±0.8
2. Control		2.8±0.8
Sex: of kid		*
1 Male	49	2.7±0.8
2 Female	41	2.6±0.8
Breed		*
1 Boer	42	2.6±0.9
2 Cross (Boer X Indigenous feral)	48	2.7±0.8
Litter size		**
1	17	3.6±0.4a
2	28	3.1±0.5b
3	33	2.3±0.6c
4	12	1.6±0.3d

** Significant (P<0.01)

* Significant (P<0.05)

ns Not significant

abcd Values in the same column with different subscripts are differ significantly

The perinatal kid mortality rate within 48 hours after birth is set out in Table 4.7. The overall perinatal mortality rate within the 48h postpartum was 22.3%. A significantly (P<0.05) higher perinatal mortality rate was recorded in kids of the pregnant supplemented does group, when compared to the control does (31.9% and 14.0%, respectively). Perinatal mortality rate was significantly (p<0.01) affected by kid birth weight and litter size. Perinatal kid mortality rates increased with an increase in litter size (r=0.46375) and decreased with an increase in total litter birth weights in all the groups(r=-0.77293) No effect of sex on perinatal mortality was observed.

Table 4.7 Effects of litter size, sex of the kids and kid birth weight on the perinatal mortality rate of goat kids

Variables	N	Perinatal mortality rate (%)
Pregnancy supplementation		*
1 Supplemented	47	31.9
2 Control	43	14.0
Birth weight of kids		**
1 x<2kg	22	50.0a
2 2≤x<2.8kg	24	37.5b
3 2.8<x≤3.3kg	19	5.3c
4 x>3.3kg	25	0.0c
Litter size		**
1	17	0.0a
2	28	17.95b
3	33	18.2b
4	12	83.3c
Sex		ns
1 Male	49	22.5
2 Female	41	24.4

** Significant (P<0.01)

* Significant (P0.05)

ns Not significant

abc Figures with same subscripts within the same column differ significantly

CHAPTER 5

DISCUSSION

5.1 BODY WEIGHT

Neither of the two supplementation treatments (flush feeding prior to AI or late pregnancy supplementation prior to kidding) had a significant effect on body weight of the does. Animals from both groups (flush fed and control) tended to lose body weight from the beginning of the experiment until AI. The reason for a decrease in body weight might be due to stress. During flushing period, the flush fed animals were separated from the control to appropriate pens to be fed and this might have imposed additional stress to the animals. Later, between week 5 and 6, animals may have been stressed due to oestrous observations following the end of progestagen treatment, as it was done 3 times a day and also due to AI. Bearden and Fuquay (1980) have reported a loss in body weight, depression of appetite and reduced thyroid activity due to stress in animals. Body weight at breeding had a significant effect on conception rate. A higher doe body weight during synchronization and AI was associated with a higher conception rate, regardless of the synchronization treatment used or flush feeding implemented. These results support the conclusion of Cissè et al (1994), who recorded that does which conceived were heavier, when compared to those that did not conceive. There was no significant difference on conception rate and litter size between the does that gained or lost body weight prior to breeding. This is contrary to the findings of Parry *et al* (1990), who found that body weight loss prior to breeding is associated to a lower fertility rate and litter size.

After AI, all the animals gained weight (3kg to 4kg) for 5 weeks until week 11 (onset of winter), where pregnant does gained 1kg more than the non-pregnant does, probably due to foetal growth. Between weeks 11 and 20 all the animals tended to gradually lose body weight. The loss of body weight at this particular stage could possibly be ascribed to the winter season and the poor quality of the pastures. At this particular time the pastures on which does

depended on for their nutrients were dry and low in protein. These results support the work of Cisse et al. (1994) who reported a rapid decline in pregnant does during winter season due to decline in quantity and quality of herbaceous pastures. During the last weeks of pregnancy the pregnant does tended to increase body weight, possibly due to rapid foetal growth, while non-pregnant animals maintained their low body weight. Supplementary feeding during the last 6 weeks of pregnancy also failed to have a significant effect on body weight of does. This was quite unexpected and may be due to type and quantity of supplement. These results were different from the report of Blakely and James (1982) who suggested that supplementation during late pregnancy should lead to increase increase in body weight

5.2 OESTROUS RESPONSE

The response to oestrous synchronization, the time to the onset and the duration of the induced oestrus are important aspects for a successful AI programme, as these parameters determine the success rate of AI (Evans & Maxwell, 1987). In fixed time AI progammes the time of insemination is determined in relation to the time of progestagen treatment withdrawal. Therefore these three parameters (response, onset and duration of oestrus) are usually recorded to analyse the possible causes of poor conception rates following AI. With this information it is possible to if poor conception rate is due to wrong time of Ai or failure in AI technique.

Only 17.8% of the experimental animals were found to be cyclic prior to the onset of the synchronization treatment. One of the reasons for this low oestrous activity may be due to the time of the year (season) when the experiment was initiated. Oestrous detection was performed in early autumn (mid February to early March) which is early in the breeding season. According to Evans and Maxwell (1987), there is a gradual increase of ovarian activity as new the breeding season in sheep and goats approaches. Therefore, there is a strong reason to believe that most of the does at this time of the year were not cyclic, or demonstrated weak signs of oestrus (silent heat).

Of the 5 does, which lost their progestagen devices/sponges during the synchronization period, 3 does did not show signs of oestrus following the cessation of progestagen treatment. Despite the fact that the progestagen agents were immediately replaced when such incidents were observed, this might have contributed the failure of these animals to respond to the oestrous synchronization programme. The two other does which also lost their progestagen agents (and were replaced) came onto oestrus after progestagen treatment withdrawal. One of the reasons for these differences may be the period in which the animals were without progestagen treatment, which however could not have been more than a few hours.

In the present study, 96.6% of the does came into oestrus following a 16 day progesterone treatment. These results are similar to those of Baril and Saumande, (2000), Freitas *et al* (1996) and Freitas *et al* (1997). However, few researchers have obtained 100% oestrous response following synchronization (McGovern, 1971; Ishwar and Pandey 1992). The response obtained was higher than the 73.5% reported by Greyling and Van Der Nest (2000), working on the same goat breeds. It is evident that the three progestagen treatments used were very effective in synchronizing oestrus in goat does and none of them showed a significant advantage over the other.

The mean time to onset of oestrus following cessation of progestagen treatment was 30.1±5.5 hours. This supports the findings of Greyling et al (1997) who found the onset of oestrus following cessation of progestagen treatment in sheep to be 30.5h. However, this time interval from cessation of progestagen treatment to the onset of oestrus is shorter than that reported by Ishwar and Pandey (1992) on Black Bengal goats and by Doijodi *et al.* (1992) on Angora goats. These variations in the onset of oestrus may be due to breed differences which is known to have an influence on the time to oestrus (Ahmed *et al.*, 1998). The onset of oestrus in the present study might have been hastened by the presence of teaser bucks, as animals were teased every 8 hours for at least 30 minutes following progestagen treatment withdrawal (Romano & Fernandez Abella, 1997). The onset of oestrus was significantly affected by progestagen treatment but not by flush feeding prior

to synchronization. The CIDR treated animals exhibited oestrous signs earlier than the MAP and FGA groups. For the MAP and FGA treated animals, the onset of oestrus did not differ significantly and this contradicts with the results of Romano (1998) who found a difference on the onset of oestrus between MAP and FGA treatments in goats. However, the present results is comparable to those found by Greyling and Van Niekerk (1990b) and Freitas *et al* (1996).

Neither progestagen treatment nor flush feeding had a significant effect on the duration of the induced oestrus. These results are contradictory to those obtained by Selvaraju *et al* (1997) who recorded a significantly longer duration of oestrus in MAP when compared to FGA and CIDR treated does. The mean duration of induced oestrus (33.2±13.4h) in the present study was comparable to the natural duration of oestrus in Boer goat does (37.4±8.6h) recorded by Greyling (1988). It would, therefore, seem as if the oestrus activity remained normal and was not affected by the hormonal treatments used. This mean duration of induced oestrus is, however, shorter when compared to the findings of Greyling and Van Niekerk (1990b) and Ahmed *et al* (1998), but comparable to the reports of Devendra and Burns (1983), Taminic *et al* (1984) and Van Der Nest (1997).

5.3 MEAN SERUM PROGESTERONE CONCENTRATIONS FOLLOWING OESTROUS SYNCHRONIZATION

The mean serum progesterone concentration profiles of the CIDR treated does for the first 4 days after progestagen releasing device insertion was higher when compared to MAP and FGA treated does. In the group of does treated with CIDR the mean serum progesterone concentration increased rapidly after device insertion from 4.8±4.1ng/ml to 9.5±5.8ng/ml on day 4 and then decreased gradually. The serum progesterone concentration of CIDR treated does remained significantly higher than the MAP and FGA treated does until day 16 of treatment. This is in agreement with the reports of Selvaraju and Kathiresan (1995) and Wheaton *et al* (1993) who found that serum progesterone concentration in does treated with CIDR increased rapidly after device insertion to reach maximum, and then decrease gradually.

The mean serum progesterone concentrations in the MAP and FGA treated animals dropped gradually from an initial value of 2.6±5.5ng/ml and 1.0±0.9ng/ml to 0.3±0.1ng/ml and 0.3±0.1ng/ml at cessation of treatment and then remaintained low. When the majority of the does were in oestrus (32h following progestagen withdrawal) the serum progesterone levels were low and significantly different for the three progestagen treatments (MAP; 0.3±0.2ng/ml, FGA; 0.2±0.5ng/ml and CIDR; 0.4±0.1ng/ml), This is in agreement with the work done by Thorburn and Schneider (1972). At AI the mean progesterone levels did not differ significantly between the three progestagen treatments. There was an increase in progesterone levels after AI for both pregnant and non-pregnant does due to increased luteal activity (CL fomation), which is normal at this phase of the oestrous cycle (Greyling, 1999).

A positive correlation between the serum progesterone concentration at 21 days following AI and pregnancy status (r=0.5286) was recorded. Twenty-one days following AI pregnant does had a significantly higher serum progesterone concentration (17.3±6.9ng/ml), compared to the non-pregnant does (3.6±5.4ng/ml). These results indicate that pregnancies can be accurately confirmed as early as 21 days after AI using serum progesterone tests. It is, also evident from the present study that animals with serum progesterone concentrations of between 10.4ng/ml and 24.3ng/ml, 3 weeks after AI can be safely considered pregnant. The only problem with this method of pregnancy diagnosis is that it cannot differentiate between pseudopregnancy or an extended luteal phase (Ahmed et al., 1998), thus, a few false positive pregnancy diagnostic animals can be expected.

5.4 CONCEPTION RATES

The non-return rate of does from 14 to 23 days after AI was 91.0%. This is much higher when compared to the conception rate found 40 days after AI using an ultrasonic rectal probe (52.0%) and confirmed at kidding. The non-return rate is a subjective indication of conception and depends on the accuracy of oestrous detection and is subject to human error and failing to observe animals that returned to oestrus, could also affect its accuracy. Ritar

et al (1989) and Ahmed et al (1998) found the same pattern where the non-return rates were found to be higher than the conception rates obtained through rectal palpation. It can, thus, be concluded that the non-return method is not a reliable technique to test for pregnancy. Furthermore, females that do not return to oestrus are not necessarily pregnant as animals might have a silent oestrus or other physiological conditions. Therefore, this method is not very reliable and not recommended to indicate the success of AI. Serum progesterone levels 21 days after AI were a much better indicator of pregnancy status, comparable to rectal ultrasonography at 40 days after AI.

The overall conception rate was fairly low, when compared to the results of Faure *et al* (1983), Greyling *et al* (1994) and Greyling and Van Der Nest (2000). However, Baril and Saumande (2000) have reported conception rates lower than 50%, and explained that the reason for such low conception rates was due to the late onset of oestrus following cessation of progestagen treatment. The reasons for low conception rate following oestrous synchronization in this study might be due to impeded sperm transport or untimely inseminations. Low conception following oestrous synchronization with progestagen has been reported elsewhere by many researchers, who indicated impeded sperm transport as the cause for the poor results (Croker *et al.*, 1975; Quispe *et al.*, 1994, Greyling *et al.*, 1994). A possible reason for the low conception rate in the present study could be the stress induced by the two inseminations implemented or excessive handling during blood sampling. When comparing the conception rate of the does from which blood was sampled and the rest of the does, there was no significant difference in conception rate between the two. These results, however, indicate that stress was not an important factor limiting conception. This is contradictory to the results of Corteel *et al* (1988), who found low fertility rates after two inseminations to be related to stress. The animals used in the present study had been previously subjected to progestagen/PMSG treatment and there is, therefore, a possibility that the low conception rate obtained could be a consequence of a high level of anti-PMSG antibodies related to repeated treatments (Baril *et al.*, 1992a; 1992b; Baril & Saumande, 2000). Individual doe results seem to indicate that does that came to oestrus 48 and 56 hours

following treatment removal did not conceive. The interval from progestagen withdrawal to onset of oestrus, however, did not seem to have a significant effect on the conception rate. Animals with a long induced oestrous period (56h) were not diagnosed pregnant, and, hence, the duration of the induced oestrous period in the experiment did not have a significant effect on conception rate.

In the present study CIDR had a lower conception rate, when compared to MAP and FGA treatments, although the differences were not statistically significant. The results obtained in this trial are markedly different from the high conception rates achieved with CIDR's ranging from 64.5% to 83.3% reported by several authors (Waldron *et al.,* 1999; Selvaraju & Katherisen, 1995; 1997), but they are in the line with results of Moore *et al* (1988; 1989). The reasons for lower conception rate using the CIDR may be attributed to breed differences or the time of insemination as suggested by Moore *et al.* (1988; 1989)

5.5 GESTATION LENGTH, LITTER SIZE AND TOTAL LITTER WEIGHT

The mean gestation length recorded was 149.1±4.1 days. The gestation length was more or less the same in all the progestagen treatments. These results are in agreement with the reports of Oh *et al.* (1971), Abad Gavin *et al.* (1982) and Ishwar and Pandey (1992), who found no significant differences in the gestation length due to oestrous synchronization and PMSG or HCG administration. The duration of pregnancy was also not affected by flush feeding or late pregnancy supplementation. Other durations of pregnancy in goats of 149.9 days, 151 days and 150.8 days have been reported by other researchers (Devendra & Burns, 1983; Amoah & Gelaye, 1990b). The reason for these variations reported in gestation length may be attributed to breed differencesas suggested by Devendra and Burns (1983). The gestation length for does bearing quadruplets was significantly shorter than for does bearing singles twins or triplets. This could be explained by the lack of uterine space due to the increased total litter weight that induces stress resulting in an earlier kidding. Ritar et al (1989) and Amoah and Gelaye (1990b) reported a shorter gestation period for does carrying multiple kids compared to does

carrying single kids. Some researchers observed the sex of the kids to affect gestation length with male foetuses having shorter gestation periods than those with female foetuses (Shelton, 1960; Amoah & Bryant, 1983) but the sex effect on gestation length was not observed in this current experiment. As it can be expected multiple births had significantly heavier total litter weight than single births.

The mean litter size recorded was 2.0±0.9, which is higher than that reported by other researchers (Casey & Van Niekerk, 1988; Amoah & Gelaye, 1990b). A significantly lower mean litter size of 1.8±0.9 was observed in flush fed animals, as opposed to control animals (2.3±1.0). The reason for this was uncertain. It was expected that the flush fed group would have a higher litter size as was observed in sheep (Greyling & Venter, 1994). The failure to observe this effect in the present study can possibly be explained by the low voluntary intake of flushing feed and type of supplementation used (crushed maize grains). From the 300g maize/day offered to the does, only a third to half was consumed. At the time when the maize was offered to the does, the natural pastures were quantitatively and qualitatively in a very good nutritional state, therefore, the animals in both treatments were getting enough nutrients from the pasture for their nutrient requirements. Body weight at breeding had a significant effect on litter size. Does lighter than 41kg produced significantly lower litter sizes, when compared to heavier does at breeding. This is contrary to that reported by Waldron *et al* (1999), but in agreement with the results of Mukasa-Mugerwa and Lahlou-Kassi (1995), in sheep. A positive correlation between the dam weight at breeding and litter size was found in this study, which indicates that litter size increases with an increase in body weight at breeding. This correlation was, however, low (r=0.35948) but significant. Progestagen treatments as well as late pregnancy supplementation had no significant effect on the total litter weight of the does.

5.6 Kid birth weights and perinatal mortality rates

Late pregnancy supplementation is known to have effect on birth weight (Rattray, 1977). This was however not observed in this study. The possible reason for this could be that does were in a good body condition with

adequate energy reserves throughout pregnancy, therefore supplementation had a minimal effect on birth weight. Cross-kids (Boer X Indigenous feral) were significantly heavier than Boer kids at birth, which could be an indicator of heterosis. These results were in agreement to the reports of Devendra and Burns (1983) and Bajhau and Kennedy (1990), who found that crossbred kids had heavier birth weights than pure breeds. A negative correlation was found between birth weight and litter size, an aspect that was also observed by Epstein and Hertz (1964) and Amoah and Bryant (1983). The birth weights were 3.6±0.4kg, 3.1±0.5kg, 2.3±0.6kg and1.6±0.3kg for singles, twins, triplets and quadruplets, respectively, and the differences were significant. The implication is that much of the variation in birth weight is associated with birth type (Gebrelul *et al.,* 1994). The male kids were significantly 100g heavier than the female kids which is in agreement with Devendra and Burns (1983).

Kids from multiple births are always weaker at birth than single kids as a result of physiological starvation in the uterus and lower energy reserves. The survival rate of multiple kids is, therefore, usually lower as these kids are weak to suckle and hence the low energy reserves get depleted very fast (Alexander, 1990; Mukasa-Mugerwa & Lahlou-Kassi, 1995; Awemu *et al.,* 1999). Some kids from multiple births were stillborn but not generally the whole litter, especially in those kids born early in the kidding season. It has been seen that the duration of pregnancy decreases with an increase in litter size. Therefore, the reason for stillbirths might be related to the number of foetuses carried during a shorter gestation period. In this study it was observed that does with multiple births had a tendency to groom the first kids and abandon those born last. This could also, in turn, increase the perinatal mortality rate in multiple births. During the whole kidding period, only one doe kidded at night and both her kids died due to low temperatures and being to weak to suckle. All other does kidded at warmer hours of the day between 8.00 am and 18.00 pm. This is in agreement with Barlow *et al* (1987) and Allan et al (1991), who reported mortality of kids born at night to be related to low temperatures and low vigour (weak to stand hence unable to suckle). There was also a higher perinatal mortality rate in kids from supplemented does, compared to the control does. These results are contrary to that found

in sheep. Nutritional supplementation during pregnancy generally results in an increase in birth weight hence lower mortality rate (Rattray, 1977, Rattner *et al.*, 1994). Here once again the type and quantity of supplementation could have played a role. Another possibility is a confounding effect of the interaction of higher litter size and lower kid birth weight.

Birth weight had a significant effect on perinatal mortality rate of kids. Kids with a birth weight of less than 2kg had the highest perinatal mortality rate (50%). Perinatal mortality rates tended to decrease with an increase in the kid birth weight. This is in agreement with results reported by Mtenga *et al* (1994) and Rattner *et al* (1994). Kids with lower birth weights have lower energy reserves and are therefore unable to withstand harsh environmental conditions just after birth (Awemu *et al.,* 1999) and therefore have higher mortality rates. The effect of sex of the kids was not found to be an important factor as far as perinatal mortality rates were concerned. This is contrary to the findings of Ebozoje and Ngere (1995), who reported higher death rates in female kids compared to male kids in West African Dwarf goats.

CHAPTER 6

GENERAL CONCLUSIONS

Regarding the reproductive performance in goats, no beneficial effect was recorded as emanating from flush feeding (300g crushed maize/doe for 3 weeks before AI) nor from late pregnancy supplementation (300g whole maize grains/doe for 6 weeks prior to kidding). Body weight of the does at breeding had a significant effect on conception rate, with heavier does (46.2±7.9kg) showing significantly higher conception rate when compared to lighter does (41.5±8.6kg).

A relatively low percentage of does were observed to be cyclic prior to oestrous synchronization at the onset of the breeding season. Following oestrous synchronization 96.6% (all groups) of the does responded and demonstrated oestrous signs. No significant difference was recorded following oestrous synchronization between the three progestagen treatments (MAP, FGA and CIDR) in oestrous response, duration of oestrus and conception rates. However, the time to oestrus was significantly ($P<0.05$) shorter in CIDR treated does, compared to FGA and CIDR treated does.

CIDR treated does had significantly ($P<0.05$) higher progesterone levels when compared to MAP and FGA treated does from day 4 after device insertion to 8 hours after progestagen withdrawal. No significant difference in serum progesterone concentration was recorded between the three progestagen treatment groups at oestrus and time of breeding.

The overall conception rate achieved (52%) was lower than that recorded by other researchers on the same goat breed, but in the line with other reports in different goat breeds. The recorded non-return rate was much higher than the actual conception rates confirmed 40 days after AI with ultrasonoghraphy and at kidding. This indicates the non-return to oestrus to be a very poor indicator of conception rate following AI. Serum progesterone concentration 21 days

after AI proved to be a very good indicator of conception rate, producing results comparable to rectal ultrasonography at 40 days following AI.

The mean gestation length for does bearing quadruplets was significantly ($P<0.01$) shorter, compared to does bearing singles, twins and triplets. The total litter weight increased with an increase in litter size. The mean litter size recorded was 2.0±0.9 kid/doe. Heavier does (>41kg) at breeding had a significantly ($P<0.01$) larger litter size than lighter does (<41kg).

The male and crossbred kids (Boer goat X indigenous) were on average 100g heavier than female and pure Boer goat kids. Kid birth weights were negatively correlated ($r=-0.7729$) to litter size. Variation in birth weight was associated with birth type. Perinatal mortality rates were positively correlated ($r=0.4637$) to litter size and negatively correlated ($r=0.7729$) to kid birth weights. The high mortality rate recorded in quadruplets makes the aim of such big litters non-viable for commercial farming.

It is concluded that oestrous synchronization with the use of progestagen (irrespective of the type of progestagen used) is effective in synchronizing oestrus in does. The timing of AI as implemented in this trial was readily acceptable, however a question mark hangs over the type, duration and time of nutritional supplementation which would benefit the overall reproductive performance of such an AI programme. Very little work has been done on the aspect of nutritional flushing or supplementation in goats and the potential promise it holds. This aspect warrants further investigation.

ABSTRACT

SYNCHRONIZATION OF OESTRUS IN INDIGENOUS GOATS: THE USE OF DIFFERENT PROGESTAGEN TREATMENTS

by

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A study aimed at comparing the efficiency of different progestagen treatments used for oestrous synchronization in indigenous South African goats was carried out between February (autumn) and September (spring), 2000. The study was carried out at Paradys experimental farm, of the University of the Orange Free State situated approximately 20km south of Bloemfontein, in the Free State province.

Forty-eight indigenous feral does and 42 Boer does were used in this experiment, during the normal breeding season. The two breeds were randomly allocated and distributed between the three progestagen synchronizing treatment groups of 30 does per group. The treatment groups were medroxyprogesterone acetate (MAP), fluorogestone acetate (FGA) and controlled internal drug release dispenser (CIDR) groups. These three main progestagen treatment groups were further subdivided into six flush feeding groups of 15 does each, namely A1 (MAP X flush feeding); A2 (MAP X control); B1 (FGA X flush feeding); B2 (FGA X control); C1 (CIDR X flush feeding) and C2 (CIDR X control). Three groups (A1, B1 and C1) were flush

fed with crushed maize for 3 weeks prior to breeding. Progestagen treatment was administered for 16 days. All does were injected with 300IU PMSG im at the time of progestagen withdrawal. Oestrus was detected with the aid of vasectomized bucks at 8 hour intervals for a period of 96 hours following progestagen treatment. Blood samples were collected at 4 day intervals during synchronization and at 8 hour intervals after progestagen treatment removal, as well as at days 14 and 21 following AI. Six weeks prior to kidding, pregnant does were divided into two groups, one supplemented with whole maize grain, while another one acted as a control group, irrespective of flush feeding and progestagen treatment prior to pregnancy. The parameters measured, included body weight, oestrous response, onset of oestrus, duration of oestrus, conception rate, gestation length, total litter weight, litter size, kid birth weight, sex of kids and mortality rates of kids.

Body weight of the does was not affected by progestagen treatment, flush feeding or pregnancy supplementation. Higher body weights at breeding were associated with a higher conception rate. Weight gain or loss prior to breeding had no effect on conception rate and litter size. Prior to synchronization, only 17.8% of the experimental does were observed to be cyclic. Following oestrous synchronization, the overall oestrous response recorded was 96.6%. Oestrous response for three progestagen treatments was 93.1%, 96.7% and 100.0% for MAP, FGA and CIDR, respectively. Progestagen treatment had a significant ($P<0.01$) effect on the time to onset of oestrus following cessation of progestagen treatment, with CIDR treated does exhibiting oestrus earlier (27.2±4.5h), compared to the FGA (30.9±4.6h) and MAP (32.2±7.1h) treated does. There was no significant difference on the duration of induced oestrous period between the three progestagen treatment groups (FGA: 32.0±13.7h; MAP: 32.6±13.8h and CIDR: 35.2±13.7h).

The mean serum progesterone concentration in CIDR treated does was significantly ($P<0.05$) higher from day of device insertion until cessation of treatment, when compared to the MAP and FGA treated does. No significant difference in serum progesterone concentrations was observed between MAP and FGA treated does throughout the observation period. At the onset of

oestrus, the mean serum progesterone concentrations were 0.3±0.2ng/ml, 0.2±0.5ng/ml and 0.4±0.1ng/ml for MAP, FGA and CIDR, respectively. The difference was non-significant. At 21 days following AI, pregnant does had significantly ($P<0.01$) higher serum progesterone concentrations (17.3±0.9ng/ml), than the non-pregnant does (3.6±5.4ng/ml).

The overall conception rate for all groups was 52.2%. The conception rates for the CIDR, MAP and FGA groups were 46.7%, 51.7% and 60.0%, respectively. The differences were non-significant. The mean gestation length for all groups was 149.1±4.1 days. Gestation length was not affected by progestagen treatment, flush feeding or late pregnancy supplementation. Does bearing quadruplets had a significantly ($P<0.05$) shorter gestation length (142.7±2.8 days), when compared to does bearing singles, twins and triplets (150.0±2.8 days, 148.8±4.3 days and 150.0±4.1 days, respectively). The total litter weight for single births was significantly ($P<0.01$) lower, than that of multiple births (3.6±0.4; 6.0±0.9; 6.7±1.5; 6.4±0.5 for singles, twins, triplets and quadruplets, respectively). The mean litter size was 2.0±0.9 and this was not affected by progestagen treatment. Flush fed does had a significantly ($P<0.05$) lower litter size, when compared to the control does (1.8±0.9 vs 2.3±1.0). Does lighter than 41kg produced a significantly ($P<0.01$) lower litter size, when compared to heavier does.

The average birth weight of the kids was 2.7±0.5kg and was not affected by late pregnancy supplementation. Crossbred (Indigenous X Boer) and male kids (2.7±0.8kg and 2.7±0.8kg, respectively) were significantly ($P<0.05$) heavier when compared to pure Boer and female kids (2.6±0.9kg and 2.6±0.8kg) at birth. The mean birth weights for quadruplets, triplets, twins and singles were 1.6±0.3kg, 2.3±0.6kg, 3.1±0.5kg and 3.6±0.4kg, respectively, and these differed significantly ($P<0.01$) from each other. The overall perinatal mortality rate of kids up to 48 hours postpartum was 22.3%. Kids from supplemented pregnant does had significantly ($P<0.05$) higher perinatal mortality rate when compared to kids from the control does (31.9% vs 14.0%), respectively. Perinatal mortality rates of kids increased with an increase in litter size and decreased with an increase in birth weight.

It is concluded that synchronization of oestrus with the use of progestagen (irrespective of the type used), is efficient in synchronizing oestrus. The type, duration and time of nutritional supplementation as well as the body condition of the animal should be born in mind whenever flush feeding and supplementation programmes are considered. There are many factors (nutritional and managerial) that could influence the conception rate following fixed-time AI in goats.

OPSOMMING

SINKRONISASIE VAN ESTRUS BY INHEEMSE BOKKE: DIE GEBRUIK VAN VERSKILLENDE PROGESTAGEEN BEHANDELINGS

deur

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'n Studie gemik op die vergelyking van verskillende progestageen behandelings op die doeltreffendheid van estrus sinkronisasie by inheemse Suid-Afrikaanse bokke is uitgevoer tussen Februarie (Herfs) en September (Lente), 2000. Die studie is uitgevoer op Paradys proefplaas van die Universiteit van die Oranje-Vrystaat, geleë ongeveer 20 km suid van Bloemfontein in die Vrystaat provinsie.

Ag-en-veertig inheemse bokooie en 42 Boerbokooie is in die studie gebruik, tydens die normale teelseisoen. Die twee rasse is ewekansig geallokeer tussen die drie progestageen sinkronisasie behandelingsgroepe (30 ooie per groep). Die behandelingsgroepe was medroksiprogesteroon (MAP), fluorogestoon asetaat (FGA) en 'n beheerde interne hormonale verspreider (CIDR). Hierdie drie hoof progestageen behandelings is verder onderverdeel in ses prikkelvoedingsgroepe (15 ooie per groep), naamlik A1 (MAP x prikkelvoeding); A2 (MAP x kontrole); B1 (FGA x prikkelvoeding); B2 (FGA x kontrole); C1 (CIDR x prikkelvoeding); C2 (CIDR x kontrole). Die drie groepe (A1, B1, C1) het prikkelvoeding van gebreekte mielies ontvang vanaf 3 weke voor KI. Progestageen behandeling is toegedien vir 16 dae. Alle ooie het 300

IU PMSG binnespiers ontvang met progestageen onttrekking. Estrus waarnemings is elke 8 ure vir 'n periode van 96 uur na progestageen behandeling m.b.v. gevasektomiseerde ramme gedoen. Bloed monsters is gekollekteer met 4 dae intervalle tydens sinkronisasie en na onttrekking met 8 uur intervalle, asook by dag 14 en 21 na KI. Ses weke voor lam is die dragtige ooie verdeel in twee groepe, die een groep het byvoeding van heel mielies ontvang, terwyl die ander groep gedien het as kontrole. Parameters gemeet het ingesluit, liggaamsgewig, estrus respons, begin van estrus, duur van estrusperiode, konsepsiesyfer, duur van dragtigheid, werpselgrootte, totale werpselgewig, geboortegewig van lammers, geslag van lammers en mortaliteite by lammers.

Liggaamsgewig van die ooie is nie betekenisvol beïnvloed deur progestageen behandeling, prikkelvoeding of byvoeding tydens dragtigheid. Hoër liggaamsgewigte by paring was geassosieerd met 'n hoë konsepsiesyfer. Liggaamsgewig toename of afname voor teling het geen effek op konsepsie en werpselgrootte gehad nie. Voor sinkronisasie was slegs 17.8% van die ooie siklies. Met sinkronisasie is 'n algehele estrus respons van 96.6% gemeet. Estrus respons vir die drie progestageen behandelings was 93.1%, 96.7% en 100% vir die MAP, FGA en CIDR groepe respektiewelik. Tipe progestageen behandeling het 'n betekenisvolle ($P<0.01$) effek gehad op die tyd tot estrus na progestageen behandeling, met die CIDR groep wat estrus vroeër (27.2 ± 4.5h) getoon het, vergeleke met FGA (30.9 ± 4.6h) en MAP (32.2 ± 7.1h) behandelde ooie. Geen betekenisvolle verskil in die duur van die geïnduseerde estrusperiode is gevind tussen die groepe (FGA: 32.0 ± 13.7h; MAP: 32.6 ± 13.8h; CIDR: 35.2 ± 13.7h).

Die gemiddelde serum progesteroonkonsentrasie in die CIDR behandelde ooie was betekenisvol ($P<0.05$) hoër vanaf die dag van behandeling tot die beëindiging van behandeling, wanneer vergelyk word met die MAP en FGA-groepe. Geen betekenisvolle verskil in serum progesteroonkonsentrasie is waargeneem in die MAP en FGA behandelde ooie tydens die observasieperiode. Aan die begin van estrus was die serum progesteroonkonsentrasies 0.3 ± 0.2ng/ml, 0.2 ± 0.5ng/ml en 0.4 ± 0.1ng/ml

vir die MAP, FGA en CIDR groepe respektiewelik (geen betekenisvolle verskil). By 21 dae na KI het dragtige ooie 'n betekenisvolle (P<0.01) hoër serum progesteroonkonsentrasie (17.3 ± 0.9ng/ml) gehad, vergeleke met die nie-dragtige ooie (3.6 ± 5.4ng/ml).

Die gemiddelde konsepsiesyfer vir alle groepe was 52.2% en was nie beïnvloed deur prikkelvoeding of progestageen behandelings nie. Die konsepsiesyfers behaal vir die CIDR, MAP en FGA groepe was 46.7%, 51.7% en 60.0% respektiewelik. Die gemiddelde dragtigheidsduur vir alle bokooie was 149.1 ± 4.1 dae, met hierdie parameter wat nie beïnvloed word deur progestageen behandeling, prikkelvoeding of laat-dragtigheid byvoeding nie. Ooie met vierlinge het 'n betekenisvolle (P<0.05) korter dragtigheidsperiode (142.7 ± 2.8 dae), vergeleke met ooie wat enkelinge, tweelinge en drielinge (150.0 ± 2.8 dae, 148.8 ± 4.3 dae en 150.0 ± 4.1 dae, respektiewelik) gehad. Die totale werpselgewig vir enkelinge was betekenisvol (P<0.01) laer as veelvoudige geboortes (3.6 ± 0.4; 6.0 ± 0.9; 6.7 ± 1.5; 6.4 ± 0.5 vir enkelinge, tweelinge, drielinge en vierlinge, respektiewelik). Die gemiddelde werpselgrootte vir alle diere was 3.2 ± 0.9 en dit was nie betekenisvol geaffekteer deur progestageen behandeling. Prikkelvoeding het gelei tot 'n betekenisvol (P<0.05) laer werpselgrootte, vergeleke met kontrole diere (1.8 ± 0.9 vs 2.3 ± 1.0). Bokooie ligter as 41kg het betekenisvol (P<0.01) laer werpselgroottes produseer, vergeleke met swaarder diere.

Die gemiddelde geboortegewig van die lammers was 2.7 ± 0.5kg en was nie beïnvloed deur laat-dragtigheid byvoeding. Kruis (Inheems x Boer) en manlike lammers (2.7 ± 0.8kg en 2.7 ± 0.8kg respektiewelik) was betekenisvol (P<0.05) swaarder as Boer en vroulike lammers (2.6 ± 0.9kg en 2.6 ± 0.8kg) met die geboortegewig vir vierlinge, drielinge, tweelinge en enkelinge was 1.6 ± 0.3kg, 2.3 ± 0.6kg, 3.1 ± 0.5kg en 3.6 ± 0.4kg respektiewelik, en het betekenisvol (P<0.01) verskil van mekaar. Die algehele mortaliteit van die lammers tot 48 uur na-geboorte was 22.3%. Lammers van gesupplementeerde dragtige ooie het 'n betekenisvol (P<0.05) hoër mortaliteitssyfer gehad, vergeleke met lammers van kontrole ooie (31.9% vs

14.0%). Peri-natale mortaliteite van lammers het verhoog met 'n verhoging in werpselgrootte en het afgeneem met 'n toename in geboortegewig.

Samevattend kan gesê word dat sinkronisasie van estrus deur die gebruik van progestageen (ongeag die tipe gebruik) in S.A. Boer en Inheemse bokooie, doeltreffend is. Die tipe, duur en tyd van byvoeding, asook die liggaamskondisie van die dier moet in gedagte gehou word wanneer prikkelvoeding en byvoedingsprogramme oorweeg word. Daar is verskeie faktore (voeding en bestuur) wat konsepsie kan beïnvloed na vasgestelde tyd KI by bokke.

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