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**IMPROVING THE REPRODUCTIVE EFFICIENCY OF
SMALLSTOCK BY CONTROLLED BREEDING**

ZELEKE MEKURIAW ZELEKE

**IMPROVING THE REPRODUCTIVE EFFICIENCY OF
SMALL STOCK BY CONTROLLED BREEDING**

by

ZELEKE MEKURIAW ZELEKE

A Thesis submitted
in accordance with the academic requirements for the degree

of

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**Faculty of Natural and Agricultural Sciences
Department of Animal, Wildlife and Grassland sciences
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Republic of South Africa**

Promoter: Prof. J.P.C. Greyling

Co-promoter: Dr. LMJ. Schwalbach

**Bloemfontein
March 2003**

Universiteit van die
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DEDICATION

♥ To my wife, Mistirie Tilahun, for your love and encouragement in achieving this objective. Above all thank you very much for your patience and understanding my absence.

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DECLARATION

I hereby declare that this thesis submitted by me to the University of Free State for the degree, Philosophae Doctor, has not previously been submitted for a degree at any other University. I further cede copyright of the thesis in favour of the University of the Free State.



Zeleke Mekuriaw Zeleke

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March 2003

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LIST OF ABBREVIATIONS

ACTH	adrenocorticotrophic hormone
AI	artificial insemination
BC	Body condition
BCS	body condition score
BHO	Blackhead Ogaden
BW	Body weight
CATMOD	categorical modeling
CIDR	controlled internal drug release
CL	corpus luteum
CRH	corticotrophin releasing hormone
DMRT	Duncan's multiple range test
eCG	equine chorionic gonadotrophin
FGA	fluorogestone acetate
FSH	follicle stimulating hormone
GLM	general linear model
GnRH	Gonadotrophin releasing hormone
hCG	human chorionic gonadotrophin
IM	intramuscular
IU	international unit
LH	luteinizing hormone
MAP	medroxyprogesterone acetate
MGA	melengestrone acetate
MOET	multiple ovulation and embryo transfer
P ⁴	progesterone
PGF ₂ α	prostaglandin F ₂ alpha
PMSG	pregnant mare serum gonadotrophin
RLU	relative light units
SC	subcutaneous
SSA	Sub-Saharan Africa

IMPROVING THE REPRODUCTIVE EFFICIENCY OF SMALL STOCK BY CONTROLLED BREEDING

CHAPTER 1

GENERAL INTRODUCTION

Livestock production is one of the most economically important agricultural enterprises in developing countries in general, and the sub-Saharan Africa (SSA) in particular. However, the yearly growth rate in livestock production is too slow (2.6% for meat and 3.2% for milk) to satisfy the needs of a rapidly growing human population in this region (Winrock International, 1992). If this trend continues, the region is expected to face massive shortages in milk and meat supplies by 2025. This low supply of animal products in the developing world is, unfortunately, against the background that 52% of the world's cattle, 24% of the sheep and 63% of the goats found in this region (Jahnke, 1982). The obvious reason for the under supply of animal products in developing countries is the low productivity of the animals.

According to estimates of the World Bank, animal production (meat and milk) must increase by 4% per year until 2025 to improve the nutritional status and minimize food imports to the developing countries (McIntire *et al.*, 1992). Ruminant livestock production is expected to account for 60% of the envisaged increase in meat production and almost all of the milk. Among ruminant animals, sheep and goats are the most appropriate animals to be farmed under the prevailing environmental (climate, feed resources and disease prevalence) and economic (limited capital) situations of SSA. Sheep and goat farming can be more efficient than large ruminant production in many ways under the existing African production systems. Sheep and goat farming, when compared to cattle requires a lower initial capital investment, a smaller farming area, can be managed by family labour, requires less maintenance feed, products

are in manageable quantities, has lower risk of total loss, little cultural and religious taboos against its utilization, and a higher reproductive rate.

Despite their real importance, it is difficult to accurately determine the contributions of sheep and goats to the food supply and the general welfare of humans. Available statistics are misleading, because much of the production from these species does not enter the formal trade channels and is, therefore, not reported. Even then, estimates indicate that sheep and goats account for approximately 22% of the total food production from ruminants in tropical Africa (Jahnke, 1982). It is estimated that ruminants supply over 3.2 million tonnes of meat per year, representing over 72% of the total meat production. Meat production from sheep and goats accounts for approximately 30% of the total red meat production and over 20% of the total meat output of SSA. The figures on meat production from sheep and goats have been calculated from carcass weights, which in turn have been estimated from dressing percentages. In the African context, and indeed in most developing countries, the conventional concept of dressing percentage is relatively inappropriate, as almost all parts of the animal are consumed. Thus, actual meat outputs from these species in traditional production systems are believed to be higher than the current estimates. Sheep and goats also account for approximately 21% of the total milk production in SSA (Jahnke, 1982). Most importantly, production from sheep and goats makes a valuable contribution to food resources in areas where large ruminant farming could not be sustained due to climatic and/or economic limitations of the farming systems. Thus, sheep and goats are believed to have a great potential to contribute significantly to meat and milk production in Africa and hence meeting the current shortage created by the fast growing human population, provided that considerable efforts are made to improve their productivity.

Productivity of indigenous African sheep and goats can be improved by improving their genotype and/or environment. There are two options to improve the genotype of the indigenous animals. These are by (i) crossbreeding with exotic breeds or (ii) selecting among the existing local breeds. Whichever the choice is, assisted reproduction techniques especially oestrous synchronization and artificial insemination (AI) are key tools to enhance the genetic potential of the animals in general, and that of sheep and goats in particular. The use of AI

minimizes the cost of importing and maintaining a large number of live genetically superior male animals, reduces the risk of disease transmission and enables the use of these superior animals for breeding purposes even after their death. For the success of AI, the artificial control of the reproductive cycle of the female is also a pre-requisite. One of the techniques by which the animal's reproductive process can be manipulated is known as the synchronization of oestrus or the artificial induction of oestrus. This technique creates the opportunity for AI to be performed at a fixed time and to ensure that adequate numbers of animals are in oestrus at AI. Due to the fact that oestrous detection is prone to human error (Ahmed, *et al.*, 1998), oestrous synchronization allows a farmer to predict the time of oestrus with reasonable accuracy, avoiding the time consuming exercise of oestrous detection (and the subsequent handling stress) and thus makes AI more acceptable. Oestrous synchronization 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 synchronizing oestrus is to have parturition at a favourable period of the year with respect to climate and marketing patterns. Furthermore, this technique helps enhance biological and economic efficiency of production by making the best use of human and material resources available in a particular farming environment. For instance, synchronization of oestrus enables the farmer to schedule livestock handling and breeding times to fit in with the work schedule. It also allows the scheduling of the kidding and lambing season to a time when forage is available and the nutritive content of the pastures are more acceptable to the animal. This will result in improved milk production and consequently a higher kid and lamb survival and growth rates. By having a number of females in oestrus during a very short period of time, insemination and parturition activities can be restricted to a very short time.

Although extensive research has been done on the improvement and application of these techniques on small stock breeds in developed regions of the world such as Europe and North America, very little work has been done on the effectiveness and applicability of such assisted reproductive techniques on tropical breeds under African extensive production systems. The mere reason given for not applying controlled reproduction techniques in most African sheep and goat production systems in the past was that it could not be applied in small scale

subsistence farming conditions. However, attention was not paid to the emergence of progressive small-scale commercial farms where assisted reproduction techniques could be applied — especially for the upgrading of their herds. Thus, taking into consideration the existence of differences between developed and developing countries in terms of sheep and goat breeds, management systems and climatic conditions, the effectiveness and the applicability of oestrous synchronization and AI techniques — the response of these indigenous sheep and goat breeds managed under extensive farming systems to these techniques need urgent attention by researchers.

This study was, therefore, initiated to evaluate and develop acceptable and adapted oestrous synchronization protocols that could result in improved reproductive performances from induced oestrus and AI in indigenous sheep and goat breeds managed under extensive production conditions of Africa.

The broad objectives were:

1. To study the effect of intravaginal progestagen sponges (MAP and FGA) and pregnant mare serum gonadotrophin (PMSG) on the synchronization efficiency and fertility following synchronized oestrus and AI in Dorper sheep maintained under extensive veld conditions of South Africa during the transition period from the breeding to the non-breeding season
2. To study the effect of type and duration of intravaginal progestagen treatment and time of PMSG administration relative to intravaginal progestagen sponge withdrawal on synchronization efficiency and fertility from synchronized oestrus and AI in Blackhead Ogaden sheep maintained under extensive management systems in Ethiopia.
3. To study the effect of type and duration of intravaginal progestagen sponge treatment and time of PMSG administration relative to intravaginal progestagen sponge withdrawal on the synchronization efficiency and fertility following AI in Somali goats under extensive management systems in Ethiopia

CHAPTER 2

LITERATURE REVIEW

2.1. ARTIFICIAL REGULATION OF REPRODUCTION IN SHEEP AND GOATS

2.1.1. Introduction

Domestic sheep (*Ovis aries*) and goats (*Capra hircus*) are two distinct species in the family *Bovidae*. They are among the first to be domesticated: sheep for wool and meat, and the goat for milk, meat and fiber (Hafez & Hafez, 2000).

Sheep and goats are highly adaptable to a broad range of environments. They can utilize a wide variety of plant species and are thus complementary to cattle and camels (Schwartz, 1983). Sheep and goats are more meaningful to humans during periods of cyclical and unpredictable food shortages. These small stock also help balance the energy and protein requirements of human beings during normal variations in the availability of meat and milk from cattle between seasons and years. In actual terms, sheep and goats produce lower quantities of milk than cattle. However, when their body weight (BW) is taken into account, their milk production efficiency is higher than other species with the possible exception of camels (Wilson, 1991). During dry periods of the year, these relatively minor levels of output from small stock become more significant (Coppock *et al.*, 1982). It has been estimated that up to 40 years may be needed for cattle to attain the numbers and production levels existing prior to a severe drought (Wilson, 1991). Due to their shorter generation interval and higher reproductive rate, small ruminants in general have a much shorter recovery period. Although regional and breed variations exist, small stock appear to withstand periods of drought better than cattle (Campbell, 1978). The droughts of the early 1980's, which affected Ethiopia and

the Sahel, including Sudan, resulted in cattle losses of up to 80%, while small stock losses did not exceed 50% (Wilson, 1991).

Particularly, under smallholder production systems, sheep and goats are more important than cattle as they require a low initial capital investment and low maintenance costs, are able to use marginal land and crop residues, produce milk and meat in readily usable quantities, and are easily cared for by the family members. Sheep and goats are prolific and need relatively short periods of time to increase flock sizes after catastrophes or in periods of high prices. Thus, the offtake rate can respond to price increases (Winrock International, 1983). Therefore, there is a need to identify and mitigate factors that hamper productivity of these livestock species.

The seasonal pattern of reproduction of small stock limits the reproductive rate of both the ewe and doe in the temperate regions. Factors such as nutrition, management and genotype also contribute to lower reproductive rates of small stock in the tropics. Manipulation of reproduction by genetic, physiological and environmental methods could increase not only the frequency of breeding per year and the litter size, but also the survival of the of kids and lambs, and thus the overall productivity of these species. Various techniques have been developed to manipulate the reproductive process in farm animals to the advantage of increasing the efficiency and profitability of production. One of the most commonly used techniques for artificial manipulation of the reproductive process is oestrous synchronization.

2.1.2. Merits of oestrous synchronization

There are several advantages for implementing an oestrous synchronization program. It will, for example, allow the farmer to schedule intensive livestock handling and breeding periods to fit in with the work schedule and other required activities (Gordon, 1983). It also allows the scheduling of the kidding and lambing season to a time when forage and the nutritive content of the pastures are more acceptable to the animal. This will result in improved milk production and consequently a higher kid and lamb survival and growth rates (Baril & Saumande, 2000). By having a number of females in oestrus during a very short period of time, insemination or

mating and parturition activities can be restricted to a very short time interval (Van Rensburg, 1973; Gordon, 1983). 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, oestrous synchronization allows a farmer to predict the time of oestrus with reasonable accuracy and also reduce the time consuming exercise of oestrous detection and help making AI more acceptable (Ahmed, *et al.*, 1998). Oestrous synchronization 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 the synchronization of oestrus will be to have parturition at a favourable 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 assured. 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. On the other hand, in regions where a seasonal market or an expected peak in market demand occurs around a specific date (i.e., Christmas or any other religious event), creating an increased demand for animal products, it is possible to concentrate births at a specific time, to provide specific age groups of animals (e. g. lambs or kids) for the market.

2. 1.3. Hormonal control of the oestrous cycle

An understanding of how females control their cyclic activity and how the timing of events around ovulation occurs is a key element for the effective artificial control of the reproductive processes. The regular ovulatory patterns in the ewe and doe are the result of the activities of four main organs and a complex arrangement of stimulatory and inhibitory signals passing between them (Lindsay, 1988). These organs are the hypothalamus — an area near the center

of the brain; the pituitary gland — a structure at the base of the brain; the ovary and the uterus (Hafez *et al.*, 2000). Messages between these organs are mainly of two types: chemical (in the form of hormones) and electrical (in the form of nerve impulses), while there is the hybrid system in which chemical messenger substances are passed along nerve fibers (only to transmit information from the hypothalamus to the pituitary gland).

The hypothalamus receives messages from all over the body and from the environment, e.g. nutritional status of the animal, the time of the year (photoperiod), stress levels and the presence of the male (Hafez & Hafez, 2000). Furthermore, the hypothalamus receives information from the ovaries, the pituitary and pineal gland. These sources of information provide a mechanism whereby the reproductive activity of the animal can be in tune with the environment in which the animal finds itself. This is done by sending messages to the pituitary gland in the form of neuro-hormones (messenger substances produced by the nerve cells). These substances are collectively called releasing factors or gonadotrophin releasing hormones (GnRH).

The pituitary gland produces and stores the two main hormones (gonadotrophins) that directly control the function of the ovary. These are the follicle stimulating hormone (FSH) and luteinizing hormone (LH). The sole means by which the pituitary exerts its influence is by the release of its hormones. Hormones are released from the pituitary in response to signals from both hypothalamus and the ovary (Hafez & Hafez, 2000).

The pineal gland (epiphysis) originates as neuroepithelial invagination from the roof of the third ventricle of the brain under the posterior end of corpus callosum and is responsible for the production of the hormone, melatonin. The hormonal activity of the pineal gland is influenced by both the dark-light cycle and the seasonal cycle, causing it to play an important role in the neuro-endocrine control of reproduction. The gland converts neural information via the eyes through daylight length into an endocrine output of melatonin, which is secreted into the blood stream and cerebrospinal fluid. Melatonin mediates the response to changes in the photoperiod in sheep and goats. The melatonin levels are high during the dark periods and low during light periods of the day. These differences in the pattern of melatonin secretion

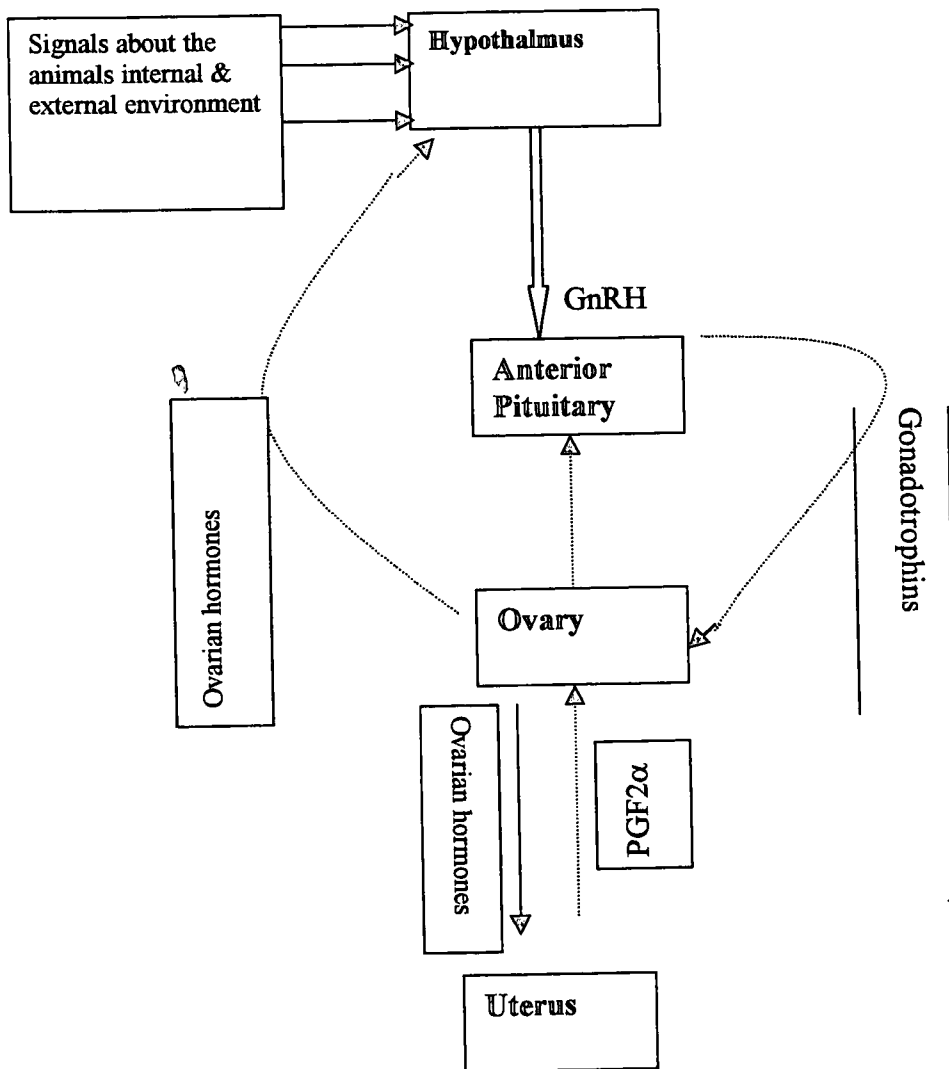
probably act as a signal indicating day length to the neuro-endocrine axis. Long daily periods of elevated secretion of melatonin which occurs in the season of the year with short days are probably responsible for the induction of ovarian cyclic activity in ewes and does. There is evidence to suggest that the premammillary area of the hypothalamus is an important target for melatonin to regulate the reproductive activity (Malpaux *et al.*, 1998).

The ovary produces ova and hormones that contribute to the cyclic reproductive patterns of the ewe or doe. Ova are produced in the ovary by follicles under the influence of hormones from the pituitary gland. Several thousands of these follicles are present in the ovaries from birth (Edquist & Stabenfeldt, 1993). After puberty, small numbers of follicles are recruited from the large pool at each oestrous cycle and these begin to mature or ripen. Eventually, these follicles become hollow and are filled with follicular fluid. The cells lining the hollow cavity of these follicles, the granulosa, are the sources of one of the ovary's hormone, oestrogen. This is called a steroid hormone due to the chemical family to which it belongs. It is the predominant hormone during the follicular phase of the oestrous cycle that stimulates the production of luteinizing hormone (LH), which in turn signals the ovary to ovulate. After ovulation (rapture of the mature follicle), the cells lining the cavity of the collapsed follicle eventually form luteal cells, and these produce the second ovarian hormone, namely progesterone. Progesterone powerfully inhibits GnRH secretion, and prevents the LH peak discharge (Baird *et al.*, 1976; Thimonier, 1979; Skinner *et al.*, 1998). Due to its action, the LH frequency is reported to occur as slow as once every 3 to 10h (Baird & McNelly, 1981; Karsch *et al.*, 1984). It also maintains oestradiol secretion at low levels, which appears to act synergistically with progesterone to limit LH secretion (Karsch *et al.*, 1980). Progesterone also maintains pregnancy in livestock. The ovary also produces two other important hormones, namely relaxin and inhibin, which play an important role during parturition and the inhibition of FSH secretion. In general, hormones produced by the ovary are important signals by which the hypothalamus and the pituitary gland guide the cyclical pattern of ovulation in the ewe or doe.

The uterus is the site where the fetus grows. It is also the site where one of the reproductive hormones, prostaglandin (PGF₂α), is produced. This hormone is produced if the previous

ovulation fails to result in a viable embryo. The main role of $\text{PGF}_{2\alpha}$ is to cause luteolysis (degeneration of the corpus luteum) so that no more progesterone will be produced by the corpus luteum. The reduction of serum progesterone concentration will remove the blocking effect on the hypothalamus and pituitary gland, allowing another oestrous cycle to occur (FSH and LH secretion consecutively).

Figure.2.1. Schematic representation of the relationships between the main female reproductive organs (source:Hafez and Hafez, 2000)



Therefore, the oestrous cycle in all livestock species is composed of hormonally well-defined luteal and follicular phases, which vary in overall length according to the species (Hafez & Hafez, 2000). The luteal phase in sheep and goats is always significantly longer than the follicular phase.

2.1.4. Principles of oestrous synchronization

Attempts to control the occurrence of oestrus and ovulation in sheep and goats whether in the natural breeding season or during the anoestrous season are usually based on trying to simulate the activities of the cyclic sheep's or doe's corpus luteum, especially its action in producing progesterone in quantity for about 2 weeks and shutting off production sharply and completely at the end of oestrous cycle (Gordon, 1997). In general, oestrous synchronization involves two alternative approaches: The first approach involves the luteolysis (removing or inducing the demise of the natural corpus luteum), so that all animals in an appropriate group enter the follicular phase of the oestrous cycle at the same time, and are still closely synchronized at the ensuing oestrus. The second alternative involves the suppression of follicular development during an artificially extended luteal phase. On removal of the pharmacological agent after a sufficient treatment period, all animals should enter the follicular phase at the same time and exhibit oestrus approximately synchronously (Hunter, 1980).

Bearing in mind that attempts are usually made to synchronize the breeding of animals in a large batch of the flock, it is necessary to assume a random distribution of females with respect to the stage of their oestrous cycle. This would almost certainly be the situation in a large flock of sheep and goats maintained under extensive conditions. A satisfactory treatment must, therefore, aim to regulate the cycle of all animals in such a way that on cessation or withdrawal of treatment, a very high proportion, if not all, of the females subsequently exhibit oestrus simultaneously (Lindsay, 1988).

Assuming a random distribution of stages of the oestrous cycle at the onset of treatment, the duration of treatment to maintain all females in the luteal phase must therefore be in excess of

the natural duration of the luteal phase of the animals. On the other hand, if the basis of the treatment is to precipitate the follicular phase prematurely, then the form and/or frequency of treatment must be sufficient to be effective in all animals that were initially distributed throughout all stages of the oestrous cycle (Hunter, 1980).

2.1. 5. Methods of oestrous synchronization in ewes and does

One of the difficulties associated with animal reproduction is that almost everything related to the actual mating occurs when the female is receptive, rather than the herdsman's discretion. Thus, procedures to manipulate ovarian activity so that ovulation is regulated to allow mating at predetermined times would be useful. Currently, no technique regulates ovulation precisely, however, reasonably effective pharmacological agents are available to synchronize oestrus in mature, cyclic females, or to stimulate the follicular phases in near pubertal or acyclic females (Lindsay, 1988). The choice between these methods depends on the specific farming conditions and the environment in general. This means that there is no hard and fast rule to recommend a specific synchronization technique, as the return to be obtained from the technique can vary depending on breed, season, location, farming condition and even individual differences between animals. Nonetheless, to be acceptable for routine use in commercial livestock production units, any oestrous-controlling procedure must fulfill a number of essential criteria. One obvious requirement is that it must be effective in regulating ovarian activity in the maximum number of the treated females, so that most of the treated animals will experience oestrus approximately at the same time. In general, the higher the efficiency and the more precise the control (compactness), the more effective the procedure will be. A second desirable objective is that fertility should not be depressed at the induced oestrous period. A slight reduction in fertility may be tolerated if the control of oestrus is precise, but an ideal procedure would not suppress the chance of conception or normal embryonic development. In addition to being effective in regulating oestrous activity and not depressing fertility, ease of administration is also important. Some other requirements for an ideal oestrous cycle-regulating procedure are absence of undesirable side effects, the production of potentially non-toxic tissue residues, and cost efficiency. Any compound or procedure under consideration should be evaluated for its ability to satisfy most or all of the

above-mentioned criteria. The methods used for oestrous synchronization can be divided in to natural and hormonal techniques.

2.1.5.1. The natural method of oestrous synchronization

The natural methods of oestrous synchronization refer to the manipulation of the ovarian activity of anoestrous females by natural methods — like exposing them to bucks or rams, androgenized wethers or testosterone treated females (Mellado & Hernandez, 1996; Godfrey *et al.*, 2001), the fleece of male animals (Walkden-Brown *et al.*, 1993), by manipulating the light environment (photoperiod) or a combination of photoperiod and exposure to intact males. These methods of oestrous synchronization are useful tools to initiate oestrous activity and to induce oestrous response and ovulation in small ruminants.

Much of research has been undertaken on the effect of males to induce oestrus in anoestrous ewes (Bowen, 1988; Walkden-Brown *et al.*, 1993; Restall *et al.*, 1995; Mellado & Hernandez, 1996; Silva *et al.*, 1998; Romano *et al.*, 2001; Rekwot *et al.*, 2001). According to Walkden-Brown *et al.* (1993), the male effect is an effective means of inducing ovulation and oestrus in seasonally anovulatory does. It is further identified that the female response may be influenced more by the intensity of the buck stimulus applied and the age and body weight, than the seasonal variation in the responsiveness of the does. Silva *et al.* (1998) and Romano *et al.* (2001) indicated the continuous presence of a male to increase the percentage of out-of-season kidding in Alpine dairy goats, under tropical conditions in Mexico.

The male effect can be successfully induced by the use of androgenized wethers and testosterone-treated does during the breeding season but was not effective during the non-breeding season (Restall *et al.*, 1995; Mellado & Hernandez, 1996). The fleece/hide of bucks alone is also reported to induce an ovulatory oestrus in seasonally anovulatory does, although the response obtained is not comparable to that obtained by buck stimulation (Walkden-Brown, *et al.*, 1993). The duration of the exposure period to males also affects the ovulatory response of does (Rekwot *et al.*, 2001). Buck stimulation for 12 days showed no significant increase in kidding rate and litter size in cycling crossbred goats under range conditions in

Mexico (Mellado *et al.*, 1994). For efficient synchronization, the isolation of females from males for a period of 6 to 8 weeks before re-exposure to males is necessary. The minimum distance of separation is controversial. According to Bowen (1988), the minimum distance to be effective is 500m downwind for does. However, Walkden-Brown *et al.* (1993) reported that separation from does by 100m is sufficient to prevent an ovulatory response by bucks.

Pheromonal communication also plays an important role in mammalian behaviour and the reproductive processes. Chemical communication with pheromones is one of the means for transmitting such information (Rekwot *et al.*, 2001). However, the male effect in goats is not a simple reflex response to olfactory cues, but rather a complex response involving the integration of a range of exteroceptive stimuli from the buck (Walkden-Brown *et al.*, 1993). Nevertheless, the introduction of a male induces a rapid increase in LH pulse frequency, leading to a pre-ovulatory LH surge (Oldham *et al.*, 1980; Ungerfeld & Rubianes, 1999; Romano *et al.*, 2000; Lucidi *et al.*, 2001; Knights *et al.*, 2002), similar to that observed during the oestrous period. Even though the male effect is found to be effective during seasonal anoestrus, its use during the breeding season is not very effective (Godfrey *et al.*, 1997).

An alternative to synchronize oestrus naturally is by controlling the photoperiod. The photoperiod can be modified by the association of long days 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 summer light environment. This in turn will make the animals unresponsive to the short days of autumn and winter. This is due to the fact that by the end of the long day treatment, animals interpret the prevailing photoperiod as short days, as the natural photoperiod is of shorter duration than that imposed by the photoperiod treatment. This will result in elevated melatonin secretion during the night at the end of winter and beginning of spring, to initiate sexual activity in females. In a study by Traldi *et al.* (2000), the photoperiod treatment was shown to induce a better response to the male effect, and induce a series of ovulatory oestrous cycles during spring, resulting in good fertility. In their study, 92.2% of does subjected to artificial photoperiod, responded to the presence of the buck and manifested oestrus within an

interval of between 10 to 30 days after the introduction of males. The kidding rates recorded were 70.1%.

In general, the natural methods of synchronization are relatively cheaper than the hormonal methods. Furthermore, they satisfy the modern consumer's preference for "hormone-free" animal products. However, the variability in the onset of oestrus that is inherent to these natural methods requires the females to be inseminated at the observed oestrous period. Based on these variations in response, it has become apparent that oestrous synchronization in small stock would be more efficient with the use of hormones especially when AI is to be performed at a fixed time (Godfrey *et al.*, 1997; Baril & Saumande, 2000).

2.1. 5.2 Hormonal methods of oestrous synchronization

Another option to synchronize oestrus is with the aid of pharmacological agents. It involves the application of hormonal treatments to a large number of females with the aim of manipulating the oestrous cycle. The aim of these treatments is to make all the treated animals exhibit oestrus more or less simultaneously, or in such a way that the time to onset of oestrus can be predicted for the majority of animals (Van Rensburg, 1973; Hunter, 1980). The most frequently used hormones for this purpose fall into two groups — luteolytic drugs and progesterone or progestagens (Hunter, 1980; Evans & Maxwell, 1987; Carlson *et al.*, 1989; Romano, 1996). The first category of synchronization agents are based on the administration of prostaglandin ($\text{PGF}_2\alpha$) or its analogues to cause luteolysis of the natural corpus luteum (CL). The second category is based on the administration of progesterone or synthetic progestagens to suppress follicular development during an artificially extended luteal phase. Upon removal of the progestagen-blockage following an adequate period of treatment, all animals enter the follicular phase and will ovulate at approximately the same time.

2.1.5.2.1. Prostaglandins or their analogues

The application of prostaglandin $F_{2\alpha}$ in the artificial induction of oestrus was implemented after comprehending the source and functions of these hormones in the natural reproductive processes. During the ovulatory cycle of the ewe or doe, $PGF_{2\alpha}$ is synthesized in and released from the endometrium of the uterus and causes regression of the corpus luteum (Goding, 1974; Baird & Scaramuzzi, 1975). This has been justified by observations of a complex series of peaks of short duration of $PGF_{2\alpha}$ in the utero-ovarian venous blood, the frequency of which increases as oestrus approaches, reaching a maximum level of 20ng/ml. These peaks of $PGF_{2\alpha}$ are associated with a fall in the secretion of progesterone (Thimonier, 1979). In the natural reproductive process, luteolysis would seem to involve more gradual regression of the gland, unlike induced regression by the use of exogenous prostaglandin or its analogues which could have a very rapid and dramatic effect on steroid synthesis in the luteal cells (Corteel, 1975; Stacey *et al.*, 1976). From the discovery of this phenomenon, prostaglandins and their analogues have been used to synchronize oestrus in cattle and small stock with acceptable synchronization rates (Britt & Roche, 1980; Gordon, 1983; Godfrey *et al.*, 1997; Ahmed *et al.*, 1998).

The administration of prostaglandin to sheep or goats during the mid to end of the luteal phase of the cycle causes regression of the CL (Thimonier, 1979). It has been shown that a 16-aryloxy prostaglandin injection to ewes in the mid-cycle induces luteolysis, and complete luteal regression is effective after 15 to 20h (depending on the breed). This is followed by oestrus 36 to 44 hours after administration. Due to complete luteal regression, the inhibitory effect of progesterone on the pituitary gland is removed. Thus, the pituitary gland continues releasing increasing amounts of gonadotrophins, which stimulate follicular growth and the occurrence of oestrus eventually within 2 to 3 days after $PGF_{2\alpha}$ treatment (Bearden & Fuquay, 1980; Evans & Maxwell, 1987).

In sheep, luteal regression with the aid of $PGF_{2\alpha}$ can only be induced between day 4 to 14 of the oestrous cycle, whereas in goats it occurs between day 5 to 16 (Cognie & Mauleon, 1983).

The implication of this is that the CL will not be responsive to $\text{PGF}_2\alpha$ administered during the refractory period of the cycle before days 3-4 and after days 14-16 (i.e., the period when the CL does not react to $\text{PGF}_2\alpha$). According to Ott *et al.* (1980) and Henderson *et al.* (1984) oestrous synchronization with prostaglandin has resulted in unsatisfactory results in sheep and goats. Prostaglandin analogues such as cloprostenol have been reported to produce a more synchronized oestrus than that obtained with a progestagen/gonadotrophin treatment. The subsequent fertility has been reported to be somewhat reduced (Tekin *et al.*, 1992). However, later findings by Ahmed *et al.* (1998), Greyling and Van Niekerk (1991) and Ishwar and Pandey (1992) indicated cloprostenol in combination with PMSG to synchronize oestrus more efficiently in goats than intravaginal sponges. Furthermore, Greyling and Van Niekerk (1991) recorded no significant difference in synchronization efficiency between different doses of cloprostenol (62.5, 125, or 250 μg) in Boer goats with the double injection regime. Thus, the use of $\text{PGF}_2\alpha$ requires multiple injections (Evans & Maxwell, 1987; Carlson *et al.*, 1989; Greyling & Van Niekerk, 1991). When 2 injections are given 11 days apart, synchronization of oestrus is successful and all the cycling treated animals respond within 3 to 5 days after the second injection (Hearnshaw *et al.*, 1974).

Current literature available on the use of prostaglandin in cyclic sheep or goats is much less than that available for cattle. This may be partly due to the fact that prostaglandin is more limited for use in controlled sheep and goat reproduction during the anoestrous period. A functional corpus luteum is required for prostaglandin to induce luteolysis, thus making this technique only suitable for oestrus synchronization in small stock during the breeding season (Cognie & Mauleon, 1983). It also does not really improve fertility over that of progestagens (Carlson *et al.*, 1989). Due to all of these inherent limitations, the method of using prostaglandin or its analogues for oestrous synchronization is found to be inferior to the progesterone method of oestrous synchronization in small stock.

2.1.5.2.2. Exogenous Progesterone or Progestagens

In female animals, progesterone exerts a negative feedback on LH secretion so that the endocrine events that lead to maturation of the pre-ovulatory follicles and their subsequent ovulation are inhibited until progesterone declines with CL regression. Thus, exogenous progestagens are used to mimic this natural process, but in a way of extending the luteal phase of the oestrous cycle. The use of progesterone or its analogues involves the administration of the agent so that the natural CL regresses naturally during the period when progestagen is administered. With this approach, the exogenous progestagen continues to exert a negative feedback on FSH and LH secretion, even after CL regression has occurred in the animals. When progestagen is later withdrawn, follicular growth starts simultaneously in all treated females and, oestrus and ovulation occurs within 2-8 days (Evans & Maxwell, 1987). Due to their effectiveness, progestagen treatments have been extensively used for oestrous synchronization in small stock (Mellado *et al.*, 1998).

There are several routes in which progesterone or progestagen treatment can be administered, all aimed at inducing efficient synchronization. Some of the techniques of administration include: oral treatments, the use of skin implants and the use of intravaginal releasing devices (Hunter, 1980).

2.1.5.2.2.1. *The oral administration of Progestagen*

Medroxyprogesterone acetate (MAP), a highly potent progestagen, is used to synchronize sheep all over the world. A product such as melengestrol acetate (MGA), an orally active synthetic progestagen that was developed for cattle, is now also used for the induction and synchronization of oestrus in ewes (Safranski *et al.*, 1992; Umberger & Lewis, 1992; Jabbar *et al.*, 1993).

Keisler (1992) established dosage and treatment schedules for ewes in conjunction with both Ralgro® (Zeranol) and PG-600®. These trials indicated that the twice daily feeding of 0.125

mg MGA for an 8-day period could induce an out-of-season synchronized oestrus in anestrus ewes. Periods of administration longer than 8 days are reported to have no apparent beneficial effect on oestrous response. Zeranol can be administered between 30 to 54 hours post MGA feeding at a rate of 0.5 to 5 mg to improve oestrous induction and synchronization efficiency. These results were not consistent and higher doses appeared to depress the fertility at the induced oestrus. Supplementing Zeranol with PG-600® also produced satisfactory results, with 70 to 80% of the ewes demonstrating oestrus when treated with 5 ml PG-600® at the end of the MGA feeding period. PG-600® also increased the ovulation rate at the induced oestrus.

The oral administration of MGA to a commercial flock either with PG-600® at the end of the MGA administration period, or lutalase (PGF₂α) administered 12 days following the end of MGA oral administration has been used in a treatment protocol (Plugge *et al.*, 1993). In their study, oral MGA administration induced oestrus early in the natural breeding season and in conjunction with PG-600® produced a dose-related increase in ovulation rate. However, ewes receiving lutalase had a lower pregnancy rate following treatment. Although the results with this technique are comparable to the results of other techniques, various considerations including time and labour costs involved in oral dosing, difficulty to achieve a smooth and steady input of progestagen or to obtain a sharp predictable result make such a procedure less practical (Gordon, 1983).

2.1.5.2.2.2. *Intravaginal administration*

The treatment of preference for oestrous synchronization, (in and out-of-season breeding) in sheep and goats has historically been the progestagen impregnated intravaginal sponge. Earlier studies by Robinson *et al.* (1967), Colas (1975) and Gordon (1975a;b) indicated that a high level of progestagen, followed by its rapid withdrawal and adequate ovarian stimulation is a prerequisite for acceptable fertility in sheep. It is now well accepted that only compounds with characteristics similar to progesterone, especially those with a short half-life are suitable for controlled reproduction (Robinson, 1982; 1988).

A commonly used intravaginal device is the fluorogestone acetate (FGA)-based sponge (45 mg), marketed as Chronogest® or Cronolone®. These sponges have been widely used either in conjunction with pregnant mare serum gonadotropin (PMSG) (Eppleston & Roberts, 1986; Pearce *et al.*, 1986), follicle stimulating hormone (FSH) (Cloete & Heydenrych, 1987) or prostaglandin (Bretzlaff & Madrid, 1989) to more compactly synchronize and/or induce a superovulatory response. A similar product is the 6-methyl-17-acetoxypregesterone (MAP)-treated intravaginal sponge (Veramix®, Repromap®), containing 60 mg of this progesterone analogue. The latter type of sponge has also been used in conjunction with PMSG (Kiesling *et al.*, 1986; Draincourt & Fry, 1992), FSH (Draincourt & Fry, 1992; Ryan *et al.*, 1992) or prostaglandin (Battye *et al.*, 1988). In some instances, sponges impregnated with natural progesterone in higher doses (400-500 mg) have also been used and similar synchrony and fertility performances to that of progestagen-impregnated sponges were achieved (Hamra *et al.*, 1986; Echterkamp *et al.*, 1993).

In the 1980's, a new intravaginal progesterone impregnated device the so-called Controlled Internal Drug Releasing (CIDR) dispenser was developed in New Zealand. The device is constructed from a natural progesterone impregnated medical silicone elastomer, molded over a nylon core. 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, 1984; Welch & Tervit, 1984; Mcmillan, 1986; Carlson *et al.*, 1989). This device is reported to be equally effective when compared to sponges in controlling ovulation and fertility in goats (Ritar *et al.*, 1990; Selvaraju & Kathiresan, 1995; Selvaraju *et al.*, 1997; Motlomelo, 2000), sheep (Greyling & Brink, 1987) and in sheep and goats (Selvaraju *et al.*, 1997; Daniel *et al.*, 2001). Trials using CIDR pessaries in sheep by Wheaton *et al.* (1993) indicated a similar response to that of progestagen sponges by Hamra *et al.* (1989) and Steffan *et al.* (1983). Few findings even support the superiority of CIDR over progestagen sponges in terms of oestrous response (Welch, 1984; Lynch 1985; Greyling & Brink, 1987; Van Der Nest, 1997; Motlomelo, 2000) and kidding rates (Selvaraju *et al.*, 1997).

The use of the CIDR device has its own merits and drawbacks. Some of the merits of using this device are that the use of natural progesterone instead of the analogue in the vaginal

sponges may facilitate the licensing of this product in some countries such as the US (Hamra *et al.*, 1986). Furthermore, withdrawal of the CIDR is not accompanied by the fluid discharge seen at sponge withdrawal (Greyling & Brink, 1987; Carlson *et al.*, 1989; Van der Nest, 1997), and for such reasons it is aesthetically more pleasant to handle than the sponge. In most instances, an earlier onset of oestrus was observed in ewes treated with the CIDR device, when compared to the sponges (Greyling & Brink, 1987; Knight *et al.*, 1988; Shackell, 1991; Smith *et al.*, 1991a,b; Knight *et al.*, 1992; Wheaten *et al.*, 1993).

On the other hand, the CIDR device also has disadvantages. One of the main disadvantages of using the CIDR devices is the higher incidence of loss (13.5%) compared to sponges (6.7%) (Greyling & Brink, 1987). This finding was supported by the findings of Knight *et al.* (1988) who reported a 6.3% loss of the CIDR's, compared to 0.8% loss in progestagen intravaginal sponges and it being less effective than progestagen sponges in synchronizing cyclic ewes. The other disadvantage is that the device is more expensive than the progestagen sponge (Crosby *et al.*, 1988).

2.1.5.2.2.3. Progestagen implant treatments

An alternative approach to the intravaginal route for sustained progestagen administration is the use of implants. The earliest form of implant was a silicone rubber progesterone-impregnated device (Dziuk & Cook, 1966). Reports on the use of these implants appeared in the 1970's in the USA and Greece (Xenoulis *et al.*, 1972). It has been indicated that the use of these implants requires greater skill and experience, and could not compare to the speed and simplicity of the intravaginal sponge technique (O'Reilly, 1972; Xenoulis *et al.*, 1972; Keane, 1974; Gordon, 1975a,b).

Thus, subsequent approaches have been directed at designing a much smaller implant for use as an ear implant impregnated with the potent progestagen, norgestmet. Initially, it was developed as one of the oestrous synchronization methods for cattle, based on a higher level of progestagen as an ear implant for oestrous synchronization (Synchromate-B®). With this

technique, does (Bretzlaff & Madrid, 1985; Menger & Neubert, 1985) and ewes (Woody *et al.*, 1983; Tritschler *et al.*, 1991) are implanted with the norgestomet implants for a period of approximately 14 days and a gonadotropin, either FSH or PMSG, is administered at the time of implant removal. Generally, there is no acceptable response and synchrony of oestrus without gonadotropin treatment. Studies have indicated that the implant dose provided for cattle (6 mg norgestomet) can be reduced to 3 mg (Bretzlaff & Madrid, 1985; Bretzlaff *et al.*, 1991) and 2 mg (Tritschler *et al.*, 1991), by dividing the cattle implant into smaller portions for small stock. Following synchronization, does and ewes come into oestrus within 72 hours (Bretzlaff *et al.*, 1991). However, the results for the norgestomet ear-implant in some countries, such as Ireland, did not make the device a realistic alternative to the intravaginal sponge (Boland *et al.*, 1979).

2.1.6. Factors influencing the success of an oestrous synchronization program in sheep and goats

It should be emphasized that successful controlled reproduction in small stock is not only a matter of using appropriate hormonal techniques, but is also one of ensuring that the agents are employed in situations where acceptable results can be achieved. Difficulties in the past in some areas of controlled reproduction have undoubtedly arisen not only from inadequacies in the hormone treatments themselves, but also in trying to pursue unnecessarily ambitious objectives, such as two lamb or kid crops within one year. It is necessary to bear in mind that many external and internal factors are likely to influence the type of response achieved in a controlled reproduction program. These factors have to be mitigated as they can mask the importance of oestrous synchronization.

2.1.6.1. The effect of season on oestrous synchronization efficiency

The seasonality of sexual activity in both sheep and goats is governed by photoperiod, with oestrous activity commencing during the period of short and decreasing day length (Hafez & Hafez, 2000). The extent of this seasonal influence on reproductive activities in small stock varies, depending on the latitude and the breed of the animal. The impact of season is more

prominent in extreme northern and southern latitudes and animals originating from these regions. There are breeds of sheep and goats with no real seasonal anoestrus, when maintained under optimal environments. This is true for breeds in tropical and sub-tropical regions, but may also be evident in other breeds located far from the equator. In South Africa, Greyling and Van Niekerk (1989) observed the Boer goat to show peak breeding activity during autumn, and lowest activity in late spring to mid summer. However, periods of complete anoestrus were never observed. In Japan, Shiba goats are considered to be continuous breeders and do not show seasonal variations in fertility throughout the year (Sawada *et al.*, 1995).

During the non-breeding season, the uterine environment of the anoestrous female animal is not conducive to sperm transport (Wallace, 1992). As a result, conception rates at induced oestrous periods out of the natural breeding season will be lower in both sheep and goats. It further restricts the period of milk yield and extends kidding intervals, which reduces the number of kids born (Kennaway *et al.*, 1987).

The length of the sexual season varies according to the breed and the nutritional status of the animal (Evans & Maxwell, 1987; Jainudeen & Hafez, 1987). The question of how seasonal changes in day light length result in the onset and offset of the breeding activity has been addressed in different ways (Walton *et al.*, 1977). During the anoestrous period, oestradiol exerts a strong negative feedback to the hypothalamus and anterior pituitary gland to reduce the secretion of gonadotrophins. As a result, the LH pulses occur infrequently despite the absence of a CL and the virtual absence of circulating progesterone. In between these pulses, the circulating LH concentration decreases to undetectable low levels. Thus, there is an insufficient gonadotrophin stimulus for the final stages of follicular maturation and for the pre-ovulatory oestradiol rise. This prevents the serum LH surge and ovulation (Karsch *et al.*, 1984).

Although its importance on the ovarian activity is controversial, prolactin has been seen as the most prominent seasonal hormone, with the highest concentrations occurring in the blood during long daylight length and the lowest concentrations during short day length periods

(Buys *et al.*, 1990). Certain researchers have demonstrated that a low prolactin concentration coincides with the onset of ovarian activity (Thimonier *et al.*, 1978; Kennaway *et al.*, 1983), whereas others contradict in essence that ovarian activity still exists in the presence of high prolactin levels (Worthy *et al.*, 1985).

Besides prolactin, another hormone known as melatonin secreted by the pineal gland has been shown to control reproductive activity in small stock (Kennaway *et al.*, 1984). This hormone appears to mediate the suppressive effect of long days, as well as the inductive effect of short days (Karsch *et al.*, 1984), via neuroendocrine systems regulating these activities (Bassett, 1992). The concentration of melatonin in the blood is higher during dark periods and lower during light periods (Kennaway *et al.*, 1987). It has been reported that exogenous melatonin administered to anoestrous goats exposed to a long days (16h light: 8h dark) treatment, exhibited maximum sexual activity outside the natural breeding season (Chemineau *et al.*, 1986; Amoah & Gelaye, 1990).

The influence of season on the reproductive performance of small stock can be mitigated by the artificial manipulation of oestrus (Chemineau, 1983, 1985; Scott & Montgomery, 1990; Devenson *et al.*, 1992; Kandil, *et al.*, 1993; Romano, 1993; Mufti, *et al.*, 1997; Gootwine, *et al.*, 1997; Kareta, *et al.*, 1999). However, the degree of success in inducing oestrus and attaining acceptable fertility rates has been inconsistent and frequently low during the early and mid-anoestrous period (Robertson, 1977; Senn & Richardson, 1992). In ewes, the mean incidence of oestrus and conception at the induced oestrus tends to be low during the seasonal anoestrous period, compared to during the natural breeding season following progestagen/PMSG treatment (Scott & Montgomery, 1990; Kandil, *et al.*, 1993; Rajamahendran *et al.*, 1995; Mufti, *et al.*, 1997). The superovulatory response of Chios sheep to PMSG treatment was compared during two seasons of the year. The interval from sponge withdrawal to the onset of oestrus was significantly shorter in autumn, compared to in spring, with no significant difference regarding the superovulatory response, collection and fertilization rate or number of ova and embryos collected. Clinical signs of oestrus were initiated earlier in autumn than in spring (Samartzi *et al.*, 1995). Previous studies also indicated that the time to onset of oestrus is significantly shorter during the natural breeding

season in sheep and goats, compared to the non-breeding season (Smith, 1988; Pierson, *et al.*, 2001). However, the interval to ovulation (Knight, *et al.*, 1992; Pierson *et al.*, 2001) and oestrous cycle length (Kandil, *et al.*, 1993) are not affected by season.

The use of the male effect to synchronize and induce reproductive activity during the seasonal anoestrous period in females was found to be ineffective, especially in sheep and goat breeds that are extremely seasonal. For instance, in breeds exhibiting only moderate seasonality (e.g. Merino sheep and Creole goats), the introduction of the male can synchronize and induce an ovulatory response throughout the anoestrous season (Chemineau, 1983). However, in more seasonal breeders, the male effect is limited to about one month prior to the onset and one month after the end of the natural breeding season (Delgado *et al.*, 2000). There are at least 3 phases, namely an active period of spontaneous ovulation, a responsive phase in which ovulation and pregnancy can be induced in anovular does, and a quiescent phase in which anovular does do not respond to male stimuli (Restall, 1992). Breaking the influence of season either by the male effect or by administration of hormones can be more difficult when female animals are lactating. For instance, a continuous gonadotrophin infusion was found to induce consistently out-of-season breeding in non-lactating ewes, but could not break the combined seasonal and lactational anoestrus (Fray *et al.*, 1996).

Besides the photoperiodic effect, rainfall has been shown to be significantly correlated with fertility and the response to induction of oestrus. Rainfall appears to be a key factor in initiating ovarian activity during the transition to the breeding season (Galina *et al.*, 1995). Precipitation and temperature have also shown a significant correlation with fertility (Notter, 2000). Under uniform feeding conditions throughout the year, the reproduction of Nubian goats in Mexico was less affected by season than in goats in the more northern latitudes. Rainfall and temperature seemed to be factors influencing sexual activity in these goats (Mellado *et al.*, 1996).

2.1.6.2. *The effect of nutrition on oestrous synchronization efficiency*

It is a well-established fact that follicular development in mammals is affected by nutrition. This effect can either be indirect, acting by way of the hypothalamic-pituitary axis, to alter the secretion of gonadotrophins, or it can be direct, acting on the ovary to mediate the action of the gonadotrophins on the follicle. The mechanism of action of nutrition on ovulation was proposed by Smith (1988). In this study, increased nutrients (protein) produced an increase in both liver size and the concentration of hepatic microsomal enzymes. This results in an increased level of oestradiol metabolism, which in turn is reflected by an increased level of FSH prior to and during luteolysis. Such increases in FSH may be responsible for the greater number of developing follicles ovulating.

According to Rhind *et al.* (1991), both body condition and the level of feed intake affect the gonadotrophin profiles and the reproductive activity via a direct effect on the hypothalamic/pituitary sensitivity to the steroid feedback or inhibin secretion. 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 (grain diets) fed ewes, compared to ewes fed a lower energy (hay) diet (Downing & Scaramuzzi, 1991). During the follicular phase, ewes with a high nutrient intake had significantly higher LH frequencies 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).

On the contrary, it has been reported that under-nutrition has no significant effect on basal LH and FSH profiles, but is associated with a decrease in the number of goats exhibiting a pre-ovulatory surge of LH, a reduced magnitude of the surge, and a reduced incidence of ovulation. Thus, short-term under-nutrition appears to decrease reproductive performance by interfering with gonadotrophin production (Mani *et al.*, 1996).

Nutritional factors that may exert an action on follicular development in sheep have also been studied. Downing *et al.* (1990) recorded that the infusion of branched chain amino acids over

a 5-day period in the late stages of the oestrous cycle significantly increased ovulation rate in sheep. Further studies by Scaramuzzi and Murray (1994) revealed that insulin-mediated uptake of glucose may reduce the capacity of the selected (dominant) follicle to suppress the development of subordinate follicles, thereby increasing ovulation rate. Based on the above-mentioned fact, the feeding of ewes or does with high-energy diets prior to mating (flushing), is recommended. This feeding strategy, however, may result in variable responses depending on the duration of the flushing period, intensity of flushing and type of nutrient used for flushing (Greyling & Venter, 1994), initial body condition (Downing & Scaramuzzi, 1991), environment and season (Gordon, 1983; Sormunen-Cristian & Jauhiainen, 2002). According to Steel (1996), Downing and Scaramuzzi (1991) and Kusina *et al.* (2001), short-term energy intake appears to be sufficient to increase ovulation rate and hence an increase in the number of kids produced per litter. However, Rattray (1977) reported that the increase in intake level or feeding concentrates prior to mating tends to increase ovulation rate, while the degree of oestrous response appears to be influenced by the duration of the increased nutrition. Findings by Greyling and Venter (1994) reveal difficulty in determining the optimum duration of flushing in grazing ewes, as responses are variable. However, a period of 2 to 3 weeks prior to mating has been generally agreed upon as ideal for flush feeding small ruminants prior to mating. The ovulation rate and fecundity following 3 weeks of flushing was significantly higher, but flushing did not affect the duration of the induced oestrus, conception and lambing rate. Flushing for 3 weeks, starting 1 week before sponge withdrawal gave the best results (lambing rate of 95%). It was further concluded that flushing has a beneficial effect on the overall reproductive performance (Venter & Greyling, 1994).

A recent finding by Hemingway *et al.* (2001) indicates that the provision of a sustained release of multi-trace elements (vitamin bolus), significantly increased twinning and pregnancy rates. According to Rhind *et al.* (1998), ewes subjected to a restricted level of nutrition prior to weaning have a significantly lower lifetime incidence of multiple births, than those on a high plane of nutrition. Nutritional restriction, however, did not significantly affect the percentage of barren ewes, irrespective of the time at which it was applied. Positive relationships were recorded between the nutritional treatments in early and in adult life and the birth weight of lambs born from these ewes. It was further concluded that under-nutrition

of female lambs during the first months of life resulted in a reduction of lifetime reproductive performance, irrespective of the nutritional status during adult life (Rhind *et al.*, 1998).

2.1.6.3. The effect of body weight (BW) and body condition (BCS) on oestrous synchronization efficiency

The BW of the ewe or the doe is made up of two components, namely the basic skeletal size of the animal on the one hand and the BCS on the other hand. There are contradictory data on the effect of BCS and BW at mating on the reproductive performance of small stock. According to Coop (1966), the BW of the ewe at mating (representing the static effect) has been shown to influence subsequent litter size. The effect is mainly the result of differences in ovulation rate, but with some involvement of embryo mortality (Edey, 1969). In physiological terms, it is known that ewes with a high BCS have more large oestrogenic ovarian follicles than ewes with a low BCS (Rhind *et al.*, 1989). Rhind *et al.* (1993) examined FSH stimulated follicle development in ovaries of ewes with a high or low BCS, and concluded that these differences did not affect the responsiveness of the ovary to circulating concentrations of FSH.

In Australia, live weight alone has been found to be a more accurate predictor of ovulation rate than BCS (Cumming, 1977). In this particular study, heavier ewes within a flock were found to have a higher ovulation rate than lighter ewes, showing a 2.5 to 3.0% increase for each kilogram increase in live weight. Similar work by Smith (1988) also drew the attention to the relationship between live BW immediately prior to mating and an increase of 2% in ovulation rate for each additional kilogram of live weight in sheep. Rondon *et al.* (1996) demonstrated that the onset of seasonal anoestrus could be significantly influenced by BCS in Aragonesa ewes implanted or re-implanted with melatonin. The high BCS groups (≥ 2.75 out of 5) and the low BCS groups (≤ 2.50 out of 5) were compared and the ovulation rate was found to be significantly higher in the first group (1.78), compared to the second group (1.44). The BW of ewes was found to affect the birth weight of the lambs and the total litter weight (Michels *et al.*, 2000).

As it is the case in ewes, BCS has an effect on the overall reproductive performance in does (Mellado *et al.*, 1996; Gonzalez, *et al.*, 1999). According to their findings, a higher kidding

rate can be achieved if does have a BCS \geq 4 (\geq 4 out of 5), under extensive conditions in the arid zones of Mexico. Regueiro *et al.* (1999) indicated that lighter dairy goats had a higher incidence of short oestrous cycles and a lower kidding rate than heavier animals when synchronized with progestagen sponges and PMSG. Thus, the efficiency of eCG administration to increase litter size in goats can be masked by the BW of female animals at the time of synchronization treatment (Regueiro *et al.*, 1999).

2.1.6.4. The effect of age of the female on the efficiency of oestrous synchronization

Age of the female is known to have a definite effect on ovulation rate (Devendra & Burns, 1983; Gordon, 1983; Laliotis *et al.* 1993; Pintato *et al.*, 1996; Sarmah *et al.*, 1996; Gootwine, *et al.*, 1997). 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; Sarmah *et al.*, 1996; Gootwine *et al.*, 1997; Anwar & Ahmed, 1999). In addition to an increase in birth rate, fecundity has also been found to increase with an increase in the age of the doe (Devendra & Burns 1983; Fourie & Heydenrych, 1983). In synchronized sheep and goats, the interval from progestagen releasing device removal to the onset of oestrus is variable. Fenton *et al.* (1997) reported the onset of oestrus to be earlier in older ewes than in 2-tooth ewes. On the contrary, Eppleston *et al.* (1994) reported the onset of oestrus to be earlier in ewe hoggets (19 to 20 months old), compared to 3 to 7 year old ewes. The duration of oestrus was also found to be longer in 1 to 2 year old does, compared to those of 2 to 3 years of age (Gootwine *et al.*, 1997). Furthermore, Walkden-Brown *et al.* (1993) revealed that the oestrous response is positively correlated to the age of the does. Oestrous cycle length is, however, not affected by age of the ewes (Kassem *et al.*, 1990).

Specific experiments conducted on sheep showed that both old age and immaturity have a profound effect on the prolificacy of sheep. Prolificacy of older (> 8-year-old) ewes was consistently reduced by 0.7 to 0.2 lambs, compared to adult ewes. Compared to mature ewes, prolificacy was lowered by 0.6 to 0.7, 0.3 and 0.1 lambs in 1, 2 and 3-year old ewes, respectively (Notter, 2000).

However, in oestrous synchronized sheep and goats, it is not clear whether the reduced fertility is due to the age or the number of synchronization treatments previously administered to the females. Baril *et al.* (1993) found no effect of age on the time of onset of oestrus after removal of progestagen in goats. However, the fertility rate of does older than 3.5 years that had previously received 0 to 2 progestagen treatments tended to be higher, compared to the fertility of females in the same age group that were never synchronized. The conception rate at the first induced oestrus following treatment was, however, lower than at the subsequent oestrus, possibly due to an interference in the pattern of uterine contractions (Hawk *et al.*, 1981), thereby reducing the motility of the spermatozoa in the progesterone treated animals (Lalotis *et al.*, 1993). The rate of abortion was also higher in older than in younger goats (Hussain *et al.*, 1996).

2.1.6.5. The effect of stress on oestrous synchronization efficiency

Stress is defined as the inability of an animal to cope with its environment — a phenomenon that often hampers the animal's genetic potential for production (Dobson & Smith, 2000). A number of stressors are applicable. The most common are environmental (heat, humidity), nutritional and handling (transportation, AI, blood sampling, etc.). High ambient temperatures, high direct or indirect solar radiation, and humidity are environmental stress factors that impose a strain on animals. There is unequivocal evidence that hyperthermia is deleterious to any form of productivity, regardless of breed and stage of adaptation. A specific example of the impact of heat stress on cattle reproduction is given by Al-Katanani, *et al.* (2001) who stated the proportion of viable embryos from superovulated cattle to be reduced in periods of heat stress. There is an associated reduction in the number of transferable embryos due to reduced superovulatory response, lower fertilization rate, and reduced embryo quality following heat stress (Hassen *et al.*, 2001). Another recognized effect of elevated body temperature is also an adaptive depression in the metabolic rate, associated with a reduced appetite (Silanikove, 2000).

It is suggested that a variety of endocrine regulatory aspects exist, whereby stress limits the efficiency of reproduction. Transportation produces an immediate constant increase in arginine vasopressin (AVP) and corticotrophin-releasing hormone (CRH) secretion in ewes.

Adrenocorticotrophic hormone (ACTH) reaches a maximum level in the first hour, while cortisol is the highest during the second hour of transportation. According to this work, the negative feedback mechanism appears to operate mainly at the pituitary level during the transport and at the hypothalamus during hypoglycemic periods. There is also endocrine evidence to show that stressors interfere with the precise timing of reproductive hormone release within the follicular phase in dairy cattle. Transport of insulin in the blood reduces the frequency and amplitude of gonadotrophin releasing hormone and the LH pulses, suggesting that these stressors also delay the onset of the pre-ovulatory LH surge. It is suggested that opioids mediate these effects and progesterone/glucocorticoid receptors are not involved. There is also evidence to support the effects at pituitary level as exogenous ACTH injection or transport reduces the amount of LH release by challenges with GnRH. The reduction in exogenous GnRH/LH secretion ultimately deprives the ovarian follicle of adequate gonadotrophin support leading to a reduced oesterdiol production due to slower growing follicles. Thus, there is level of interference by stressors on the ovary in dairy cattle (Dobson & Smith, 2000).

The stress factor induced by the handling of females at the time of AI could also reduce the fertility rates obtained, especially if the animals are not accustomed to being handled (Romano *et al.*, 1996; Dobson, *et al.*, 2001). Two inseminations within an oestrous period are believed to increase the secretion of cortisol, which could inhibit the secretion of hormones responsible for successful fertilization. In a study where the effect of the duration of progestagen treatment in goats was compared to the frequency and amplitude of the pre-ovulatory LH discharge, the overwhelming factor associated with the variation in time to onset of the LH pre-ovulatory 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 LH pre-ovulatory peak (Corteel *et al.*, 1988).

The existence of differences in susceptibility to stressors between species or breeds of livestock is documented. 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 a water retention capacity, a higher sweating rate, a lower basal heat metabolism and a

relative constant heart rate and constant cardiac output (Shkolnik *et al.*, 1980). These properties enable goats to tolerate heat stress better than sheep or cattle (Lu, 1989). However various forms of environmental stresses (climate) or physical stress (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).

Ehnert and Moberg (1991) examined the disruption of oestrous behaviour in ewes by management-related stress. Isolation of the ewe from other flock members induced higher corticosteroid levels and blocked the expression of oestrus in 33% of the animals. Eight hours of transportation similarly increased corticosteroid concentrations and inhibited oestrus in most animals. Such results indicate that management-related stress could block oestrous behaviour. The effect of the physical transport on the LH surge release in ewes during the follicular phase of the cycle was examined by Phogat and Dobson (1995), and it was found that transport reduced the self-priming effect of GnRH on the pituitary gland and delayed the onset of the pre-ovulatory LH surge.

2.1.6.6. Type of progestagen sponges and oestrous synchronization efficiency

Most of the findings observed thus far are in favour of FGA sponges compared to MAP sponges (Gordon, 1974; Eppleston & Roberts, 1986; Greyling *et al.*, 1988). On the contrary, recent comparisons reported by Romano *et al.* (1995) and Romano (1996) between FGA (30 mg) and MAP (60mg) on synchronization efficiency in dairy goats during the fall revealed that neither pessary retention, oestrous duration nor fertility was affected by the different treatments. These findings are in agreement with those of Al-Kamali, *et al.* (1990), who revealed no significant difference in the percentage of ewes lambing and the number of lambs born per ewe lambing between ewes synchronized with FGA and MAP. However, in the same study, oestrus started 12h earlier in the FGA group than in the MAP group. Both progestagens recorded good oestrous synchronization, albeit with different post-withdrawal to onset of oestrus times (Romano, 1996).

2.1.6.7. Duration of progestagen treatment

Many studies have been carried out to test the effect of the duration for which the intravaginal progestagen sponges are left in situ on fertility and oestrous behaviour (Greyling *et al.*, 1985; Corteel *et al.*, 1988, Amoah & Gelaye, 1990; Pintato *et al.*, 1996). The results reported are, however, somewhat contradictory. Studies done by Amoah and Gelaye (1990) and Pintato *et al.* (1996) indicate no significant difference between 11 and 21 days sponge treatment in terms of oestrus, follicular activity or ovulation rate in goats. Thus, long and short treatment periods are equally efficient in synchronizing oestrus. This is also in agreement with the work of Ritar *et al.* (1987) who recorded no effect on the length (15 and 20 days) of CIDR treatment regarding the non-return rate following cervical insemination in goats.

The work done by Corteel *et al.* (1988), however, indicated fertility to be much lower when goats are synchronized for 21 than for 11 days. These findings are supported by Moore *et al.* (1988), who reported the existence of a progressive decline in fertility and prolificacy when the intravaginal progestagen treatment is longer than 18 or 19 days. The break down of sperm cells following AI was given as a justification for the decline in fertility in long-term progestagen treatment. Similarly, Vinales *et al.* (2001) compared the effect of long-term (12 days) and short-term (6 days) MAP treatment in terms of pregnancy rate, and found a significantly higher pregnancy rates in the short-term treatment (87%), compared to the long term treated ewes (67%). The justification given for this difference is the lower pregnancy rate observed after a long-term progestagen treatment to be related to a slower follicular turnover that promoted the ovulation of the persistent dominant follicle. Short-term treatment resulted in a higher pregnancy rate presumably due to the ovulation of newly recruited growing follicles. The attempt made to improve pregnancy rates by injecting PMSG resulted in negative effects when combined with the short-term progestagen treatment and had no effect with long-term treatment (Vinales *et al.*, 2001). Greyling and Van Niekerk (1991) and Greyling and Van Der Nest (2000) obtained higher fertility rates of approximately 73 to 74% with long-term (14 to 16 days) progestagen/PMSG treatment in indigenous goats.

The effect of duration of progestagen treatment is also reported to vary depending on the season of the year. For instance, in goats treated with intravaginal progestagen for 11 days, fertility was higher during the non-breeding season. This is related to the effect of prolactin, as the pre-ovulatory discharge of prolactin after treatment for 11 days is more rapid and more marked than after synchronization for 21 days. The inhibitory effect of prolactin does not seem to prevent ovulation, but induces the premature regression of the subsequent corpora lutea. As a result it is not clear whether or not an increase in the pre-ovulatory discharge of prolactin resulting from progestagen administration for 11 days could improve luteogenesis and hence fertility (Corteel *et al.*, 1988).

It was further found that when reducing the duration of progestagen treatment to a period shorter than the natural luteal phase, it is necessary to administer an injection of prostaglandin or an analogue 48 hours prior to the end of the progestagen treatment. This induces the regression of any CL's present. When a short-term (11 days) progestagen treatment with PMSG is combined with a prostaglandin injection 48 hours before sponge removal, the oestrous response is satisfactory (98%). The fertility rate following AI was higher for a short than a long progestagen treatment period (61.1% vs 56.7% for 11 and 21 days, respectively) (Baril & Saumande, 2000). However, the addition of a prostaglandin injection to short (11 days) progestagen/PMSG treatment did not reflect the potential of this technique (approximately 61% conception).

2.1.6.8. Dose level and impregnation of progestagen in intravaginal sponges

There are contradictory statements regarding the recommended dose level of progestagen in the sponges. Robinson (1968) suggested that many of the progestagen doses employed to induce oestrus were too low to mimic the action of the natural CL fully. On the contrary, Lamond (1964) stated that optimal fertility in synchronized ewes was likely to be associated with minimal doses of intravaginal progesterone. As to the optimal dose of FGA, reports suggest it to lie between 20-40mg per pessary (Robinson *et al.*, 1967; Thimonier & Cognie, 1971; Colas *et al.*, 1973; Robinson, 1974; Vipond & King, 1979; Heany *et al.*, 1980; Smith *et al.*, 1981).

In respect to MAP sponges, a 60mg dose has been developed for commercial use. Absence of a significant difference in terms of oestrous response, duration of induced oestrous period, mean LH and progesterone concentrations, conception and lambing rates was reported for ewes treated with 60mg, 40mg and halved 60mg sponges outside the breeding season (Greyling *et al.*, 1994). Fecundity was found to be significantly higher in ewes subjected to halved sponges (30mg) compared to those receiving whole sponges. The superiority of halved MAP sponges over whole sponges has also been confirmed for ewes during the breeding season when combined with a 300IU PMSG injection at sponge withdrawal (Greyling *et al.*, 1997). Similar findings by Oliveira *et al.* (2001) indicated the possibility of re-using the sponges for at least one more time, because of enough progestagen being present in the sponge at withdrawal — sufficient for inducing, and synchronizing oestrus in cycling does.

Besides the dose level of progestagen, the rate of progestagen absorption from the intravaginal sponge is also believed to be affected by the impregnation procedure. For instance, Gordon (1971) reported a significantly higher oestrous response and lambing rate resulting from a thorough dispersion of a 30mg dose of FGA in the sponge matrix — such a dispersion of the progestagen in fine crystal form ensures a higher absorption rate of the agent. Similar suggestions were made by Robinson *et al.* (1968) that sponges impregnated with a 15mg dose of FGA in a well-dispersed form could result in a significantly higher conception rate than sponges carrying 30mg, but with the compound unevenly dispersed.

2.1.6.9. Dose, time and route of PMSG injection for efficient oestrous synchronization

Although cyclic ewes or does can be expected to demonstrate oestrus shortly after intravaginal progestagen withdrawal in the absence of exogenous gonadotrophin, a low dose of PMSG (375IU) can result in a more predictable and compact synchronization of oestrus or ovulation, which can have a favourable effect on the outcome of fixed time AI (Colas *et al.*, 1973; Jennings & Quirke, 1976; Zhang & Yuan, 1988; Knight *et al.*, 1992; Artiningsih *et al.*, 1996; Cordova *et al.*, 1999; Cline, 2001). Several considerations may influence the decision as to whether a FSH-type preparation should be employed and, if employed, the dose level and

timing of administration. The advantage of using PMSG to stimulate increased pre-ovulatory follicular development is that it is readily available in large quantities at a low cost, and can also be administered as a single dose due to its long half-life (Gordon, 1997). The long half-life, however, can be disadvantageous as it may cause over and/or prolonged ovarian stimulation, leading to a second wave of follicular development after ovulation and a secondary rise in oestradiol-17 α , which may interfere with fertilization. The second and out of sequence follicular wave could also interfere with embryo quality (Alfurajji *et al.*, 1993).

As to the choice of dose level of gonadotrophin following progestagen treatment, it would appear to lie within the range of 375-750IU PMSG per animal. The possibility of depressing rather than enhancing conception rate by over stimulation with PMSG has been suggested by Larson *et al.* (1970), Gordon (1971), Botha *et al.* (1975) and Crosby *et al.* (1991).

Eppleston *et al.* (1991) studied the effect of time of PMSG and GnRH administration on the time of ovulation, LH secretion and reproductive performance of ewes following intra-uterine insemination with frozen semen. Results indicated treatment with PMSG 24h before sponge removal to shorten the time of onset of oestrus and a time of ovulation. Similar results were also reported for goats by Zhang and Yuan (1988). Administering PMSG injections 24h prior to pessary removal and treatment with GnRH increased fertility rate. The time of PMSG treatment reduced the time of ovulation, and treatment with GnRH resulted in a more synchronous ovulation, but neither treatment variation provided a constant improvement in fertility (Eppleston *et al.*, 1991).

The administration of 1200 IU PMSG to female goats 2 days prior to the withdrawal of progestagen sponges led to a biphasic ovulatory response such that up to several ovulation points were present prematurely at the time of sponge withdrawal followed by a superovulatory wave of ovulation occurring approximately 2 days after sponge withdrawal. Thus, the LH bioactivity inherent to PMSG can directly induce ovulation (Cameron & Batt, 1991). There has been occasion when the source of PMSG has been shown to have an effect on the oestrous response of oestrous synchronized ewes. Al-Kamali *et al.* (1990) indicated the source of PMSG to significantly affect the conception rate and litter size in sheep. Besides the

dose and source of PMSG, route of administration has been considered as a factor affecting the efficiency of oestrous synchronization. The pre-ovulatory LH surge was found to be significantly shorter in subcutaneous injected does, compared to those injected intramuscularly (Greyling & Van Niekerk, 1989).

2.1.6.10. Mating method (natural vs AI) and synchronization efficiency

The effect of the method of mating on the reproductive performance of synchronized sheep and goats has been evaluated by many researchers (Lalotitis *et al.*; 1993; Stellflug *et al.*, 1993; Lalotitis *et al.*, 1996; Selvaraju *et al.*, 1997). The overall mean conception rates have been found to be higher following natural service than AI in sheep (Lalotitis *et al.*; 1993; Stellflug *et al.*, 1993) and goats (Lalotitis *et al.*, 1996). Natural mating has also been found to reduce the duration of the induced oestrous period (Selvaraju *et al.*, 1997).

Although natural service generally results in better conception rates than AI, the success of females bred naturally or artificially depends on several factors (Amoah & Gelaye, 1990). It is important that when a comparison is made between the two methods, emphasis should not be put only on fertility rate, as this may lead to a biased conclusion. With natural mating, females are mated more than once and often by different males within the same oestrous period (Evans & Maxwell, 1987). Acceptable results from AI can also be obtained by the use of high quality semen, proper timing of AI and the use of qualified inseminators (Parker & Pope, 1983; Amoah & Gelaye, 1990). Therefore, under practical farming conditions the use of both natural service and AI can be employed. The choice of any of two or a combination of both methods depends on the objectives.

2.1.6.11. Type of AI and place of semen deposition on conception rate

The quality of semen used and the place of semen deposition in the female reproductive tract via AI is known to give variable results in terms of conception and kidding/lambing rates. Evans and Maxwell (1987) and Moore *et al.* (1988) reported low conception rates in goats inseminated cervically with frozen-thawed semen after progestagen/PMSG treatment. This

low conception rate is supported by Moore *et al* (1989), who reported a kidding rate of below 30% using the same method. However, better kidding rates (56%) have been reported by Bowen (1988) following cervical insemination after progestagen treatment. The degree of cervical penetration during insemination with frozen semen has also been reported to affect fertility in sheep significantly. A linear increase in fertility was achieved as the penetration of the cervix increased (6 to 12.2% per cm past the external cervical os) (Eppleston, *et al.*, 1994). The ease of cervical penetration during insemination also increases with increasing ewe age (4 to 7 years), and was greater at 12h compared to at 24h after the onset of oestrus (Eppleston, *et al.*, 1994). In general, the fertility following cervical AI with frozen-thawed semen was found to be higher in goats than in sheep, probably due to the structural differences in the anatomy of the cervix of the two species (Evans & Maxwell, 1987). The anatomical structure of a doe's cervix enables deposition of semen deeper into the cervical canal or the uterus through the cervix, unlike in sheep that has an external lip that covers the external os of the cervix (Lindsay, 1991).

Intra-uterine inseminations have been found to be more successful than cervical inseminations (Moore *et al.*, 1989). By this method of AI, acceptable conception rates with frozen-thawed semen can be achieved in both sheep and goats (Evans & Maxwell, 1987). In goats, intra-uterine AI has been found to double the kidding rate that can be obtained by cervical inseminations (Moore *et al.*, 1988). Laparoscopic AI in goats, however, does not produce consistently higher conception rates, and the kidding rates are variable unlike in sheep. Intra-uterine AI by laparoscopy in goats is only recommended to save semen or when only frozen semen is available (McKelvey, 1990).

2.1.6.12 Time of artificial insemination following oestrous synchronization treatment

Artificial insemination can be performed either at a fixed time after pessary removal, or at a fixed time after the detection of oestrus. For practical purposes and for simplicity, insemination at a fixed time after pessary removal is recommended (Moses *et al.*, 1997). Many researchers agree that AI can be performed with acceptable success at a fixed time in

relation to the withdrawal of the intravaginal progestagen treatment (Evans & Maxwell, 1987; Ritar *et al.*, 1989). To attain acceptable fertility levels following AI, knowledge of the length of the oestrous period and the time of ovulation are essential, so that the time of insemination can be adjusted accordingly (Evans & Maxwell, 1987; Ritar *et al.*, 1989; McKelvey, 1990; Baril *et al.*, 1993). Effective synchronization of the onset of oestrus and time of ovulation is important to avoid the aging of gametes, which contributes to a low reproductive performance following AI (Amoah & Gelaye, 1990).

Earlier work by Maxwell *et al.* (1983) has shown a linear relationship between fertility and time of intra-uterine insemination. In this study, fertilization rates with fresh semen increased from 71% to 97% as the time of intra-uterine insemination increased from 24 to 48h after sponge withdrawal. Frozen semen resulted in high fertilization rates with AI at 48 or 55h after pessary withdrawal (Maxwell *et al.*, 1984a; b). According to Evans and Maxwell (1987), the optimum time for cervical AI in sheep is 48 to 58h after the cessation of treatment. While for intra-uterine inseminations (laparoscopy) with frozen-thawed semen, the optimum time is 60 to 66h after pessary withdrawal. A similar study conducted by Karagiannidis *et al.* (2001) revealed that a better conception rate is obtained when a double fixed time AI is performed at 48 and 72h after sponge withdrawal for Chios and Chios X Vlachiki sheep breeds. For the Vlachiki breed a better conception rate was obtained when fixed AI was implemented at 48 and 60h following sponge withdrawal in MAP and PMSG treated ewes, during the breeding season. These results imply breed variation in terms of appropriate fixed time AI to attain a better conception rate.

According to Baril *et al.* (1993), 98.1% of synchronized does exhibited oestrus within 24 to 72h after the intravaginal progestagen sponge removal. The fertility of does that come into oestrus later than 30h after sponge withdrawal was lower than in those that exhibited oestrus within 30h after sponge withdrawal and AI conducted at 43 to 45h after pessary removal. This lower fertility obtained was associated with the time of the LH peak, which occurred concurrently with the onset of oestrus. Synchronization generally has no effect on prolificacy,

suggesting that the low fertility achieved in goats is not related to an abnormal ovarian response, but to the inappropriate time of insemination. It was also reported that animals inseminated less than 5h after the LH peak have a low conception rate. This has been confirmed by several researchers who recorded a higher fertility rate in animals inseminated 60h after sponge removal than to those inseminated 48h after cessation of treatment (Maxwell *et al.*, 1984a; Eppleston & Roberts, 1986). In other trials these differences were not noted (Smith *et al.*, 1981).

2.1.6.13. The effect of the number of inseminations on the reproductive performance

The effect of the number of inseminations performed within one oestrous period on fertility following progestagen treatment has resulted in different pregnancy rates being recorded (Evans & Maxwell, 1987; Amoah & Gelaye, 1990). It is well known that fertility can be increased by increasing the number of 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 24h after the onset of standing oestrus resulted in better conception rates than a single insemination 12h after onset of standing oestrus. The difference obtained, however, is so small that it is not worth the effort, especially when fresh (diluted or undiluted) semen is used (Evans & Maxwell, 1987; Amoah & Gelaye, 1990). Does induced to ovulate during the breeding season recorded better conception rates following one insemination (42 to 43h after pessary removal) than after two inseminations (Amoah & Gelaye, 1990). Two inseminations in a single oestrous period are, however, recommended when frozen-thawed semen is used for cervical inseminations. This is not recommended for laparoscopic AI. It should also be taken into account that the time and labour spent on two inseminations and the stress on the animal is much higher than with a single AI (Evans & Maxwell, 1987).

2.1.6.14. Ovarian status at the time of progestagen treatment on the oestrous response

Studies by Freitas *et al.* (1996) recorded the influence of the ovarian status on the response to oestrous synchronization treatment in dairy goats during the breeding season, and found the number of follicles on days 0 and 9 of progestagen treatment not to be related to the time of

the onset of oestrus, the occurrence of the LH peak or ovulation rate. The number of CL's on day 9 influenced the time of the LH peak, but not the time of onset of oestrus. In does with 2 or 3 CL's on day 9 of progestagen treatment, the LH peak occurred 46.9h after the end of progestagen treatment, and in does with 1 or 0 CL 42.2 and 42.5h after treatment, respectively. These findings suggest that the number of CL's at luteolysis is a factor contributing the variability of oestrous response after synchronization (Freitas *et al.*, 1996).

Treatment with MAP intravaginal sponges increased the number of follicular waves from 3 to 4 or 5, when sponges were inserted on days 6 or 12 of the cycle. Treatment with MAP sponges does not effectively synchronize oestrus and ovulation in cyclic ewes due to the difference in follicular patterns and the stage of the cycle at the time of sponge insertion (Leyva *et al.*, 1998). Gonzalez *et al.* (1996), on the other hand revealed follicular populations prior to exogenous gonadotropin administration, including the number of large follicles, not to influence the number of CL's — showing that the presence of large follicles at the time of superovulatory treatment does not affect the ovulation rate in the ewe.

2.1.6.15. Reproductive wastage and oestrous synchronization

A reproductive loss in the form of embryonic absorption, abortions, stillbirths or neonatal mortalities is responsible for low productivity of sheep and goats. Some of the factors involved in reproductive losses are feed quality (Hussain *et al.*, 1996), age of the dam (Engeland *et al.*, 1997), type of birth (litter size) (Galina *et al.*, 1996), birth weight and season of the year (Awemu *et al.*, 1999).

Reproductive losses were found to be higher in goats fed poor quality silage compared to those on good quality silage. The level of energy in the diet also exacerbated the occurrence of abortions in goats. The feeding of poor quality silage combined with low energy for a period of 91-120 days of gestation increased the incidence of abortion in goats. However, reproductive losses were the lowest and the numbers of kids born per goat after normal pregnancy were highest in goats fed good silage, irrespective of the energy level (Hussain *et al.*, 1996).

Engeland *et al.* (1997) evaluated the effect of the age of the mother on abortion rates and recorded the rate of abortion to be higher in older than in younger does. This may be due to an increase in litter size as the age of the mother advances. Awemu *et al.* (1999) indicated that litter size increases with parity in red Sokoto does, with the largest litters being recorded at the fifth parity.

The type of birth (singleton, twins, triplets etc.) also has an effect on the mortality rate of the offspring in sheep and goats. For instance, the mortality in Pelibuey and Blackbelly sheep under tropical management systems was found to increase to 23% when more than two lambs were nursed by one ewe and reduced to 8% when only one lamb was born (Galina *et al.*, 1996). Type of birth indirectly affects the birth weight of kids, which again has its effect on the survival of the offspring. Generally, mortality tended to decrease with an increase in birth weight (Awemu *et al.*, 1999).

Season of the year also has a significant influence on the mortality rate of kids. Kiddings occurring in the wet season are associated with heavier mortalities than those occurring in the dry season of the year. The possible reason for the higher mortality rate for kids born in the wet season may be due to the incidence of the larger litter sizes during this season of the year (Awemu *et al.*, 1999).

In general, advanced age, difficulty in conceiving, low social status in the flock, and multiple pregnancies with ≥ 3 foetuses and previous foetal losses are significantly associated with current reproductive loss in goats (Engeland *et al.*, 1997). As the aim of oestrous synchronization is to improve productivity of animals, these aspects must be taken into consideration. Thus, reproductive losses incurred due to some or all of the above-mentioned reasons could hinder the achievement of this proposed objective.

2.1.6.16. Other minor factors affecting synchronization efficiency

Besides nutritional status, stress factors, physiological status of the female animals and many other factors are believed to influence the responses obtained from oestrous synchronization programs using intravaginal sponges. Among these, the placement of the intravaginal sponge, dusting of intravaginal sponges with antibiotic powder, washing of applicators after each sponge insertion and contact of sponges with lubricants markedly influence the loss of sponges. Furthermore, the time of implant removal in anoestrous ewes may have an effect on the interval from sponge removal to the pre-ovulatory LH surge (Cunningham *et al.*, 1977; 1980). These findings are supported by Robinson (1980) who also stated that a diurnal pattern of mating is evident in normal cyclic sheep, and suggested that oestrus may be affected in similar way by the time of day when progestagen treatment ceases.

2.2. SUMMARY

Sheep and goats are the most important and sustainable livestock animals as a source of meat and milk in the developing countries. They are more important than cattle and the buffalo for the resource poor farmers of Africa, as they require less initial capital investment and are easier to manage. However, their importance in developing countries is underestimated, as most of the products from these animals do not enter the official market, but are consumed by the producers at household level or marketed informally. Nonetheless, small ruminants are expected to help fill the gap in meat and milk production in Africa, provided that their productivity is improved.

Productivity in sheep and goats, like in any other livestock, is primarily affected by their reproductive efficiency. Animal production could not be realized in the absence of the reproductive processes. In the case of sheep and goats, the major products are lambs and kids. So increasing the lambing and kidding rates, in addition to enhancing the growth and survival rates of the offspring, address the most important elements of production efficiency. Furthermore, by matching the kidding and lambing seasons with the availability of labour, feed and market demand, farm profitability could be increased. However, these situations

cannot be met under the natural reproductive rhythms. Thus, accelerated reproductive efficiency with the aid of controlled breeding is feasible under improved management conditions in developing countries.

There are many ways by which reproduction can be manipulated artificially in farm animals. These include oestrous synchronization, AI, multiple ovulation and embryo transfer (MOET). Oestrous synchronization (artificial induction of oestrus) is, however, a pre-requisite for the effective application of MOET and fixed time AI. There are mainly two ways by which oestrus can be synchronized in sheep and goats: namely, a natural method and a hormonal method. The natural method of oestrous synchronization involves the use of photoperiod, nutritional flushing and the introduction of males. Their effectiveness varies, depending on the season, breed, location and other genetic and environmental factors. The intensity (compactness) of synchronization by the natural method is not as effective as that can be achieved by the hormonal method, although the natural method of synchronization is considered to be cheaper. The hormonal method of oestrous synchronization on the other hand involves the use of either natural hormones (progesterone and/or. prostaglandins) or synthetic analogues of progesterone (progestagens) or prostaglandin. Prostaglandins or their analogues are found to be effective only during the breeding season in cyclic ewes and does. The effectiveness of synchronizing anoestrous ewes and does is far below the synchronization efficiency expected when using progesterone or progestagens in cyclic females. Progesterone or progestagens are commercially used to synchronize oestrus in sheep and goats, as they are effective both during the breeding season and anoestrous period, especially when combined with PMSG. Progesterone or its analogues can be administered via different methods. Some of the methods of application used are implants, oral administration and intravaginal sponges. The intravaginal treatment is currently the most extensively used method of administration due to its simplicity in application and in achieving a definite and immediate withdrawal of the agent unlike that experienced with oral administration. Although this method is widely used in synchronizing oestrus in sheep and goats, and it is effective in terms of oestrous response, the fertility levels achieved so far are lower than that of natural oestrus. The fertility response to be achieved by this technique can be influenced by many internal and external factors. Some of the internal factors that can influence the reproductive performance following

oestrous synchronization include: age, body weight, body condition, breed and physiological status (lactation, postpartum anoestrus, etc) of the female. The external factors that play a role include season, nutritional status, management stress, synchronization procedures, insemination techniques and post synchronization management. Therefore, attention should be paid to the choice of the method of synchronization and the factors playing a role in determining the efficiency of oestrous synchronization — as the ultimate goal of controlled breeding is to optimize productivity and reproductivity.

CHAPTER 3

EFFECT OF TYPE OF PROGESTAGEN SPONGE AND TIME AND ROUTE OF PMSG ADMINISTRATION ON SYNCHRONIZATION EFFICIENCY AND FERTILITY IN DORPER EWES

3.1. INTRODUCTION

The Dorper is a hardy South African composite sheep breed originated from a cross between Black-headed Persian ewes and Dorset Horn rams in the early 1940's. The name 'Dorper' is thus a coupling of the first syllables of the parent breeds, namely 'Dorset and Persian'. The founders of the new composite breed combined the hardiness and fertility of the Black-headed Persian with the mutton producing capability of the Dorset Horn (Cloete *et al.*, 2000). The breed is currently in numerical terms, the largest mutton sheep in South Africa and has spread to many countries throughout the world. These sheep are readily found throughout southern and central Africa, the Middle East, America and Australia (Terblanche, 1979). Dorpers are primarily a mutton sheep breed and have the ability to adapt to the more arid regions and produce high quality mutton under extensive veld conditions (Degen & Kam, 1992). The breed also adapts well to the more temperate regions and has extensively been used in accelerated mating systems (Basson *et al.*, 1969; Manyuchi *et al.*, 1991; Schoeman & Burger, 1992).

As the Dorper is mainly used for commercial mutton production, improving the genetic value and the reproductive performance of this breed is of paramount importance for efficient use of its productive potential. Some research has been carried out on the hormonal manipulation of the reproductive cycle of Dorper ewes, particularly oestrous synchronization. The superovulatory response at the induced oestrus by application of PMSG and FSH to increase litter size has also been exploited (Pretorius & Viljoen, 1968; Van Zyl *et al.*, 1987; Erasmus *et*

al., 1994). Most of the reproductive researches on the Dorper done thus far focus on the artificial manipulation of oestrus using hormones, either during the anoestrous period or during the natural breeding season. However, information regarding synchronization efficiency and fertility in Dorper sheep during the transition period from the breeding to the non-breeding season is non-existent. This aspect needs further research as the ovarian activity of the ewes during the transition period from the breeding to the anoestrous season is different from that experienced during the breeding or anoestrous seasons (Bartlewski *et al.*, 1999). It is believed that improving reproductive efficiency during this transition period in sheep would help achieve a continuous and year-round supply of mutton. Furthermore, the combined effect of progestagen impregnated intravaginal sponge, time of PMSG administration relative to sponge removal, and route of PMSG administration on oestrous response and subsequent fertility has not been fully evaluated. Thus, the aim of this study was to assess the effect of sponge type, route and time of PMSG administration relative to sponge removal on the efficiency of oestrous synchronization and the fertility of the induced oestrus in Dorper sheep during the transition period from the natural breeding to the anoestrous season (May/June).

3.2. MATERIAL AND METHODS

3.2.1. Study site

The experiment was conducted between May 23 to June 7 (end of autumn/beginning of winter) at Glen Agricultural College, located approximately 30km North-east of Bloemfontein, in the Free State province of the Republic of South Africa. The site is situated at 26°20'E longitude and 28°57"S latitude and at an altitude of 1310m above sea level. The yearly absolute minimum and maximum temperatures in the area are 3°C (June) and 34.4°C (January), respectively. The mean annual total rainfall of the area recorded is 551.9mm and falls predominantly during summer (October – March).

3.2.2. Animals and management

Two hundred and twenty-four Dorper ewes, ranging from maiden to multiparous were selected from one flock and used in the study (Plate 3.1).



Plate 3.1. Flock of Dorper ewes used in this study

The ewes were maintained in paddocks at night and allowed to graze on natural veld pasture during the day. The co-dominant grass species of the area are *Eragrostis lehmanniana* (love grass) and *Themeda trianda* (red grass) with the rare presence of *Cymbopogon plurinodis* (turpentine grass), *Heteropogon contortus* (tanglehead), *Tragus koelerioides* (creeping carrot seed grass or copper grass), *Digitaria eriantha var smutsii* (finger grass) and *Aristida congesta* (spreading prickly grass). All ewes were provided with a salt lick ad libitum throughout the year. Clean water was always available.

Prior to the commencement of the actual experiment, age, parity and body weight (BW) of all ewes were recorded. Ewes were individually identified with the aid of ear tags. The ewes were initially divided into 14 similar groups of 16 ewes each, balanced with regard to age, parity and BW. From the initial 224 ewes with which the experiment commenced, 22 of them were rejected and removed from the experiment. The reasons for taking out of these ewes from the experiment was that 21 of them were found to be pregnant prior to synchronization treatment as a result of accidental exposure to a ram, and one ewe lost her sponge. Thus the trial was conducted on a total of 202 ewes.

3.2.3. Treatments and experimental protocol

3.2.3.1. Treatment layout

Each group of ewes was randomly assigned to one of the 14 synchronization treatments as set out in Table 3.1.

Table 3.1. Experimental layout of the trial and treatment groups

Sponge type↓	Time of PMSG administration→	Route of PMSG						
		Intramuscular			Subcutaneous			Control
		-24h	0h	+24h	-24h	0h	+24h	no PMSG
MAP		1	2	3	4	5	6	13
FGA		7	8	9	10	11	12	14

The respective treatment groups were:

1. MAP (60 mg; Upjohn) sponges, for 14 days plus 300 IU PMSG (Fostim; Upjohn) administered intramuscularly (i.m.) 24h prior to sponge withdrawal (n=16)
2. MAP (60 mg; Upjohn) sponges for 14 days plus 300 IU PMSG (Fostim; Upjohn) administered i.m. at sponge withdrawal (n=14)
3. MAP (60 mg; Upjohn) sponges for 14 days plus 300 IU PMSG (Fostim; Upjohn) administered i.m. 24h after sponge withdrawal (n=13)
4. MAP (60 mg; Upjohn) sponges for 14 days plus 300 IU PMSG (Fostim; Upjohn) administered subcutaneous (s.c.) 24h prior to sponge withdrawal (n=14)
5. MAP (60 mg; Upjohn) sponges for 14 days plus 300 IU PMSG (Fostim; Upjohn) administered s.c. at sponge removal (n=14)
6. MAP (60 mg; Upjohn) sponges for 14 days plus 300 IU PMSG (Fostim; Upjohn) administered s.c. 24h after sponge withdrawal (n=16)
7. FGA (40mg) sponges for 14 days plus 300 IU PMSG (Fostim; Upjohn) administered i.m. 24h prior to sponge withdrawal (n=14)
8. FGA (40mg) sponges for 14 days plus 300 IU PMSG (Fostim; Upjohn) administered i.m. at sponge withdrawal (n=15)

9. FGA (40mg) sponges for 14 days plus 300 IU PMSG (Fostim; Upjohn) administered i.m. 24h after sponge withdrawal (n=15)
10. FGA (40mg) sponges for 14 days plus 300 IU PMSG (Fostim; Upjohn) administered s.c. 24h prior to sponge withdrawal (n=15)
11. FGA (40mg) sponges for 14 days plus 300 IU PMSG (Fostim; Upjohn) administered s.c. at sponge withdrawal (n=13)
12. FGA (40mg) sponges for 14 days plus 300 IU PMSG (Fostim; Upjohn) administered s.c. 24 after sponge withdrawal (n=13)
13. MAP (60 mg; Upjohn) sponges alone for 14 days (control) (n=15)
14. FGA (40mg) sponges alone for 14 days (control) (n=15)

3.2.3.2. Progestagen treatment

Two types of intravaginal progestagen sponges were used in this trial (MAP; 60mg and FGA; 40mg). The intravaginal progestagen sponges were inserted deep into the vagina with the aid of an applicator. Applicators were rinsed in clean warm water after each insertion and lubricated with antiseptic cream to serve as a lubricant and to prevent vaginal infections. All animals were closely observed, and checked twice daily for sponge losses during the 14-day treatment period.

3.2.3.3. Oestrous observations

From sponge withdrawal, all ewes were observed for overt signs of oestrus for periods of 30 minutes at 8h-intervals for a 96h period — starting from the time of sponge withdrawal. Teaser rams fitted with aprons were used to facilitate oestrous detection. After a period 30-day following AI, 8 fertile Dorper rams were introduced to the flock to mate those ewes, not conceiving from the preceding AI. These rams were kept with the flock for a period of 30 days.

3.2.3.4. AI procedures

Semen was collected from 4 healthy and fertile adult Dorper rams trained for semen collection with the aid of an artificial vagina (Plate 3. 2). Fresh semen (immediately after collection) was diluted at the rate of 1:2 with sterile skimmed cow milk. The viability of the semen sample was evaluated prior to insemination based on forward sperm motility. All ewes were inseminated cervically with 0.1ml diluted semen (approximately 150×10^6 sperm/insemination) using an insemination pipette and speculum (Plate 3.3). AI was performed at a fixed time in all ewes (53-55h following sponge withdrawal).



Plate 3. 2. Semen collection of a Dorper ram with the aid of an artificial vagina

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Plate 3.3. Artificial insemination in a Dorper ewe with fresh-diluted semen

3.2.3.5. Blood sampling

Blood samples were collected from 4 animals selected in each of the 14 treatment groups. The blood collection was done by jugular veni-puncture into 10ml plain (no anti-coagulant) vacutainers (Plate.3.4). Blood samples were initially collected at 3-day intervals during intravaginal progestagen treatment starting at sponge insertion, and then at 8h intervals from the time of the progestagen sponge withdrawal for a period of 96h. Serum was separated by centrifugation of the blood samples at 1500 rpm for 15 minutes. The serum was then collected and stored in 5ml plastic tubes at -20°c until assayed for serum progesterone and LH concentrations. The blood samples collected during progestagen treatment period were used for serum progesterone concentration determinations only. From samples collected post sponge withdrawal, only one blood sample per daily collection was used for serum progesterone determinations due to high cost of hormonal assay. The serum LH concentrations were however, assayed from the entire samples collected post progestagen sponge withdrawal.



Plate 3. 4 Blood sampling for serum progesterone and LH assays

3.2.3.6. Serum progesterone assay

The serum progesterone concentration was assayed with the aid of an Automated Chemiluminescence system (Chiron Diagnostics ACS.180, USA). The system is based on a competitive immunoassay technique, using direct chemiluminescent technology. Progesterone in the sample binds to an acridinium ester-labeled mouse monoclonal anti-progesterone antibody in the light reagent. Unbound antibody binds to a progesterone derivative covalently, 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 measures progesterone concentrations up to 60ng/ml with a minimum detectable concentration of 0.11ng/ml. The analytical sensitivity was defined as the concentration of serum progesterone that corresponds to the relative light units (RLU's) of 20 replicate determinations of the progesterone zero standards. The inter- and intra-assay coefficients of variation for progesterone were 12.5% and 7.8%, respectively.

3.2.3.7. Serum luteinizing hormone (LH) assay

The serum LH concentration assay was performed with the aid of an Automated Chemiluminescence system (Chiron Diagnostics ACS.180, USA). The ACS: 180 LH2 assay is a two-site sandwich immunoassay using direct chemiluminometric technology, with constant amounts of two antibodies that have specificity for the beta sub-unit of the intact LH molecule. The first antibody, in the light reagent, is a monoclonal mouse anti-LH antibody labeled with an acridinium ester. The second antibody, in the solid phase, is a monoclonal mouse anti-LH antibody, which is covalently coupled to paramagnetic particles. A direct relationship exists between the amount of LH present in the sample and the amount of relative light units (RLU'S) detected by the system. The ACS: 180 LH2 assay measures LH concentrations up to 200ng/ml, with a minimum detectable concentration of 0.07ng/ml. The sensitivity of this test is defined as the concentration of LH that corresponds to the RLU's that are two standard deviations greater than the mean RLU's of 20 replicate determinations of the LH2 zero standard. The intra- and inter-assay coefficients of variation for LH were 7.5% and 13.1% respectively.

3.2.3.8. Body weight (BW) measurements

The BW of ewes was recorded with the aid of an oil scale. Weights were recorded early in the morning (6h00), before the animals were exposed to feed and water. The weight measurements were taken at the onset of the experiment, after AI and fortnightly thereafter until lambing.

3.2.3.9. Lambing records

Near the end of the gestation period, ewes were closely observed and when expected to lamb, were kept in separate enclosures. Data on identification, lambing date, lamb birth weight, type of birth and sex of the lamb were recorded immediately after birth (Plate 3.5). Furthermore, perinatal lamb mortalities within 24h post lambing were also recorded.



Plate 3. 5. Dorper ewes with their lambs 3 weeks after lambing at Glen Agricultural College

3.2.4. Statistical analysis

The general linear model (GLM) procedures of SAS (1999) were used to perform an analysis of variance to test the effect of synchronization treatment, type of progestagen sponge used, time and route of PMSG injection, BW and age of ewes on the time of onset to oestrus, duration of oestrus, lambing weight, gestation length and serum progesterone and LH concentrations as these values are continuous variables. The categorical modeling (CATMOD) procedures of SAS were used to test the effect of progestagen type, duration of progestagen treatment, time and route of PMSG administration on pregnancy rate, oestrous response and perinatal lamb mortalities rates as these are discrete variables.

The treatment means were compared by Duncan's multiple range test (DMRT) as described in Gomez and Gomez (1984). The 1% and 5% significant levels were used to compare the means for statistical differences.

3.3. RESULTS

3.3.1. Oestrous response

From the 202 ewes used in this trial, 196 (97.0%) exhibited overt signs of oestrus during the 96h oestrous observation period. None of the 14 synchronization treatments showed any significant difference in the percentage of ewes exhibiting oestrus (Table 3.2)

Table 3.2. Effect of the synchronization treatment on oestrous response (%) in Dorper ewes

Synchronization treatment	n	Oestrous response (%) ^{ns}
1. MAP+IM+PMSG 24h before sponge withdrawal	16	100.0
2. MAP+IM+PMSG at sponge withdrawal	14	92.9
3. MAP+IM+PMSG 24h after sponge withdrawal	13	100.0
4. MAP+SC+PMSG 24h before sponge withdrawal	14	100.0
5. MAP+SC+PMSG at sponge withdrawal	14	100.0
6. MAP+SC+PMSG 24h after sponge withdrawal	16	93.8
7. FGA+IM+PMSG 24h before sponge withdrawal	14	92.9
8. FGA+IM+PMSG at sponge withdrawal	15	86.7
9. FGA+IM+PMSG 24h after sponge withdrawal	15	100.0
10. FGA+SC+PMSG 24h before sponge withdrawal	15	100.0
11. FGA+SC+PMSG at sponge withdrawal	13	100.0
12. FGA+SC+PMSG 24h after sponge withdrawal	13	100.0
13. MAP only	15	100.0
14. FGA only	15	93.3
Total	202	97.0

n number of ewes used per treatment group in the experiment

ns not significant

No significant differences were recorded in oestrous response between ewes synchronized with MAP (60mg) or FGA (40mg) intravaginal progestagen sponges (Table 3.3 and Figure 3.1). The time of PMSG administration relative to progestagen sponge withdrawal, as well as the route of PMSG injection did not significantly affect the oestrous response in the ewes. Furthermore, neither the age nor the BW of the ewes at the time of mating significantly affected the percentage of ewes exhibiting overt oestrous signs.

3.3.2. Time to onset and the duration of the induced oestrus

Ewes commenced exhibiting oestrus 24h following the time of intravaginal progestagen sponge withdrawal, and almost all of the ewes exhibited oestrus within a 56h period following the intravaginal progestagen sponge withdrawal (Figure 3.1).

The mean time from intravaginal progestagen sponge withdrawal to the onset of oestrus and the duration of the induced oestrous period for all treatment groups were 41.6 ± 2.5 h and 20.1 ± 3.6 h, respectively.

Table 3.3. Effect of intravaginal sponge type, time and route of PMSG administration, age and body weight of ewes at breeding on the oestrous response in Dorper ewes

Factor	n	Oestrous response (%)
Sponge type		ns
MAP	102	98.0
FGA	100	96.0
Time of PMSG administration		ns
-24h	59	98.3
0hr	56	94.6
+24h	57	98.2
Control	30	96.7
Route of PMSG administration		ns
Intramuscular	87	95.4
Subcutaneous	85	98.8
Control	30	96.7
Age (years)		ns
2	90	98.9
3	39	94.8
4	23	95.7
5	27	100.0
6	23	91.3
BW (kg)		ns
40-49	24	95.8
50-59	121	98.3
60-79	57	94.7
Total	202	97.0

n number of ewes used per treatment group in the experiment

ns not significant

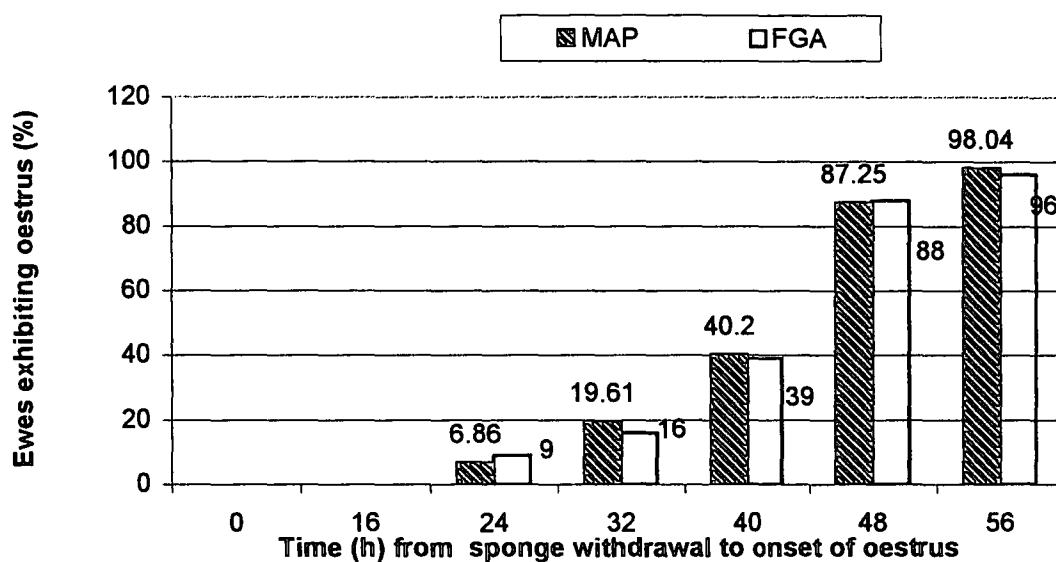


Figure 3.1. Oestrous response in Dorper ewes synchronized either with intravaginal MAP or FGA sponges

The type of oestrous synchronization treatment did not have any significant effect on the time to oestrus and the duration of the induced oestrous period in Dorper ewes (Table 3.4). The shortest mean response time from sponge withdrawal to oestrus was recorded in ewes from the treatment 7 group (FGA+IM+PMSG 24h before sponge withdrawal) (36.5 ± 2.6 h), whereas the longest mean time to the onset of oestrus was recorded in ewes from treatment 14 group (FGA with no PMSG administration) (44.1 ± 2.5 h).

Similarly, the shortest duration of the induced oestrous period was recorded in ewes from the treatment 1 group (MAP+IM+ PMSG 24h after sponge withdrawal) (12.5 ± 3.3 h), compared to ewes in the rest of the synchronization treatments. Comparatively, the longest duration of the induced oestrous period was recorded in ewes from treatment 6 (MAP+SC+PMSG 24h after sponge withdrawal) (25.4 ± 3.5 h). These differences were, however, not significant.

Table 3.4. Effect of synchronization treatment on the time to onset and the duration of induced oestrous period in Dorper ewes

Synchronization treatment	n	Ewes in oestrus	Time to oestrus (h) (Mean±SE) ^{ns}	Duration of oestrus (h) (Mean±SE) ^{ns}
1. MAP+IM+PMSG 24h before sponge withdrawal	16	16	41.2±2.3	12.5±3.3
2. MAP+IM+PMSG at sponge withdrawal	14	13	42.8±2.6	15.7±3.7
3. MAP+IM+PMSG 24h after sponge withdrawal	13	13	42.1±2.6	21.9±3.7
4. MAP+SC+PMSG 24h before sponge withdrawal	14	14	40.2±2.5	19.2±3.6
5. MAP+SC+PMSG at sponge withdrawal	14	14	40.0±2.5	17.6±3.6
6. MAP+SC+PMSG 24h after sponge withdrawal	16	15	37.9±2.4	25.4±3.5
7. FGA+IM+PMSG 24h before sponge withdrawal	14	13	36.5±2.6	18.5±3.7
8. FGA+IM+PMSG at sponge withdrawal	15	13	39.1±2.7	22.1±3.8
9. FGA+IM+PMSG 24h after sponge withdrawal	15	15	43.9±2.4	14.1±3.5
10. FGA+SC+PMSG 24h before sponge withdrawal	15	15	34.9±2.4	24.6±3.4
11. FGA+SC+PMSG at sponge withdrawal	13	13	41.7±2.6	17.9±3.8
12. FGA+SC+PMSG 24h after sponge withdrawal	13	13	39.3±2.7	22.3±3.8
13. MAP only	15	15	40.4±2.4	23.3±3.5
14. FGA only	15	14	44.1±2.5	21.2±3.6
Total	202	196	41.6±2.5	20.1±3.6

n number of ewes used per treatment group in the experiment

ns not significant

The type of progestagen sponge did not affect the interval from sponge withdrawal to onset of oestrus, and the duration of induced oestrous period. Neither did the time of PMSG administration relative to intravaginal progestagen sponge withdrawal nor the routes of PMSG administration have any significant effect on both the time to onset of oestrus and the duration of the induced oestrous period (Table 3.5). Similarly, no differences were observed in both the time to onset and the duration of the induced oestrous period in ewes as a result of differences in BW and age at the time of AI.

Table 3.5. Effect of progestagen type, time and route of PMSG administration, age and body weight on the time to onset and the duration of induced oestrous period following synchronization in ewes

Factor	n	Ewes in oestrus	Time to oestrus (h)	Duration of Oestrus (h)
Sponge type			ns	ns
MAP	102	100	41.9±0.9	19.9±1.3
FGA	100	96	41.7±0.9	20.3±1.4
Time of PMSG administration			ns	ns
-24h	59	58	39.5±1.2	18.7±1.7
0h	56	53	42.5±1.2	18.7±1.8
+24h	57	56	42.0±1.2	21.4±1.8
Control	30	29	43.2±1.7	22.6±2.5
Route of PMSG injection			ns	ns
Intramuscular	87	83	42.3±1.1	17.5±1.4
Subcutaneous	85	84	40.3±1.1	21.6±1.4
Control	30	29	43.2±1.7	22.6±2.4
Age (years)			ns	ns
2	90	89	43.8±1.1	17.0±1.6
3	39	37	39.3±1.6	23.1±2.3
4	23	22	38.5±2.0	22.4±2.9
5	27	27	40.6±1.9	17.7±2.7
6	23	21	39.5±2.1	18.5±3.0
BW (kg)			ns	ns
40-49	24	23	38.9±2.2	17.3±3.2
50-59	121	119	40.1±1.0	21.9±1.5
60-79	57	54	42.1±1.3	20.1±1.8
Total	202	196	41.6±2.5	20.1±3.6

n number of ewes per treatment group in the experiment

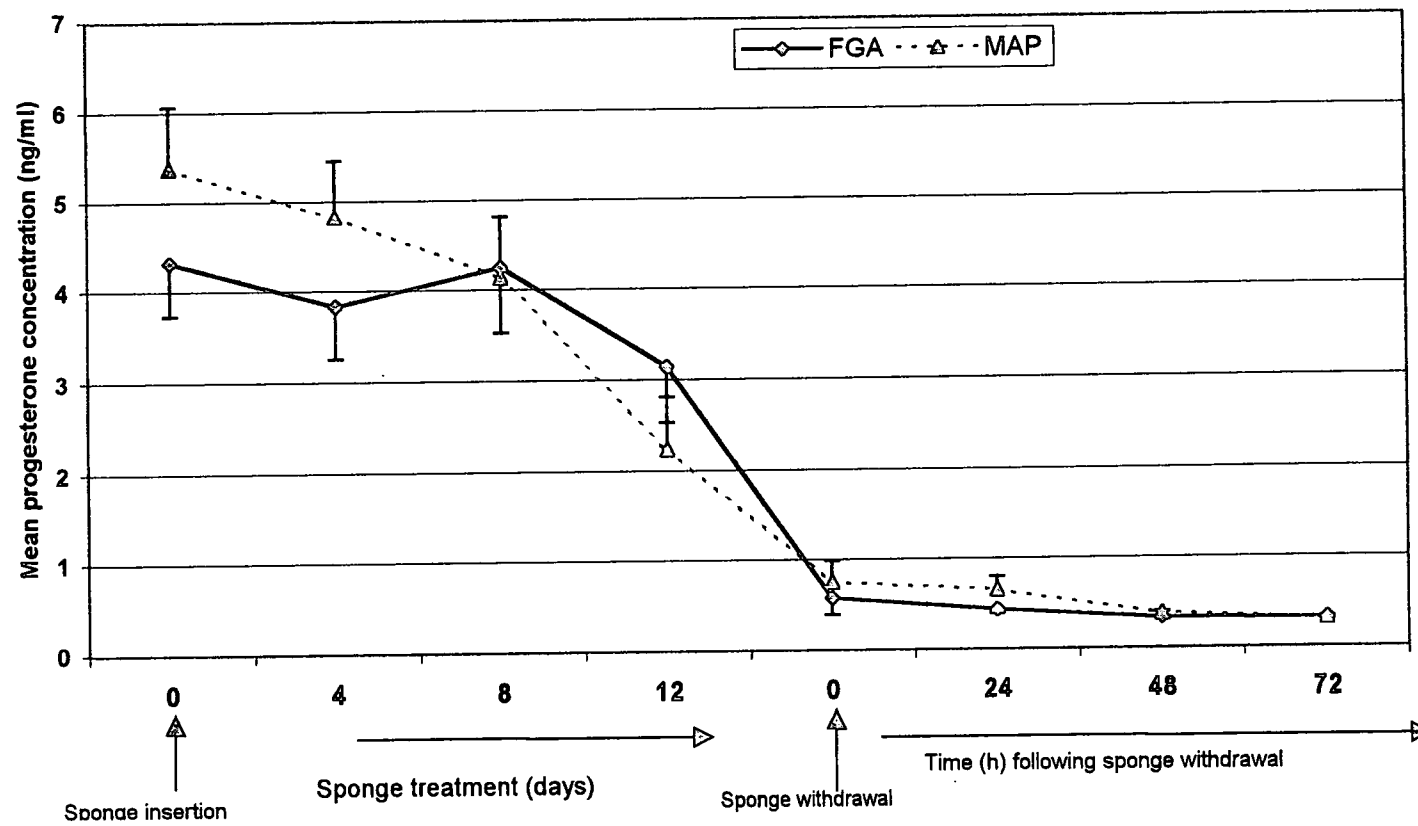
ns not significant

3.3.3. Serum progesterone concentrations

The least square means for serum progesterone concentration in oestrous synchronized Dorper ewes during both progestagen treatments (MAP and FGA) and following the removal of the sponges are set out in Table 3.6. Similarly, the pattern of the serum progesterone from the time of intravaginal progestagen sponge insertion until 72h following sponge withdrawal is illustrated in Figure 3.2. The serum progesterone values during intravaginal progestagen sponge treatment and following their withdrawal were not significantly affected by the type of progestagen. Furthermore, no significant differences were recorded in the serum progesterone concentrations during this period between ewes that conceived and those not conceiving after AI (Table 3.6 and Figure 3.3).

3.3.4. Serum LH concentrations

The mean interval from the onset of oestrus to the pre-ovulatory LH peak and from sponge withdrawal to the LH peak were 14.6 ± 5.1 h and 55.7 ± 6.2 h, respectively. There was no significant difference in the time interval from the onset of oestrus to the LH peak due to the different synchronization treatments (Table 3.7). Although not statistically significant, the shortest time interval from the onset of oestrus to the LH peak was achieved in ewes in treatment 2 (MAP + IM+ PMSG at sponge withdrawal) and 5 (MAP +SC+PMSG at sponge withdrawal) (8.0 ± 6.1 h and 7.3 ± 7.1 h, respectively), compared to ewes in the other treatments. Similarly, the time interval from the withdrawal of intravaginal progestagen sponge to the LH peak was not significantly affected by any of the treatments.



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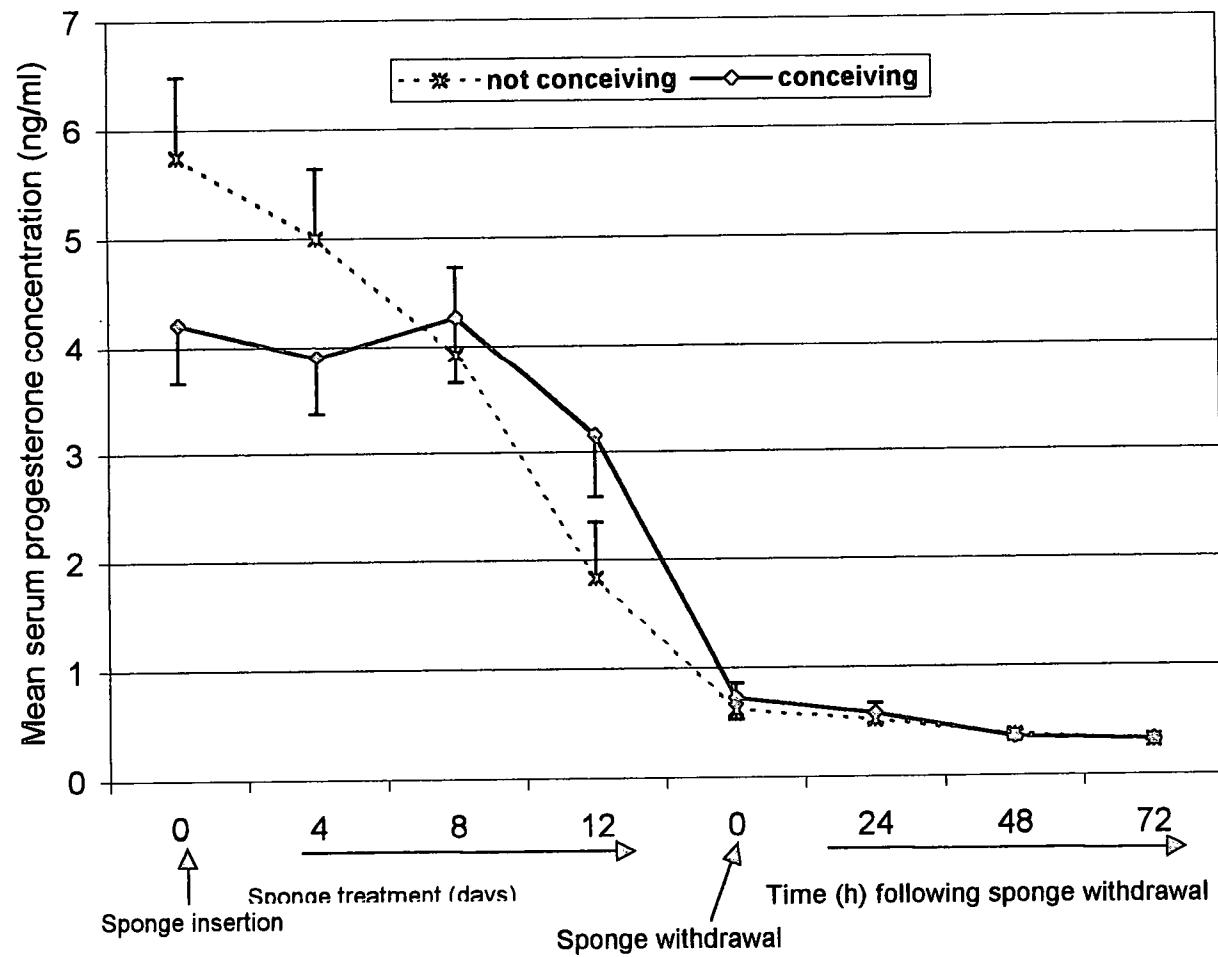


Figure 3.3. Mean serum progesterone concentrations for ewes conceiving or not, following oestrous synchronization and AI

Table 3.6. Serum progesterone (P₄) concentrations (ng/ml) during and following progestagen treatment in Dorper ewes

Factor	n	Mean P ₄ values	
		During progestagen treatment	During 72h following sponge withdrawal
Sponge type		ns	ns
MAP	28	3.56±0.95	0.48±0.22
FGA	28	4.54±1.00	0.48±0.23
Pregnancy status following synchronization treatment		ns	ns
Conceiving	36	4.08±0.33	0.46±0.08
Not conceiving	20	4.10±0.44	0.45±0.10
Total	56	4.08±0.35	0.47±0.89

n number of ewes used for blood sampling

ns not significant

The interval from the onset of oestrus to the LH peak was not significantly affected by the type of progestagen sponge used or the time and route of PMSG administration (Table 3.8). Although not statistically significant, the interval from the onset of oestrus to the LH peak was longer in ewes that received PMSG 24h prior to sponge withdrawal (18.6±2.9h) and the control group (18.5±4.1h), compared to ewes administered PMSG at sponge withdrawal and 24h after sponge withdrawal (11.8±2.9h and 11.6±2.9h, respectively). The time interval from the onset of oestrus to peak serum LH concentration was also not significantly different between ewes conceiving and those ewes failing to conceive from AI (Table 3.8). Nonetheless, the interval was shorter in ewes conceiving following AI (13.8±2.0h), compared to those failing to conceive from AI (16.4±2.6h).

Table 3.7. Effect of oestrous synchronization treatment on the time interval (h) from the commencement of oestrus and sponge withdrawal to the LH peak in Dorper ewes

Synchronization treatment	n	Interval from sponge withdrawal to LH peak (h) ^{ns}	Interval from oestrus onset to LH peak (h) ^{ns}
1. MAP+IM+PMSG 24h before sponge withdrawal	4	68.0±5.0	14.0±6.1
2. MAP+IM+PMSG at sponge withdrawal	4	56.0±5.0	8.0±6.1
3. MAP+IM+PMSG 24h after sponge withdrawal	5	54.4±4.5	10.8±5.5
4. MAP+SC+PMSG 24h before sponge withdrawal	4	54.0±5.0	16.0±6.1
5. MAP+SC+PMSG at sponge withdrawal	3	56.0±5.8	7.3±7.1
6. MAP+SC+PMSG 24h after sponge withdrawal	4	54.0±5.0	18.5±6.1
7. FGA+IM+PMSG 24h before sponge withdrawal	4	54.0±5.0	16.0±6.1
8. FGA+IM+PMSG at sponge withdrawal	4	52.0±5.0	18.0±6.1
9. FGA+IM+PMSG 24h after sponge withdrawal	4	54.0±5.0	9.0±6.1
10. FGA+SC+PMSG 24h before sponge withdrawal	4	56.0±5.0	18.0±6.1
11. FGA+SC+PMSG at sponge withdrawal	5	54.4±4.5	12.4±5.5
12. FGA+SC+PMSG 24h after sponge withdrawal	5	57.6±4.5	10.0±5.5
13. MAP only	3	50.7±5.8	19.3±7.1
14. FGA only	3	58.7±5.8	20.7±7.1
Total	56	55.7±5.1	14.6±6.2

n number of ewes used for blood sampling

ns not significant

No significant differences were observed in the time interval from sponge withdrawal to the LH peak due to progestagen sponge type, time of PMSG administration in relation to sponge withdrawal, route of PMSG administration or the pregnancy status of ewes after AI at the induced oestrus.

Although there were no significant differences in the interval from sponge withdrawal to the serum peak LH concentration between treatments, a relatively longer interval was recorded in ewes administered PMSG 24h before sponge withdrawal, compared to ewes receiving PMSG at sponge withdrawal, 24h after sponge withdrawal or the control ewes.

Table 3.8. Effect of sponge type, time and route of PMSG administration and pregnancy status following AI on the interval from onset of oestrus and sponge withdrawal to the LH peak

Factor	n	Interval from sponge withdrawal to LH peak (h)	Interval from oestrus onset to LH peak (h)
Sponge type		ns	ns
MAP	28	56.3±1.8	14.6±2.3
FGA	28	55.1±1.8	14.6±2.3
Time of PMSG administration		ns	ns
24h before	16	58.0±2.5	18.6±2.9
at sponge withdrawal	16	54.5±2.5	11.8±2.9
24h after sponge withdrawal	16	54.5±2.5	11.6±2.9
Control	8	56.0±3.5	18.5±4.1
Route of PMSG administration		ns	ns
Intramuscular	24	56.0±2.0	14.0±2.4
Subcutaneous	24	55.3±2.0	13.9±2.4
Control	8	56.0±3.5	18.5±4.2
Pregnancy status		ns	ns
Conceiving	36	55.3±2.0	13.8±2.0
Not conceiving	20	56.4±2.2	16.4±2.6
Total	56	55.7±2.0	14.6±2.2

n number of ewes used for blood sampling

ns not significant

The patterns of the mean serum LH concentration in all ewes that conceived and those failing to conceive from the induced oestrus and AI are illustrated in Figure 3. 4. The peak LH value in ewes that conceived from AI was higher (4.68 ng/ml) than in those, which failed to conceive (2.73 ng/ml) during the 96h observation period after sponge withdrawal. Furthermore, the time from sponge withdrawal to the LH peak was shorter in those ewes, which conceived, compared to those failing to conceive from induced oestrus and AI.

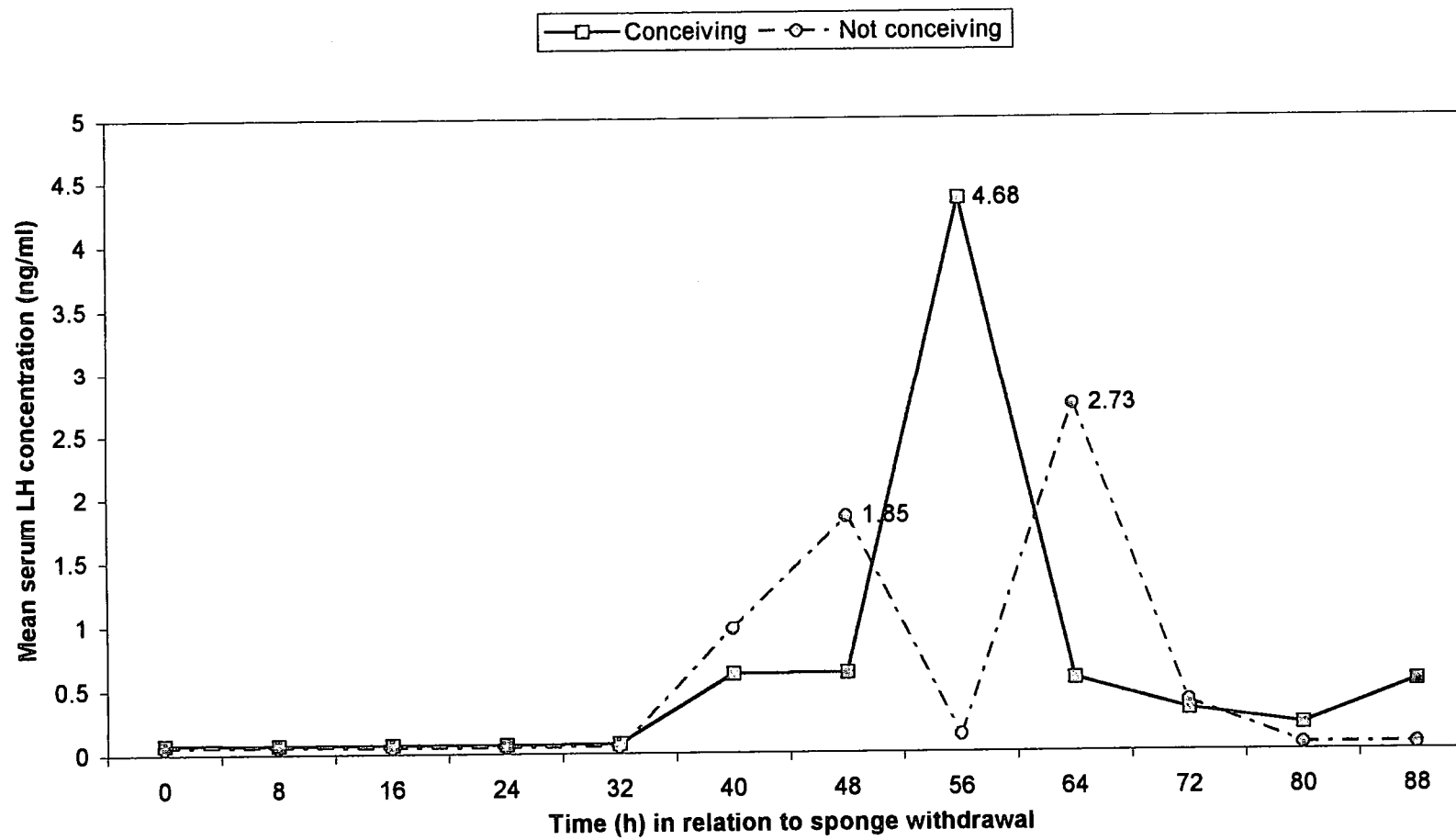


Figure 3.4. Mean serum LH concentration (ng/ml) in Dorper ewes conceiving or not following oestrous synchronization and AI

3.3.5. Reproductive performance following oestrous synchronization and AI

The overall pregnancy rate (ewes lambing/ewes inseminated X 100), lambing rate (lambs born/ewes inseminated X 100) and fecundity rate (lambs born/ewes lambing X 100) recorded following oestrous synchronization and AI in Dorper ewes were 72.3, 91.1 and 126.0%, respectively. The type of oestrous synchronization treatment significantly ($P < 0.01$) affected the pregnancy, lambing and fecundity rates of Dorper ewes. The highest pregnancy rates were achieved in ewes from synchronization treatments 1, 4, 8, 9, 10, 11 and 12, compared to ewes in the rest of the treatments (Table 3.9). The highest pregnancy rate was achieved in ewes from oestrous synchronization treatment 9 (FGA + IM+ PMSG 24h after sponge withdrawal) and 10 (FGA + SC+ PMSG 24h prior to sponge withdrawal) (93.3% or 14/15) groups whereas the lowest pregnancy rate was recorded following synchronization treatment 3 (MAP+IM +PMSG 24h after sponge withdrawal) (38.5% or 5/13).

Similarly, the highest ($P < 0.01$) lambing rate was recorded in ewes from synchronization treatments 1 (MAP+IM+PMSG 24h before sponge withdrawal) and 4 (MAP+SC+PMSG 24h before sponge withdrawal). Significantly ($P < 0.01$) higher fecundity rates were also achieved from ewes in the synchronization treatment 1 (MAP+ IM+PMSG 24h before sponge withdrawal), 4 (MAP+SC+PMSG 24h before sponge withdrawal), 6 (MAP+SC+PMSG 24h after sponge withdrawal), 8 (FGA+IM+ PMSG at sponge withdrawal) and 11 (FGA+SC+PMSG at sponge withdrawal) groups, compared to ewes in the other synchronization treatment groups. The lowest lambing and fecundity rates were recorded in ewes from synchronization treatment 7 (FGA+IM+PMSG 24h before sponge withdrawal) and 10 (FGA+SC+PMSG 24h before sponge withdrawal), respectively (Table 3.9).

Table 3.9. The effect of different oestrous synchronization treatments on the reproductive performance of Dorper ewes following AI

Oestrous synchronization treatment	n	pregnancy rate (%)	Lambing rate (%)	Fecundity (%)
1. MAP+IM+PMSG 24h before sponge withdrawal	16	87.5 ^a (14/16)	131.3 ^a (21/16)	150.0 ^a (21/14)
2. MAP+IM+PMSG at sponge withdrawal	14	64.3 ^{abc} (9/14)	78.6 ^{bc} (11/14)	122.2 ^{abc} (11/9)
3. MAP+IM+PMSG 24h after sponge withdrawal	13	38.5 ^o (5/13)	46.2 ^c (6/13)	120.0 ^{abc} (6/5)
4. MAP+SC+PMSG 24h before sponge withdrawal	14	85.7 ^a (12/14)	142.9 ^a (20/14)	166.7 ^a (20/12)
5. MAP+SC+PMSG at sponge withdrawal	14	78.6 ^{ab} (11/14)	85.7 ^b (12/14)	109.1 ^o (12/11)
6. MAP+SC+PMSG 24h after sponge withdrawal	16	62.5 ^{abc} (10/16)	87.5 ^b (14/16)	140.0 ^a (14/10)
7. FGA+IM+PMSG 24h before sponge withdrawal	14	42.9 ^o (6/14)	50.0 ^c (7/14)	116.7 ^b (7/6)
8. FGA+IM+PMSG at sponge withdrawal	15	86.7 ^a (13/15)	113.3 ^{ab} (17/15)	130.8 ^a (17/13)
9. FGA+IM+PMSG 24h after sponge withdrawal	15	93.3 ^a (14/15)	106.7 ^{ab} (16/15)	114.3 ^b (16/14)
10. FGA+SC+PMSG 24h before sponge withdrawal	15	93.3 ^a (14/15)	100.0 ^{ab} (15/15)	107.1 ^c (15/14)
11. FGA+SC+PMSG at sponge withdrawal	13	69.2 ^{abc} (9/13)	123.8 ^{bc} (16/13)	177.8 ^a (16/9)
12. FGA+SC+PMSG 24h after sponge withdrawal	13	84.6 ^a (11/13)	115.4 ^{ab} (15/13)	136.4 ^c (15/11)
13. MAP only	15	73.3 ^{abc} (11/15)	86.7 ^b (13/15)	118.2 ^b (13/11)
14. FGA only	15	46.7 ^o (7/15)	60.0 ^c (9/15)	128.6 ^{ab} (9/7)
Total	202	72.3 (146/202)	91.1 (184/202)	126.0 (184/146)

^{a, b, c} Means in a column with different superscripts differ significantly (P<0.01)

n number of ewes inseminated

No significant differences in terms of pregnancy and fecundity rates were recorded in ewes synchronized with MAP (60mg) or FGA (40mg) sponges (Table 3.10). The apparent higher pregnancy and fecundity rates obtained in ewes synchronized with FGA sponges (74.0, 97.0 and 131.1%, respectively), compared to those synchronized with MAP sponges (70.6, 85.3 and 120.8%, respectively), were not significant.

When other treatment factors are ignored, the time of PMSG administration relative to the time of sponge withdrawal had a significant ($P < 0.01$) effect on pregnancy and fecundity rates. The highest pregnancy rates were recorded in ewes receiving PMSG 24h prior to sponge withdrawal or at sponge withdrawal (78.0 and 75.0%, respectively), compared to ewes given PMSG 24h after sponge withdrawal or the control animals (70.2 and 60.0%, respectively). The lowest ($P < 0.01$) pregnancy rate (60.0%) was recorded in the control ewes. Similarly, significantly ($P < 0.01$) higher lambing (115.3%) and fecundity rates (147.8%) were achieved from ewes treated with PMSG 24h prior to sponge withdrawal, compared to ewes treated with PMSG at sponge withdrawal, 24h after sponge withdrawal or the control animals. Furthermore, the subcutaneous administration of PMSG, irrespective of sponge type, resulted in significantly ($P < 0.01$) higher pregnancy and lambing rates when compared to intramuscular administration of the same dose of PMSG. The obtained fecundity rate was higher in ewes receiving PMSG subcutaneously, compared to the control or intramuscularly injected groups although these differences were not significant.

The age of ewes did not significantly affect the overall pregnancy rate. However, the pregnancy rate tended to increase with an increase in the age of ewes (Figure 3.5). Both lambing and fecundity rates were significantly affected ($P < 0.05$ and $P < 0.01$, respectively) by the age of the ewes. Lambing and fecundity rates were significantly higher for 4 to 6-year-old ewes, compared to 2 to 3-year-old ewes (Table 3.10).

In this trial, BW at AI also significantly ($P < 0.01$) affected the reproductive performance of Dorper ewes following oestrous synchronization and AI. Significantly ($P < 0.01$) higher pregnancy, lambing and fecundity rates were recorded in ewes weighing 60 to 79kg, compared to ewes weighing below 60kg at breeding (Table 3.10).

Table 3.10. Effect of sponge type, time and route of PMSG administration, age and body weight of ewes at AI on conception, lambing and fecundity rates in Dorper ewes

Factor	n	Pregnancy rate (%)	Lambing rate (%)	Fecundity (%)
Sponge type		ns	ns	ns
MAP	102	70.6 (72/102)	85.3 (87/102)	120.8 (87/72)
FGA	100	74.0 (74/100)	97.0 (97/100)	131.1 (97/74)
Time of PMSG administration		**	**	**
-24h	59	78.0 ^a (46/59)	115.3 ^a (65/59)	147.8 ^a (68/46)
0h	56	75.0 ^a (42/56)	94.6 ^b (53/56)	126.2 ^b (53/42)
+24h	57	70.2 ^b (40/57)	73.7 ^c (42/57)	105.0 ^c (42/40)
Control	30	60.0 ^c (18/30)	70.0 ^c (21/30)	116.7 ^c (21/18)
Route of PMSG injection		**	**	ns
Intramuscular	87	70.1 ^b (61/87)	86.2 ^b (75/87)	123.0 (75/61)
Subcutaneous	85	78.8 ^a (67/85)	102.4 ^a (87/85)	129.9 (87/67)
Ewe age (years) at AI		ns	*	**
2	90	68.9 (62/90)	77.8 ^c (70/90)	112.9 ^b (70/62)
3	39	69.2 (27/39)	84.6 ^c (33/39)	122.2 ^b (33/27)
4	23	73.9 (17/23)	117.4 ^d (27/23)	158.8 ^a (27/17)
5	27	85.2 (23/27)	111.1 ^d (30/27)	130.4 ^{ab} (30/23)
6	23	73.9 (17/23)	104.4 ^d (24/23)	141.2 ^a (24/17)
Ewe BW (kg) at AI		**	**	**
40-49	24	70.8 ^b (17/24)	79.2 ^b (19/24)	111.8 ^b (19/17)
50-59	121	70.3 ^b (85/121)	81.8 ^b (99/121)	116.2 ^b (99/85)
60-79	57	77.2 ^a (44/57)	115.8 ^a (66/57)	150.0 ^a (66/44)
Total	202	72.3 (146/202)	91.1 (184/202)	126.0 (184/146)

^{a, b, c} Means in a column with different superscripts differ significantly ($P < 0.05$)

^{d, e} Means in a column with different superscripts differ significantly ($P < 0.01$)

* Significant ($P < 0.05$)

** Significant ($P < 0.01$)

n number of ewes inseminated

ns not significant

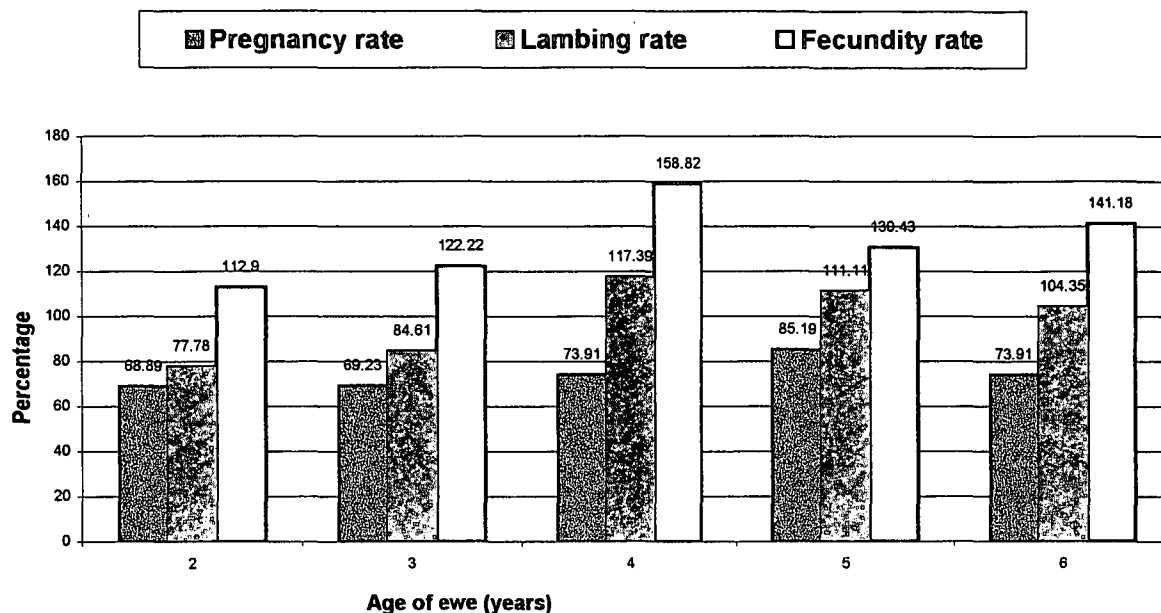


Figure 3.5. Overall effect of ewe age on reproductive performance following oestrous synchronization and AI in Dorper ewes

3.3.6. Litter size following induced oestrus and AI

The overall mean litter size recorded following synchronized oestrus and AI in Dorper sheep was 1.3 ± 0.2 . The type of oestrous synchronization treatment had no significant effect on litter size in this trial (Table 3.11). The lowest value for litter size was recorded in ewes of synchronization treatment 13 (MAP without PMSG) (1.09 ± 0.14), whereas the highest value was recorded in ewes from the synchronization treatments 1 (MAP+IM+PMSG 24h before sponge withdrawal) and 11 (FGA+SC+PMSG 24h before sponge withdrawal).

Table 3.11. Effect of oestrous synchronization treatment on litter size in Dorper ewes

Synchronization treatment	n	Litter size (Mean±SE) ^{ns}
1. MAP+IM+PMSG 24h before sponge withdrawal	13	1.5±0.1
2. MAP+IM+PMSG at sponge withdrawal	9	1.1±0.2
3. MAP+IM+PMSG 24h after sponge withdrawal	6	1.2±0.2
4. MAP+SC+PMSG 24h before sponge withdrawal	13	1.5±0.1
5. MAP+SC+PMSG at sponge withdrawal	9	1.5±0.2
6. MAP+IM+PMSG 24h after sponge withdrawal	10	1.2±0.2
7. FGA+IM+PMSG 24h before sponge withdrawal	7	1.2±0.2
8. FGA+IM+PMSG at sponge withdrawal	13	1.2±0.1
9. FGA+IM+PMSG 24h after sponge withdrawal	13	1.2±0.1
10. FGA+SC+PMSG 24h before sponge withdrawal	14	1.3±0.1
11. FGA+SC+PMSG at before sponge withdrawal	10	1.6±0.2
12. FGA+IM+PMSG 24h after sponge withdrawal	10	1.5±0.2
13. MAP only	11	1.1±0.1
14. FGA only	8	1.3±0.2
Total	146	1.3±0.2

n number of ewes lambing

ns not significant

Litter size as such did not significantly differ due to sponge type, time of PMSG administration or age of the ewes (Table 3.12). Nevertheless, litter sizes were apparently higher in ewes treated with MAP sponges, compared to in those ewes treated with FGA sponges. Comparatively, 4 to 6-year-old ewes recorded a higher litter size compared to the 2 to 3-year-old ewes — although the values recorded were not statistically different.

The route of PMSG administration induced significant ($P<0.05$) differences in litter size. The litter size was significantly higher ($P<0.05$) in ewes injected with 300 IU PMSG subcutaneously (1.6 ± 0.2), compared to control ewes (1.2 ± 0.4). The litter size obtained from intramuscular injection was intermediate and not significantly different from both the subcutaneously injected and control ewes (Table 3.12).

Besides the route of PMSG administration, differences in the BW of ewes at AI also significantly ($P<0.05$) affected the subsequent litter size. Litter size was significantly ($P<0.05$) higher in heavier ewes weighing between 60 to 79kg (1.5 ± 0.1), compared to ewes weighing less than 60 kg (Table 3.12).

Table 3.12. Effect of sponge type, time and route of PMSG administration, age and body weight of ewes at AI on litter size

Parameter	n	Litter size (Mean±SE)
Sponge type		
		ns
MAP	68	1.5±0.1
FGA	78	1.4±0.1
Time of PMSG administration		
		ns
-24h	46	1.4±0.2
0h	42	1.4±0.2
+24h	40	1.4±0.2
Control	18	1.5±0.4
Route of PMSG injection		
		*
Intramuscular	61	1.5 ^{ab} ±0.2
Subcutaneous	67	1.6 ^a ±0.2
Control	18	1.2 ^b ±0.4
Ewe age (years) at AI		
		ns
2	62	1.3±0.1
3	27	1.3±0.1
4	17	1.6±0.1
5	23	1.5±0.1
6	17	1.5±0.1
Ewe BW (kg) at AI		
		*
40-49	17	1.4 ^b ±0.1
50-59	85	1.4 ^{ab} ±0.1
60-79	44	1.5 ^a ±0.1
Total		1.3±0.2

^{a, b} Means in a column with different superscripts differ significantly (P<0.05)

* Significant (P<0.05)

ns not significant

n number of ewes lambing

3.3.7. Gestation length following oestrous synchronization

The overall mean gestation length for all experimental animals from all treatment groups was 147.4±0.3 days. The gestation length was significantly (P<0.05) affected by the type of oestrous synchronization treatment (Table 3.13). The longest gestation period was recorded from ewes in the treatment 3 (MAP+IM+PMSG 24h after sponge withdrawal) group (148.8 days), whereas the shortest was recorded from ewes in treatment 1 (MAP+IM+PMSG 24h before sponge withdrawal) and 11 (FGA+SC+PMSG at sponge withdrawal) groups (147.0 days).

Table 3.13. Effect of oestrous synchronization treatment on gestation length (days) following oestrous synchronization and AI in Dorper ewes

Synchronization treatment	n	Gestation length (Mean \pm SE)
1. MAP+IM+PMSG 24h before sponge withdrawal	13	147.00 ^c \pm 0.39
	9	148.25 ^{abc} \pm 0.44
3. MAP+IM+PMSG 24h after sponge withdrawal	6	148.80 ^a \pm 0.56
4. MAP+SC+PMSG 24h before sponge withdrawal	13	147.54 ^{abc} \pm 0.34
5. MAP+SC+PMSG at sponge withdrawal	9	147.50 ^{abc} \pm 0.44
6. MAP+SC+PMSG 24h after sponge withdrawal	10	148.10 ^{abc} \pm 0.39
7. FGA+IM+PMSG 24h before sponge withdrawal	7	147.83 ^{abc} \pm 0.51
8. FGA+IM+PMSG at sponge withdrawal	13	147.85 ^{abc} \pm 0.34
9. FGA+IM+PMSG 24h after sponge withdrawal	13	148.31 ^{abc} \pm 0.34
10. FGA+SC+PMSG 24h before sponge withdrawal	14	148.29 ^{abc} \pm 0.33
11. FGA+SC+PMSG at sponge withdrawal	10	147.00 ^c \pm 0.41
12. FGA+SC+PMSG 24h after sponge withdrawal	10	148.50 ^{ab} \pm 0.39
13. MAP only	11	147.64 ^{abc} \pm 0.37
14. FGA only	8	147.14 ^{bc} \pm 0.47
Overall	146	147.4 \pm 0.3

^{a, b, c} Means in a column with different superscripts differ significantly ($P < 0.05$)

n number of ewes lambing

In general, the type of intravaginal progestagen sponge used, the route of PMSG administration, BW of ewes at AI and the sex of the fetus did not significantly affect gestation length (Table 3.14). However, administration of 300IU PMSG 24h after intravaginal sponge withdrawal significantly ($P < 0.05$) increased the gestation length (148.2 ± 0.5 days), compared to the administration of PMSG at sponge withdrawal (147.5 ± 0.5 days), 24h before sponge withdrawal (147.4 ± 0.5 days) or the control (147.1 ± 0.5 days) ewes.

The age of the ewes had also a significant effect on their gestation length. Four year-old ewes had a significantly ($P < 0.05$) longer gestation length compared to 2, 3, 5 or 6-year old ewes.

Table 3.14. Effect of sponge type, time and route of PMSG administration, age and body weight at AI, litter size and sex of the fetus on gestation length in Dorper ewes

Parameters	n ₁	Gestation length (Mean±SE)
Sponge type		ns
MAP	68	147.6±0.5
FGA	78	147.5±0.5
Time of PMSG administration		*
-24h	46	147.4 ^b ±0.5
0h	42	147.5 ^b ±0.5
+24h	40	148.2 ^a ±0.5
Control	18	147.1 ^b ±0.5
Route of PMSG administration		ns
Intramuscular	61	147.9±0.2
Subcutaneous	67	147.9±0.2
Control	18	147.4±0.3
Ewe age (years) at AI		*
2	62	147.3 ^b ±0.5
3	27	147.2 ^b ±0.5
4	17	148.3 ^a ±0.5
5	23	147.5 ^b ±0.5
6	17	147.3 ^b ±0.5
Ewe BW (kg) at AI		ns
40-49	17	147.5±0.6
50-59	85	147.4±0.5
60-79	44	147.8±0.4
Litter size		*
1	98	148.1 ^a ±0.2
2	47	147.5 ^b ±0.2
3	2	147.1 ^b ±1.3
Sex of the fetus	n ₂	ns
Male	84	147.7±0.3
Female	100	147.4±0.3

^{a, b} Means in a column with different superscripts differ significantly (p<0.05)

* Significant (P<0.05)

n₁ number of ewes lambing

n₂ Number of lambs born

ns not significant

3.3.8. Birth weight of lambs following oestrous synchronization and AI

The effect of synchronization treatment on birth weight of lambs is presented in Table 3.15.

The type of oestrous synchronization did not affect the lamb birth weight.

Table 3.15. Effect of oestrous synchronization treatments on birth weight in Dorper ewes

Synchronization treatment	n	Lamb birth weight (kg) ^{ns}
1. MAP+IM+PMSG 24h before sponge withdrawal	20	3.8±0.2
2. MAP+IM+PMSG at sponge withdrawal	9	4.1±0.3
3. MAP+IM+PMSG 24h after sponge withdrawal	6	4.2±0.4
4. MAP+SC+PMSG 24h before sponge withdrawal	19	3.8±0.2
5. MAP+SC+PMSG at sponge withdrawal	12	3.9±0.3
6. MAP+SC+PMSG 24h after sponge withdrawal	12	4.7±0.3
7. FGA+IM+PMSG 24h before sponge withdrawal	7	4.5±0.3
8. FGA+IM+PMSG at sponge withdrawal	15	3.9±0.2
9. FGA+IM+PMSG 24h after sponge withdrawal	16	4.1±0.2
10. FGA+SC+PMSG 24h before sponge withdrawal	18	4.1±0.2
11. FGA+SC+PMSG at sponge withdrawal	14	3.6±0.2
12. FGA+SC+PMSG 24h after sponge withdrawal	15	3.9±0.2
13. MAP only	12	4.5±0.3
14. FGA only	9	4.1±0.3
Total	184	4.0±0.3

n number of lambs born

ns not significant

No significant differences in lamb birth weight were recorded between lambs born from MAP or FGA progestagen sponge treated ewes (Table 3.16). The birth weight was significantly higher ($P<0.05$) in lambs born from the control ewes ($4.9\pm 0.5\text{kg}$), compared to lambs born from ewes treated with PMSG at 24h before, 24h after or at sponge withdrawal (irrespective of the routes of administration).

Age of the ewe had a significant ($P<0.01$) effect on lamb birth weight following oestrous synchronization and AI. The lightest lambs were born from the 2-year-old ewes and the heaviest lambs were obtained from the 3 to 5-year-old ewes (Table 3.16). No significant difference in lamb birth weights were recorded between the lambs born from the 3, 4 and 5-year old ewes.

The BW of ewes at AI did not significantly affect the overall lamb birth weight. However, the weights tended to be greater for lambs born from heavier ewes (Table 3.16). A significant ($P<0.01$) difference in the lamb birth weight was recorded between single-born and twin-born lambs (Table 3.16). Single born lambs were significantly heavier ($4.5\pm 0.1\text{ kg}$) than twin-born lambs ($3.4\pm 0.1\text{kg}$). No significant differences were recorded in birth weights between twin-

born and triplet-born lambs. Furthermore, the sex of the lambs had no significant effect on lamb weight at birth.

Table 3.16. Effect of sponge type, time of PMSG administration, age and body weight of the ewe, litter size and sex of the fetus on lamb birth weight (kg)

Parameter	n	Lamb birth weight (Mean±SE)
Sponge type		
		ns
MAP	87	3.8±0.2
FGA	97	3.8±0.2
Time of PMSG administration		
		*
-24h	68	3.6 ^{cd} ±0.3
0h	53	3.3 ^d ±0.3
	42	3.6 ^d ±0.3
Control	21	4.9 ^c ±0.5
Ewe age (years) at AI		
		**
2	70	3.2 ^c ±0.2
3	33	4.0 ^a ±0.2
4	27	3.9 ^{ab} ±0.2
5	30	4.2 ^a ±0.2
6	24	3.8 ^b ±0.2
Ewe BW (kg) at AI		
		ns
40-49	19	3.7±0.2
50-59	99	3.8±0.2
60-79	66	4.0±0.2
Litter size		
		**
1	97	4.5 ^a ±0.1
2	84	3.4 ^b ±0.1
3	3	3.5 ^{ab} ±0.4
Sex of lamb		
Male	84	3.8±0.2
Female	100	3.8±0.2

^{a, b} Means in a column with different superscripts differ significantly (P<0.05)

^{c, d} Means in a column with different superscripts differ significantly (P<0.01)

* Significant (P<0.05)

** Significant (P<0.01)

n number of lambs born

ns not significant

3.3.9. Perinatal mortality rate in lambs born following synchronization and AI

A total of 10 (5.4%) lambs died during the first 24h after birth. There were no significant differences in the perinatal mortality rate of lambs between the different oestrous synchronization treatment groups (Table 3.17). There were, however, great variations among the synchronization treatment groups regarding the incidence of perinatal mortalities, even though these values were not statistically different. There was no incidence of perinatal mortalities in synchronization treatment groups 1 (MAP+IM+PMSG 24h before sponge withdrawal), 3 (MAP+IM+PMSG 24h after sponge withdrawal), 6 (MAP+SC+PMSG 24h after sponge withdrawal), 7 (FGA+IM+PMSG 24h before sponge withdrawal) and 12 (FGA+SC+PMSG 24h after sponge withdrawal), whereas the highest rates of the perinatal mortalities were recorded in synchronization treatment groups 8 (FGA+IM+PMSG at sponge withdrawal) and 9 (FGA+IM+PMSG 24h after sponge withdrawal).

Table 3.17. Effect of oestrous synchronization regime on perinatal mortality rate of Dorper lambs

Oestrous synchronization treatment	n	Perinatal mortality rate (%) ^{ns}
1. MAP+IM+PMSG 24h before sponge withdrawal	20	0.0
2. MAP+IM+PMSG at sponge withdrawal	10	10.0
3. MAP+IM+PMSG 24h after sponge withdrawal		0.0
4. MAP+SC+PMSG 24h before sponge withdrawal	17	5.9
5. MAP+SC+PMSG at sponge withdrawal	12	8.3
6. MAP+SC+PMSG 24h after sponge withdrawal	11	0.0
7. FGA+IM+PMSG 24h before sponge withdrawal	7	0.0
8. FGA+IM+PMSG at sponge withdrawal	16	12.5
9. FGA+IM+PMSG 24h after sponge withdrawal	16	12.5
10. FGA+SC+PMSG 24h before sponge withdrawal	20	5.0
11. FGA+SC+PMSG at sponge withdrawal	14	7.1
12. FGA+SC+PMSG 24h after sponge withdrawal	15	0.0
13. MAP only	12	8.3
14. FGA only	9	0.0
Overall		5.4

ns not significant

n number of lambs born

The perinatal mortality rates were not significantly affected by the type of intravaginal progestagen sponges used, the time and the route of PMSG administrations, age of the dam, litter size or the sex of the lambs (Table 3.18). A higher perinatal mortality rate was recorded

in lambs born from dams of between 40 and 49kg at AI (15.8%), compared to those born from ewes weighing above 49kg at AI.

Table 3.18. The relationship between intravaginal progestagen sponge type, time and route of PMSG administration, age and body weight of ewes at AI, litter size and sex of the lambs on perinatal mortality

Parameter	n	Perinatal mortality rate (%)
Sponge type		ns
MAP	87	4.6
FGA	97	6.2
Time of PMSG administration		ns
-24h	68	2.9
0h	53	9.4
+24h	42	4.8
Control	21	4.8
Route of PMSG injection		ns
Intramuscular	76	6.6
Subcutaneous	87	4.6
Control	21	4.8
Age (years)		ns
2	70	8.6
3	33	3.0
4	27	3.7
5	30	0.0
6	24	8.3
BW (kg)		*
40-49	19	15.8 ^a
50-59	99	5.1 ^b
60-79	66	3.0 ^b
Litter size		ns
1	97	5.2
2	84	6.0
3	3	0.0
Sex of lamb		ns
Male	84	4.8
Female	100	6.0
Overall mean	184	5.4

^{a, b} Means in a column with different superscripts differ significantly ($P < 0.05$)

* Significant ($P < 0.05$)

n number of lambs born

ns not significant

3.4. DISCUSSION

3.4.1. Oestrous response

For the success of an artificial insemination program when using synchronized breeding, it is essential to have a high oestrous response. Synchronized oestrous response is an indicator of the successful manipulation of ovarian activity in the female following hormonal treatment. In fixed time AI programs, where the time of insemination is determined relative to the time of progestagen sponge withdrawal, exhibition of oestrus is crucial to predict the time of ovulation and to determine the time of insemination. In this trial almost all of the synchronized ewes (97.0%) exhibited overt oestrus signs within the 96h-monitoring period after sponge withdrawal (Table 3.2). The oestrous response obtained in this experiment is comparable to values quoted in the literature (Greyling & Brink, 1987; Crosby *et al.*, 1991; Rosado *et al.*, 1998; Zarkawi *et al.*, 1999). Higher oestrous responses than those obtained in the present study (100%) have been reported by Greyling *et al.* (1994) in studies involving the use of MAP and 300 IU PMSG in Merino ewes outside the breeding season. The slight discrepancy between the results obtained in the current study and those of Greyling *et al.* (1994) may be contributed to differences in the breed of sheep used and the season in which the studies were carried out.

From the 14 different oestrous synchronization treatments applied on Dorper ewes during the transition period from breeding to anoestrus season, none of the synchronization treatments showed any significant advantage regarding oestrous response (Table 3.2), indicating that any of these synchronization treatments can be used to successfully induce oestrus in these ewes provided that there are no significant differences in subsequent fertility, and the cost of treatment and ease of application are considered. As it has been illustrated in Table 3.3 and Figure 3.1, the absence of significant differences in the oestrous response of ewes synchronized with MAP or FGA sponges demonstrate the equal efficiency of these agents in inducing oestrus in Dorper ewes during the transition period from the natural breeding to the anoestrous period. The comparable effect of the two intravaginal progestagen sponge types in inducing oestrus is supported by the previous findings of Crosby *et al.* (1991), Romano *et al.*

(1996), Selvaraju and Kathiresan (1997) and Romano (1998). Furthermore, the absence of a significant difference in terms of percentage of ewes exhibiting oestrus during the observation period between control ewes and those injected with 300IU PMSG (regardless of the time and route of administration), demonstrates the little advantage of using 300IU PMSG for the induction of oestrus in Dorper ewes during the specific transition period.

In this study, age of the ewe was found not to play a significant role in the response to oestrous synchronization. This result is contrary to the finding of Walkden-Brown *et al* (1993) who reported the oestrous response to be positively correlated to the age of the does. The lack of a significant difference between the different age groups of ewes in this study may be due to a relatively small difference in the age of the experimental animals (2 to 6 years). There were no extremely young or extremely old ewes to affect the response regarding oestrus, following synchronization treatment. Similarly, the difference in the BW of the ewes at AI could not be related to the percentage of ewes exhibiting overt oestrous signs during the observation period. The absence of a significant difference in terms of oestrous response demonstrates that a BW range of 40 to 79kg may not be detrimental or does not hamper the induction of oestrus following use of progestagen sponges and PMSG in Dorper ewes.

3.4.2. Time to onset and the duration of the induced oestrus

The time between sponge withdrawal and the commencement of oestrus as well as the duration of the induced oestrous period are as important as the response to oestrus because these factors are essential for estimating the time of ovulation and determining the time of AI (especially when fixed-time AI is used). The overall mean time from intravaginal progestagen (MAP and FGA) withdrawal to the commencement of oestrus and the duration of the induced oestrus in this trial was 41.6 ± 2.5 h and 20.1 ± 3.6 h, respectively (Table 3.4). The interval from progestagen withdrawal to the onset of oestrus recorded in this experiment is comparable to that of Greyling *et al.* (1994), which was 43.0 ± 7 h in ewes synchronized with MAP and treated with 300IU PMSG at sponge withdrawal, during the non-breeding season. However, the time to onset of oestrus in this trial was longer than that reported by Greyling *et al.* (1997) (30.5h), and shorter than the reports of Greyling and Brink (1987) on Karakul ewes

synchronized with MAP during the breeding season (62.5 ± 18.7 h). On the other hand, the duration of the induced oestrus period observed in this trial was relatively shorter than the period recorded by Greyling *et al.* (1997) in Merino ewes during the breeding season. These discrepancies could be due to breed and seasonal differences.

In Table 3.4, the effects of the synchronization treatments on the time to onset and the duration of the induced oestrus were compared. Absence of significant differences in terms of time to onset of oestrus (relative to progestagen sponge withdrawal) and the duration of the induced oestrous period implies that all the oestrous synchronization treatments compared are equally effective. Therefore any method can be used, provided that the effects on other reproductive parameters are found to be optimal. Under the current circumstances, it would seem that the use of either MAP (60mg) or FGA (40mg) intravaginal progestagen sponges alone is sufficient to induce oestrus, and there are no additional benefits in using PMSG. On the contrary, this complicates and increases the cost of oestrous synchronization treatments. The supporting literature on the use of combined effects of sponge types, time and route of PMSG administration on the effect of time to onset of oestrus and the duration of the induced oestrus especially in Dorper ewes, during the transition from the breeding to anoestrus season is very limited.

Absence of significant differences in terms of time to onset and the duration of induced oestrus between ewes treated with MAP and FGA intravaginal sponges (Table 3.5) demonstrates a similar efficiency of the two intravaginal progestagen sponges in inducing oestrus during the transition period in the Dorper breed. Any one of these two types of sponges can be used. Selection should be based on the availability and cost effectiveness. The results of the current trial are consistent with the previous findings of Romano *et al.* (1995) and Romano (1996). On the contrary, Romano (1998a) noted the time from sponge withdrawal to the onset of oestrus to be earlier in does treated with FGA, compared to those treated with MAP sponges. However, the duration of induced oestrus found to be similar in all groups of does. The results obtained by Selvaraju *et al.* (1997), who recorded a significantly longer duration of the induced oestrus with MAP compared to FGA treated does, also contradicts the results of this study.

Furthermore, the time to onset and the duration of the induced oestrus was not significantly affected by the time and route of PMSG administration, age or BW of ewes at breeding (Table 3.5). Eppleston *et al.* (1991) studied the effect of time of PMSG administration on the time to onset of oestrus in ewes and found the administration of PMSG 24h before sponge withdrawal to reduce the onset of oestrus relative to sponge withdrawal. This is in agreement with present results, although the difference recorded was not significant.

Unlike the previous work of Moses *et al.* (1997) who revealed a significant effect of age of the ewe on the commencement of oestrus relative to intravaginal sponge withdrawal in Merino ewes, in this trial, the age difference had no significant effect on both the time to onset of oestrus and the duration of the induced oestrous period.

3.4.3. Serum progesterone concentrations

The mean serum progesterone concentrations for all animals during intravaginal progestagen sponge treatment and in the 72h following sponge withdrawal was 4.08 and 0.47ng/ml, respectively (Table 3.6). The mean progesterone concentration during sponge treatment and in the 72h following sponge withdrawal were not significantly affected by the type of intravaginal progestagen sponges used (3.56 ± 0.95 vs. 4.54 ± 1.00 and 0.48 ± 0.22 vs. 0.48 ± 0.23 ng/ml for MAP and FGA sponges, respectively). This implies that both MAP and FGA intravaginal progestagen sponges have the same effect on the progesterone hormonal profiles of synchronized ewes. The serum progesterone concentrations during these periods were also not significantly different for ewes that conceived or failed to conceive from the subsequent AI (Figure 3.3). Thus, serum progesterone concentrations either during intravaginal progestagen treatment or during the 72h post sponge treatment observation period could not help to predict the conception rate following AI.

At the time of sponge insertion, the overall mean serum progesterone concentration was 4.74ng/ml (range of 1.40 to 17.90ng/ml) for all ewes sampled, and this value decreased to 0.67ng/ml (range of 0.19 to 5.4ng/ml) at sponge withdrawal. All progesterone values

remained below 1ng/ml for the 72h post progestagen sponge treatment period (Figure 3.2). The serum progesterone profiles observed in this experiment are in accordance with Godfrey *et al.* (1999), who revealed a decline in serum progesterone concentration below 1ng/ml following the withdrawal of progestagen sponges in sheep. These low progesterone levels following sponge withdrawal demonstrate the efficiency of the progestagen treatment to induce oestrus in Dorper ewes during the transition period from the breeding (Autumn) to the anoestrus (Winter) season. The lowest mean serum progesterone concentration (0.32 ± 0.01 ng/ml) was recorded 72h following intravaginal progestagen withdrawal. This could be related to the time of highest follicular activity (oestrogen production) when ovulation takes place.

3.4.4. Serum luteinizing hormone concentrations

The overall mean time from sponge withdrawal to the LH peak and from the onset of oestrus to the LH peak in this experiment were 55.7 ± 5.1 h and 14.6 ± 6.2 h, respectively (Table 3.7). The mean time interval from sponge withdrawal to the LH peak observed in this study is in line with Greyling *et al.* (1997), who reported an interval of 55.5h in Merino ewes synchronized with MAP sponges during the breeding season. It is, however, shorter than Greyling and Brink (1987), who recorded a period of 78.0h in Karakul ewes during the breeding season. However, the intervals from the commencement of oestrus to the pre-ovulatory LH peak observed in this study were longer than those quoted by Greyling *et al.* (1997), but comparable to those of Greyling and Brink (1987) who found the interval from the onset of oestrus to the pre-ovulatory LH peak to be 17.3h. The discrepancy between the present results and those of previous reports may be attributed to differences in breed and season of synchronization, while nutrition could also play a role.

No significant differences were recorded for the time interval from sponge withdrawal to the pre-ovulatory LH peak and from the onset of oestrus to the pre-ovulatory LH peak between the different oestrous synchronization treatments (Table 3.7). This could imply a similar effect by all the synchronization techniques evaluated. Neither the interval from the sponge withdrawal to the LH peak nor the time from onset of oestrus to LH peak were affected by

intravaginal progestagen type, time and route of PMSG administration, or between ewes that conceived or failed to conceive from the subsequent AI (Table 3.8; Figure 3.4). The magnitude of the pre-ovulatory LH surge in all ewes, which eventually conceived and those failing to conceive were 4.68 and 2.73 ng/ml, respectively (Figure 3.4). In both cases, the peak serum LH concentration obtained in this study was lower than the peak values indicated in the literature (Greyling & Brink, 1987; Greyling *et al.*, 1994; Greyling *et al.*, 1997). The reason for the low pre-ovulatory LH surge in this experiment is unclear but could be related to too long (8h) intervals between sampling which may not have been adequate to determine the real peaks. The peaks presumably occurred between blood collections and were not recorded.

3.4.5. Reproductive performance following oestrous synchronization and AI

The main focus of all reproductive management programs is to optimize the reproductive performance of farm animals. Of the reproductive parameters that necessitate improvement in controlled breeding, fertility is the most important one. The mean overall pregnancy, lambing and fecundity rates in this trial for all ewes were 72.3, 91.1 and 126.0%, respectively (Table 3.9). These values are comparable with results obtained by Hill *et al.* (1998) in Merino ewes synchronized with FGA sponges and inseminated laparoscopically with frozen semen. The results in this trial are, however, higher than that obtained by Greyling *et al.* (1988), Vosniakou *et al.* (1996), Rosado *et al.* (1998), but lower than those of Vinales *et al.* (2001), who recorded a pregnancy rate of 87% with short term (6 days) progestagen treatment in ewes. Nonetheless, the current pregnancy value falls in the acceptable range and is in agreement with most of those reported in the literature. The sort of discrepancies regarding pregnancy rate that occur in this experiment and in some reports in the literature may due to differences in breed, season and overall managerial conditions.

Of the 14 oestrous synchronization treatments evaluated in this experiment, only treatments 3 (MAP+IM+PMSG 24h after sponge withdrawal), 7 (FGA+IM+PMSG 24h before sponge withdrawal) and 13 (MAP without PMSG) resulted in a low pregnancy and lambing rates (Table 3.9). The highest pregnancy and lambing rates were achieved in ewes from oestrous synchronization treatments 9 (FGA+IM+PMSG 24h after sponge withdrawal) and 10

(FGA+SC+PMSG 24h before sponge withdrawal) (93.3 and 93.3%, respectively). The reason for the differences in the reproductive performances of ewes from the different synchronization treatments is unclear. Perhaps, those synchronization treatments which resulted in high pregnancy and lambing rates induced more favorable endocrine balances for multiple ovulations or for embryo survival. Some of these synchronization treatments could have created a less favourable hormonal uterine environment for successful sperm and/or egg transport or embryo survival in the female reproductive tract. Therefore, it can be stated that many alternatives for oestrous synchronization exist and can be developed and applied to induce oestrus and ovulation in Dorper ewes, during the transition period from the breeding to anoestrus season. The choice of a synchronization treatment depends on cost effectiveness, ease of application, the availability of the synchronizing agents and the subsequent fertility obtained.

Overall, the type of progestagen sponge (MAP or FGA) did not significantly affect the pregnancy, lambing and fecundity rates (Table 3.10). This is in agreement with the findings of Al-Kamali *et al.* (1990), Crosby *et al.* (1991), Romano *et al.* (1996) and Romano (1998). However, the present results are contrary to Gordon (1974), Eppleston and Roberts (1986), Greyling *et al.* (1988) and Hill *et al.* (1998), who reported the superiority of FGA over MAP progestagen sponges regarding pregnancy rate and overall fertility.

Many researchers have indicated the importance of administering PMSG to obtain a more predictable and compact oestrus or ovulation even though cyclic ewes or does are expected to demonstrate oestrus shortly after intravaginal progestagen withdrawal with no PMSG (Zhang & Yuan, 1988; Knight *et al.*, 1992; Artiningsih *et al.*, 1996; Cordova *et al.*, 1999; Cline, 2001). The lower pregnancy and lambing rates obtained from ewes which did not receive any PMSG, compared to those injected with 300 IU PMSG in this experiment emphasizes the importance of administering PMSG to achieve better fertility rates (Table 3.10). Besides the mere administration of PMSG to synchronize oestrus, the time of its administration relative to intravaginal progestagen withdrawal and the routes of administration were observed to be essential to improve the reproductive performance in this trial. Eppleston *et al.* (1991) studied the effect of time of PMSG and GnRH administration on ovulation, LH secretion and

reproductive performance of intra-uterine inseminated ewes with frozen semen and found that treatment with PMSG 24h before sponge withdrawal shortened the time to ovulation. A similar study done by Zhang and Yuan (1988) also indicated an increase in fertility when PMSG was administered 24h prior to sponge removal. The pregnancy rate was significantly higher ($P < 0.01$) (78.0%) in ewes receiving PMSG 24h prior to sponge withdrawal or at sponge withdrawal compared to ewes receiving the same dose of PMSG 24h after sponge withdrawal (70.2%) and the control group (60%) in this study (Table 3.10), which is in line with the findings of Zhang and Yuan (1988). However, the results of the present study are not in agreement with the findings of Eppleston *et al.* (1991) who stated that the time of PMSG treatment did not yield a constant improvement in fertility, apart from shortening the time to ovulation.

Attainment of significantly ($P < 0.01$) higher pregnancy and lambing rates in ewes given PMSG subcutaneously (78.8%), compared to ewes given PMSG intramuscularly (70.1%) demonstrates the advantage of administering PMSG subcutaneously. The reason for this difference is vague. However, Greyling and Van Niekerk (1989) also reported the pre-ovulatory LH surge to be significantly shorter in subcutaneous injected, compared to intramuscularly injected ewes. This may be due to the difference in the rate of absorption and metabolism of PMSG between subcutaneously and intramuscularly administered PMSG.

Amongst other factors known to have a definite effect on ovulation rate, is the age of the female at mating (Devendra & Burns, 1983; Gordon, 1983; Laliotis *et al.*, 1993; Pintato *et al.*, 1996). In the present experiment, an attempt was made to assess the effect of age of the ewes on the reproductive performances following oestrous synchronization treatment. Although an increasing trend in pregnancy rate was observed as the age of the ewes increased from 2 to 4 years, and again a declining trend after 5 years of age, these differences were not statistically significant (Table 3.10; Figure 3.5). On the other hand, lambing and fecundity rates were significantly higher in 4, 5 and 6-year-old ewes compared to 2 or 3-year-old ewes. The higher lambing and fecundity rates from the older ewes may be attributed to a natural increase in twinning rate, due to the fact that ovulation rate of older ewes is higher than that of ewe lambs and young ewes. 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). Fecundity was also reported to increase with an increase in the age of the dam (Devendra & Burns, 1983; Fourie & Heydenrych, 1983). Notter (2000) revealed that both old age and immaturity have a profound effect on sheep prolificacy.

In this study, BW at AI had a highly significant ($P < 0.01$) influence on pregnancy, lambing and fecundity rates (Table 3.10). Higher ($P < 0.01$) pregnancy, lambing and fecundity rates were achieved in ewes weighing between 60 and 79kg (77.2, 115.8 & 150.0%, respectively), compared to ewes weighing below 40 to 49kg (70.8, 79.2 & 11.8%, respectively) and 50 to 59kg (70.3, 81.8 & 116.2%, respectively). Most of the previous reports are in line with the current findings. There are, however, contradictory reports on the magnitude and the mechanisms involved regarding the effect of BW at mating on the subsequent reproductive performance. According to Coop (1966) BW of the ewe has a great influence on litter size; the effect being mainly on the ovulation rate and to some extent on embryo mortality (Edey, 1969). According to Cumming (1977), BW per se can be a more accurate predictor of ovulation rate, and it was found that heavier ewes within a flock to have a higher ovulation rate than lighter ewes — showing a 2.5 to 3.0% increases in ovulation rate for each 1 kg increase in BW. Similarly, Smith (1988) also drew attention to the relationship between BW prior to mating and ovulation rate, and reported an increase of 2% in ovulation rate for each additional kilogram in BW.

3.4.6 Litter size following induced oestrus and AI

Large variation was observed in the literature regarding litter size in Dorper sheep. The mean litter size obtained in this study (1.31) is in agreement with the findings of Pretorius and Viljoen (1968), Badenhorst *et al.* (1991), Manyuchi *et al.* (1991), Erasmus *et al.* (1994) and Van Niekerk (1998). These results for litter size are, however, higher than that reported by Coetzee (1964), Greeff *et al.* (1988), Ackermann (1993), Schoeman *et al.* (1995) and Van Niekerk (1998), but lower than that reported by Basson *et al.* (1969) and Cloete and De Villiers (1987). The inconsistency regarding litter size can be explained by the differences in management systems, age, BW and breed of the experimental animals.

None of the different synchronization treatments showed any significant effect on litter size in this trial (Table 3.11). Similarly, the type of intravaginal progestagen sponges used or the time of PMSG administration relative to sponge withdrawal had no significant effect on litter size (Table 3.12). In general, for all the treatments, subcutaneous injections of 300IU PMSG resulted in a significantly higher ($P<0.05$) litter size (1.6 ± 0.2), compared to the control (1.2 ± 0.4) groups (FGA and MAP). On the other hand, PMSG intramuscularly treated ewes did not produce higher litter sizes than the control ewes. The reasons for the higher litter size from subcutaneous injection as compared to control may be due to its effect on the rate of absorption and metabolism of PMSG in the target organs and liver, respectively.

Although not significant, 4 to 6-year old ewes produced higher litter sizes when compared to the 2 to 3-year old ewes. The higher litter size obtained in 4 to 6-year-old ewes is possibly due to a higher ovulation rate experienced in this older group of ewes than in the younger animals. Generally, the ovulation rate observed in mature ewes is higher than that in younger ewes (Dewi *et al.*, 1996). The effect of oestrous synchronization treatment on litter size is in agreement with the findings of Armstrong and Evans (1983), Mahmood *et al.* (1991), Dewi *et al.* (1996), Sarmah *et al.* (1996) and Gootwine *et al.* (1997).

Overall, significantly higher ($P<0.05$) litter sizes were also recorded in ewes weighing 60 to 79kg (1.5 ± 0.1), compared to in ewes weighing 40 to 49kg (1.4 ± 0.1) at breeding (Table 3.12). However, no significant differences were recorded for litter size between ewes weighing 40 to 49kg vs. 50 to 59kg and 49 to 59kg vs. 60 to 79kg. Obtaining higher litter size from heavier ewes was expected, as the ovulation rate of heavier ewes is generally reported to be higher than the ovulation rate in lighter ewes (Smith, 1988; Rhind *et al.*, 1989; Rhind *et al.*, 1993; Mukasa-Mugerwa & Lahlou-Kassi, 1995).

3.4.7. Gestation Length following synchronized breeding

The gestation length values reported in the literature for Dorper sheep are remarkably constant. Average values quoted in the literature include 146.5 days (Joubert, 1962), 147.9

days (Joubert & Louw, 1964) and 146.5 days (Van Niekerk & Mulder, 1965). According to the findings of Elias *et al.* (1985), the gestation length for the same sheep breed ranges from 146.2 to 147.7 days, depending on the age of the ewe, litter size and sex of the lamb. In this trial, the overall mean gestation length for all oestrous synchronized and artificially inseminated ewes was 147.4 ± 0.3 days (Table 3.13), which is comparable to the values reported by the other researchers

The gestation period was not significantly affected by the intravaginal progestagen type, route of PMSG administration, or the sex of the foetus (Table 3.14). However, it was significantly ($P < 0.05$) influenced by the time of PMSG administration relative to intravaginal progestagen withdrawal. The reason for obtaining a significantly ($P < 0.05$) longer gestation length in ewes receiving PMSG 24h after sponge removal is unclear, but it is doubtful if PMSG administration could have had an effect approximately 5 months later. Its effect could have been indirect as the time of PMSG administration influenced lamb birth weight.

Besides, BW of the ewes at breeding, the gestation length for ewes carrying singletons was significantly ($P < 0.05$) longer (148.1 ± 0.2 days) than for ewes carrying twins (147.5 ± 0.2 days) and triplets (147.1 ± 1.3 days). These results are in agreement with the findings of Ritar *et al.* (1989) and Amoah and Gelaye (1990) who reported shorter gestation periods in ewes carrying multiple foetuses. This phenomenon could be explained by a lack of uterine space due to the increased total litter weight, which induces stress and thus earlier lambing. The gestation length was also significantly ($P < 0.05$) longer in 4-year-old ewes compared to ewes from other age groups. The justification for this longer gestation length is not clear, but may be related to their larger body size and larger uterine space, big enough to accommodate the foetus for longer period of time. Unlike the previous reports by Shelton (1960) and Amoah and Bryant (1983) regarding the effect of sex of the lamb on the gestation length, no significant difference in gestation length was recorded for ewes carrying male or female fetuses. The discrepancy between the present study and that of Shelton (1960) and Amoah and Bryant (1983) may have emanated from breed differences.

3.4.8. Birth weight of lambs following oestrous synchronization and AI

Body weight and growth performances are important traits in all lamb producing enterprises. The mean birth weight for all Dorper lambs born in this study was 4.0 ± 0.3 kg (Table 3.15). This birth weight is comparable to the values reported by Olivier *et al.* (1984), Schoeman (1990) and Ingyangala *et al.* (1992) for the same breed of sheep (4.2, 4.3 and 4.1kg, respectively). There are reports of birth weights to be as high as 5.0kg (Schoeman & van der Merwe, 1994) or as low as 3.7kg (Ingyangala *et al.*, 1991) for the Dorper breed. The discrepancies between the observed birth weight values and those of Schoeman and van der Merwe (1994) and Ingyangala *et al.* (1991) may have emanated from differences in litter size, the proportion of sex of the offspring or the condition of the dam due to her nutritional status. As it should be expected, differences in synchronization treatments could not have an effect on birth weight of the lambs (Table 3.15). In the same way, the type of intravaginal progestagen did not affect the birth weight of the lamb. However, significantly ($P < 0.05$) heavier lambs were born from control ewes (4.9 ± 0.5 kg), compared to lambs born from PMSG treated ewes (Table 3.16). This may indirectly be due to the impact of PMSG injection on ovulation rate and the higher occurrence of multiple births.

Age of the dam and litter size had a significant ($P < 0.01$) effect on lamb birth weight in this trial (Table 3.16). The lamb birth weight was significantly lower ($P < 0.01$) in 2 and 6-year-old ewes (3.2 ± 0.2 and 3.8 ± 0.2 kg, respectively), compared to those of 3, 4 and 5-year-old ewes (4.0 ± 0.2 , 3.9 ± 0.2 and 4.15 ± 0.21 kg, respectively). The justification for the lighter birth weights in young ewes may be due to the relatively smaller uterine space. Young ewes have a small uterus compared to the mature ewes, which does not allow accommodating a large foetus. On the other hand, the lighter birth weights obtained in older ewes may be due to the higher incidence of multiple births. As it was expected, singletons in this trial were significantly ($P < 0.01$) heavier (4.5 ± 0.1 kg) than twins (3.4 ± 0.1 kg). This result is supported by the work of Epstein and Hertz (1964) and Amoah and Bryant (1983), who found a negative correlation between birth weight and litter size. The heavier birth weight from triplets in this

study is not justifiable and the reason is uncertain, as the numbers of triple births were very few compared to single and twin births.

3.4. 9. Perinatal mortality rate in lambs born following synchronization and AI

Reproductive losses in the form of embryonic resorption, abortion, stillbirths or neonatal mortality are responsible for the low productivity of sheep. In this trial, the incidence of lamb mortalities within 24h of birth was not significantly affected by the synchronization treatment (Table 3.17), the intravaginal progestagen type, time and route of PMSG administration, age of the dam, or litter size (Table 3.18). Absence of a significant difference in perinatal mortality rate due to the age of the ewes and litter size contradicts the findings of Engeland *et al.* (1997), Alexander *et al.* (1990), Mukassa-Mugerwa and Lahlou-Kassi (1995), Galina *et al.* (1996) and Awemu *et al.* (1999). The mortality rate was significantly ($P < 0.01$) related to the BW of the ewes at breeding. Mortality rate was higher in lambs born from lighter ewes weighing 40 to 50kg (15.8%), compared to ewes weighing above 50kg. The reasons for the higher incidence of perinatal mortality in lambs born from lighter ewes may be due to their lighter birth weight as well as poorer mothering ability of the young dams. These findings are in agreement with reports of Mtenga *et al.* (1994) and Rattner *et al.* (1994). The energy reserves in lambs with a lighter birth weight cannot withstand harsh environmental conditions and, therefore, this results in higher mortality rates (Awemu *et al.*, 1999). On the other hand, older ewes have proven themselves as good mothers in this flock, because ewes that fail to wean a lamb are generally culled.

Alexander *et al.* (1990), Mukasa-Mugerwa and Lahlou-Kassi (1995) and Awemu *et al.* (1999) found the survival rate in multiple kids to be lower than in singletons. These kids, due to their lower birth weight, may be born with lower energy reserves. Lack of a significant difference in mortality rate between single births and multiple births in this study is contrary to other reports. Thus, it can be said that multiple births in Dorper ewes have no significant effect on the survival rate of the lambs within a 24h post lambing period. Furthermore, the sex of the kids was not an important determinant of perinatal mortality in this trial. This is again contrary to the findings of Ebozoje and Ngere (1995), who reported higher mortality rates in female

kids, compared to male kids in West African Dwarf goats. The justification for the absence of a significant difference regarding mortality rates in male and female lambs in this particular experiment may be due to the similarity in birth weights of both sexes, which is an important factor affecting the survival of the lambs.

3. 5. CONCLUSION

In this experiment, acceptable pregnancy, lambing and fecundity rates were obtained with most of synchronization methods tested. Both MAP and FGA sponges were equally effective in inducing oestrus in Dorper ewes maintained under natural veld conditions during the transition period from the natural breeding to the anoestrous season. A longer but non-significant difference time interval from sponge withdrawal to peak serum LH concentration possibly suggests that better fertility rates might have been achieved if AI was repeated at 60h following intravaginal progestagen sponge withdrawal. Administration of 300IU PMSG subcutaneous 24h prior to or at sponge withdrawal was found to improve the reproductive performance of Dorper ewes. Higher perinatal mortality rates and lower litter sizes were recorded in the lighter ewes (40 to 49kg). Increasing fecundity or litter size by improving the body weight of ewes at AI and the use of PMSG is very important in enhancing the reproductive performance of the Dorper ewes under extensive management conditions, as no negative relationship between increased litter size and the survival rate of lambs 24h post lambing was observed.

In this study, estimation of pregnancy rate was crude as it was derived from the lambing records. There would almost certainly have been embryonic losses. The exact time of ovulation could not be estimated from the mere concentration profiles of the hormones, as the inter-sampling period made for serum hormone concentration determinations in this study was long. Thus, identification of pregnancy rates and time of ovulation by use of more improved techniques warrants further research. It would also be of great benefit to know how this breed would have responded in-and-outside the natural breeding season.

CHAPTER 4

EFFECT OF PROGESTAGEN TYPE, PRIMING PERIOD AND PMSG ADMINISTRATION ON THE EFFICIENCY OF OESTROUS SYNCHRONIZATION IN BLACKHEAD OGADEN SHEEP

4.1. INTRODUCTION

The Blackhead Ogaden (BHO) breed of sheep is found mainly in Eastern and South-Eastern lowlands of Ethiopia. This breed of sheep is also indigenous to Somalia and Kenya, where they are known as the Blackhead Somali sheep (Osman, 1985). The BHO sheep are fat-rumped and have a black head and white body (see Plate 5.1). Both sexes are polled and this breed is said to be an ancestor of the Blackhead Persian sheep and are reared primarily for meat production (Mason, 1996).

The BHO breed constitutes the majority of the sheep population in the Ogaden region, in the Eastern lowlands of Ethiopia. This sheep is second in number only to camels in this semi-arid region, and form the greater proportion of the small ruminant population in Ethiopia. Meat from this breed plays a major role in the local economy and as a source of foreign income, as there is big demand in the Middle East and the Arabian countries.

The BHO sheep is kept mainly by pastoralists under the local harsh environmental conditions of Ethiopia, where seasonal under-nourishment and scarcity of water is the order of the day. Apparently, little genetic modifications have been applied to improve the productivity and reproductivity of this sheep breed over the years. Pastoralists in these areas apply their indigenous knowledge to sustain and improve the productivity and reproductivity of the breed. Rams are selected as breeding stock based on their mature body size and body conformation. Attempts have been made by pastoralists to synchronize the lambing season with the availability of water and natural pasture (Girma, 1990). However, the progress in productivity

made by pastoralists using their traditional practices is far below acceptable, and little of their efforts have been supported by scientific facts. Thus, the current productivity and reproductivity levels of the BHO sheep are far below the producers' and the country's needs and also the breed's potential. The average mature live weight of the ewe is 30 to 35 kg (MOA, 1985) and ewes lamb once a year and most of the ewes (96%) give birth to a single lamb (Girma, 1990). The mortality rate of lambs born during the dry season is very high, and a scientific intervention to improve the productivity and reproductive efficiency of this breed is crucial. Taking into consideration the importance of this specific sheep breed and the pastoralists' desire to concentrate births during the rainy season, this study was undertaken to assess the response of this sheep breed to standard controlled breeding techniques practiced in other breeds. Thus, the oestrous synchronization response and fertility to MAP (60mg) and FGA (40mg) progestagen sponges applied for different priming periods, and the effect of PMSG administration at different times relative to sponge withdrawal were evaluated.

4.2. MATERIALS AND METHODS

4.2.1. Study site

The experiment was conducted at Alemaya University's sheep farm unit, which is located 25km from the town of Harar and 42km from Dire-Dawa, Ethiopia. This site is 9°24"N latitude, 41°5"E longitude, and situated at an altitude of 1980m above sea level. The annual total rainfall and the mean maximum and minimum temperature of the area is 870mm, 22.9°C and 7.8°C, respectively (Heluf, 1982).

4.2. 2. Experimental animals and their management

One hundred and twenty BHO sheep were purchased from local sheep producers in the Eastern part of Ethiopia. Visual observation and owners inputs were used to select a uniform group of animals — in terms of age (2-2.5 years) and body weight (15-26 kg). The sheep were transported from the site of purchase to Alemaya University by track. Maximum safety measures were taken during transportation to minimize stress. After arrival, they were kept in

isolation for a period of 4 months. During this period, the ewes were continuously observed for pregnancy so that those ewes that might have conceived prior to purchase could be excluded from the experiment. They were provided throughout the adaptation period with fresh clean water and allowed to graze on natural pastures for approximately 8h per day (8h00 to 12h00 in the morning and 14h00 to 18h00 in the afternoon). All animals were drenched with a broad-spectrum anti-helminthes, dipped with a standard acaricide solution for external parasites and vaccinated against pasteurellosis and anthrax. At the end of an adaptation period, 88 non-pregnant ewes weighing between 15 and 26 kg were selected for this study, and randomly assigned to a treatment group. Feeding management practiced during the adaptation period remained the same throughout the actual experimental period.

4.2.3. Treatment groups

Table 4.1. The different synchronization treatment groups to which the BHO ewes were allocated

Treatment group number	Progestagen sponge type	Duration of sponge priming (days)	300IU PMSG injection relative to sponge withdrawal	Number of animals/group
1	MAP (60mg)	9	24hrs before	5
2			At sponge withdrawal	5
3			Control (no PMSG)	5
4		12	24hrs before	5
5			At sponge withdrawal	5
6			Control (no PMSG)	5
7		15	24hrs before	5
8			At sponge withdrawal	5
9			Control (no PMSG)	4
10	FGA (40mg)	9	24hrs before	5
11			At sponge withdrawal	5
12			Control (no PMSG)	4
13		12	24hrs before	5
14			At sponge withdrawal	5
15			Control (no PMSG)	5
16		15	24hrs before	5
17			At sponge withdrawal	5
18			Control (no PMSG)	5



Plate 4.1. Blackhead Ogaden sheep on which the experiment was conducted

4.2.4. Intravaginal Progestagen Treatment

The sponge treatment of the ewes was done between May and June (beginning of the main rainy season). All 88 ewes were allocated to their respective treatment groups as set out in Table 4.1. Intravaginal sponges were inserted into the vagina using applicators (Plate 4.2). The applicators were rinsed in clean warm water after each insertion. An antiseptic cream was spread on the applicator to serve as a lubricant and to prevent infection of the reproductive tract.



Plate 4.2. Insertion of intravaginal sponges in Blackhead Ogaden sheep

To achieve the simultaneous removal of sponges in all treatment groups, sponge insertion was staggered at 3-day intervals. Thus, ewes to be sponged for a duration of 15 days were treated 3 days earlier than those primed for 12 days, and the same was done for ewes primed for 12

days and 9 days. Close observation of the ewes (twice daily) was done during the priming period to ensure that if animals lost their sponges, these could be replaced immediately.

4.2.5. PMSG treatment

At the end of the intravaginal progestagen sponge treatment period, animals were randomly allotted to 3 groups of 30, 30 and 28 animals, respectively. The first and the second groups were treated with 300IU PMSG at sponge withdrawal (0h) and 24h prior to sponge withdrawal, respectively. The third group of ewes was kept as a control and received no PMSG treatment. The experimental groups were balanced in terms of body weight (BW), and body condition score (BCS) and treatments were randomly allocated to the groups.

4.2.6. Oestrous observations

Behavioural manifestation of overt oestrus was recorded for a period of 30-minutes, 3 times a day at 8-hourly intervals following intravaginal sponge withdrawal for a period of 96h. Intact rams fitted with aprons were used for detecting ewes in oestrus. Between 13 and 28 days after AI, all ewes were monitored twice daily for a period of 30 minutes using the same procedure. All ewes returning to oestrus were naturally mated.

4.2.7. Blood sampling

Blood samples were collected from 6 animals per progestagen treatment group. This sampling was performed by a jugular veni-puncture into 10ml plain vacutainer tubes (no anticoagulant). Collection was initially done at sponge insertion and thereafter at 5-days intervals during the progestagen treatment period and at 8h intervals starting at sponge withdrawal for a period of 96h. After being allowed to clot (30-60 minutes), the blood samples were centrifuged at 1500 rpm for 15 minutes to recover the serum for hormonal assays. The serum samples were stored at -20°C until assayed for serum progesterone and LH concentrations. Blood samples collected from sponge insertion until its withdrawal were used for serum progesterone concentration determinations only, whereas those blood samples collected for a period of 96h

starting from the time of sponge withdrawal were used for both progesterone and LH concentration determinations.

4.2.8. Serum progesterone assay

Serum progesterone concentrations were assayed using the DRG progesterone direct solid phase enzyme immunoassay (ELISA KIT) (Cat #: EIA-1561, DRG Instruments GmbH *DRG International, Inc. Germany USA*). The test is based on a competition principle and the microplate separation method. An unknown amount of progesterone present in the sample and a fixed amount of progesterone, conjugated with horse-radish peroxidase, compete for the binding sites of the polyclonal progesterone antiserum, coated to the wells. After an incubation period of an hour, the micro-titerplate was washed to stop the competition reaction. Having added the substrate solution, the concentration of progesterone is inversely proportional to the optical density measured. A microwell reader capable of determining the absorbance at $450 \pm 10 \text{ nm}$ was used to quantify the results, and the progesterone value of each sample was obtained by using linear-linear or semi log graph paper. A standard curve was constructed by plotting the average absorbance (Y) of each reference standard against its corresponding concentration (X) in ng/ml. The lowest detectable level of serum progesterone that could be detected from the Zero Standard was 0.05 ng/ml, at the 95 % confidence level. The inter- and intra-assay coefficients of variation for serum progesterone were 15.1% and 8.2%, respectively.

4.2.9. Serum LH assay

The serum LH concentration assay was done using a solid phase enzyme linked immunosorbent technique. The assay system utilizes one anti-LH antibody for the solid phase (microtiter wells) immobilization, and another mouse monoclonal anti-LH anti-body in the anti-body-enzyme (horseradish peroxidase) conjugate solution. The test sample is allowed to react simultaneously with the antibodies, resulting in the LH molecules being sandwiched between the solid phase and enzyme-linked anti-bodies. A solution of TMB (Tetramethylbenzidine) was added and incubated for 20 minutes, resulting in development of

a blue colour. The colour development was stopped with the addition of 2N HCL, and the colour changed to yellow and was measured spectrophotometrically at 450nm. The concentration of LH is directly proportional to the color intensity of the test sample. The LH concentration was determined by calculating the mean absorbance value (A_{450}) for each set of reference standards. A standard curve was constructed by plotting the mean absorbance value on the Y-axis and concentration on the X-axis. The mean absorbance values were used for each sample to determine the corresponding concentration of LH in ng/ml from the standard curve. The minimal detectable concentration of serum luteinizing hormone by this assay was estimated to be 0.08ng/ml (Diagnostic Automation, Inc, 23961 CraftsmanRd. Suite E/F, Calabasas. California 91302, USA). The inter-and intra-assay coefficients of variation for serum LH were 14.3% and 8.5%, respectively.

4.2.10. AI procedures

Semen was collected from 5 healthy rams with the aid of the artificial vagina. Three weeks of training was allowed for the rams to adapt to mounting and ejaculating into the artificial vagina. Following each semen collection and prior to its use for artificial insemination, the viability of the sperm was microscopically evaluated according to standard procedures (Watson, 1990). Fresh semen from acceptable ejaculates was diluted at the rate of 1:2 with sterile skimmed cow milk. Each ewe was inseminated with 0.1ml diluted semen (150×10^6 sperm/insemination) at 54h following sponge withdrawal, using an insemination pipette and an intravaginal speculum.

4.2.11. Body weight (BW) and body condition Score (BCS) measurements

The BW measurements were taken at the onset of the trial (sponging), prior to AI and fortnightly thereafter until lambing with the aid of an oil scale. The BCS (1-5) was also scored prior to AI according to the method described by (Russel, 1991).

4.2.12. Lambing performance

Ewes, which were expected to lamb were kept in separate enclosures just prior to lambing. The lamb birth weight, sex of the lamb, litter size and perinatal mortalities were recorded within 24h of birth.

4.2.13. Statistical analysis

General linear model (GLM) procedures of SAS (1999) were used to perform an analysis of variance to test the combined and isolated effect of synchronization treatment, progestagen type, duration of progestagen priming, time of PMSG administration, BW, BCS and age of ewes on the time to oestrus, duration of the induced oestrus, litter size, lambing weight, gestation length and serum progesterone and LH concentrations as continuous variables.

The categorical modeling (CATMOD) procedures of SAS were used to test the effect of progestagen type, duration of progestagen treatment, time of PMSG administration, BW, BCS and age of ewes on pregnancy rate, oestrous response and peri-natal lamb mortalities as these are discrete. The treatment means were compared by Duncan's multiple range test (DMRT) as described in Gomez and Gomez (1984).

4.3. RESULTS

4.3.1. Oestrous response

The effects of intravaginal progestagen sponge type, time of PMSG administration relative to intravaginal progestagen sponge withdrawal and the duration of intravaginal progestagen treatment on the oestrous response of the BHO ewes are set out in Table 4.2. The overall oestrous response following oestrous synchronization was 91.7% (77/84).

The type of intravaginal progestagen sponge used did not have any significant effect on the oestrous response of the ewes. The proportion of ewes exhibiting oestrus was slightly higher

in the FGA treated compared to in the MAP treated ewes. Unlike the type of progestagen sponges, the time of PMSG administration relative to sponge withdrawal had a significant ($P < 0.01$) effect on the oestrous response of the ewes. The percentage of ewes coming into oestrus was significantly higher ($P < 0.01$) in PMSG treated (MAP and FGA) groups (100.0%), compared to the control groups (75.0%). Similarly, the oestrous response induced was significantly ($P < 0.01$) affected by the duration of progestagen treatment. The proportion of ewes that exhibited oestrus was significantly lower in the 9-day primed group (86.2%), compared to the 12 or 15-day primed groups (93.1% and 96.2%, respectively). Oestrous response was not significantly related to either BW or BCS of the ewes at AI.

The effects of the various oestrous synchronization treatments on oestrous response are set out in Table 4.3. The oestrous responses ranged from 25.0% to 100.0%. The lowest oestrous response was recorded in synchronization treatment 12 (FGA for 9 days with no PMSG) (25.0%). Treatments 6 (MAP for 12 days with no PMSG), 9 (MAP for 15 days with no PMSG), and 3 (MAP for 9 days with no PMSG) groups had a significantly ($P < 0.01$) higher oestrous response (60.0, 75.0 and 80.0%, respectively) than treatment 12 (FGA sponges for 9 days with no PMSG), similar to treatment group 3 (MAP for 9 days with no PMSG) and 9 (MAP for 15 days with no PMSG), but lower than all the others. With the exception of treatment 3, 6, 9 and 12, the oestrous response in all other groups was 100.0%.

Table 4.2. Effect of sponge type, BW and BCS, time of PMSG administration, duration of intravaginal progestagen sponge treatment on the oestrous response of ewes following oestrous synchronization treatment

Factor	n	Oestrous response (%)
Sponge type		ns
MAP	41	90.2
FGA	43	93.0
Time of PMSG administration		**
-24h	29	100.0 ^a
0h	27	100.0 ^a
Control	28	75.0 ^b
Duration of sponge treatment (days)		**
9	29	86.2 ^b
12	29	93.1 ^a
15	26	96.2 ^a
BW (kg)		ns
15-20	52	90.4
21-26	32	93.8
BCS		ns
2.0-2.5	14	92.9
2.6-3.0	35	91.4
3.1-3.5	23	95.7
>3.5	12	83.3
Overall	84	91.7

^{a, b} Values in a column for the same parameter with different superscripts differ significantly (P<0.01)

** Significant (P<0.01)

n number of ewes

Table 4.3. The effect of synchronization treatment on oestrous response (%) in BHO ewes

Synchronization treatment	n	Oestrous response (%)
1. MAP for 9 days + 300IU PMSG 24h before sponge withdrawal	5	100.0 ^a
2. MAP for 9 days + 300IU PMSG at sponge withdrawal	5	100.0 ^a
3. MAP for 9 days with no PMSG	5	80.0 ^{ab}
4. MAP for 12 days + 300IU PMSG 24h before sponge withdrawal	5	100.0 ^a
5. MAP for 12 days + 300IU PMSG at sponge withdrawal	4	100.0 ^a
6. MAP for 12 days with no PMSG	5	60.0 ^b
7. MAP for 15 days + 300IU PMSG 24h before sponge withdrawal	4	100.0 ^a
8. MAP for 15 days + 300IU PMSG at sponge withdrawal	4	100.0 ^a
9. MAP for 15 days with no PMSG	4	75.0 ^{ab}
10. FGA for 9 days +300IU PMSG 24h before sponge withdrawal	5	100.0 ^a
11. FGA for 9 days +300IU PMSG at sponge withdrawal	5	100.0 ^a
12. FGA for 9 days with no PMSG	4	25.0 ^c
13. FGA for 12 days +300IU PMSG 24h before sponge withdrawal	5	100.0 ^a
14. FGA for 12 days +300IU PMSG at sponge withdrawal;	5	100.0 ^a
15. FGA for 12 days with no PMSG	5	100.0 ^a
16. FGA for 15 days +300IU PMSG 24h before sponge withdrawal;	5	100.0 ^a
17. FGA for 15 days +300IU PMSG at sponge withdrawal	4	100.0 ^a
18. FGA for 15 days with no PMSG	5	100.0 ^a
Overall mean	84	91.7

^{a, b, c} Values in a column with different superscripts differ significantly ($P < 0.01$)

n number of ewes

4.3.2. The time from sponge withdrawal to oestrus and the duration of the induced oestrous period

The overall mean time from intravaginal progestagen sponge withdrawal to onset of oestrus and the mean duration of the induced oestrous period in synchronized Blackhead Ogaden ewes were 38.7 ± 3.9 and 45.1 ± 4.3 h, respectively. The administration of PMSG had a

significant ($P < 0.01$) effect on the interval from sponge withdrawal to oestrus (Table 4.4). This interval was significantly longer (48.8 ± 2.9 h) in the control group, compared to ewes treated with PMSG 24h prior to sponge withdrawal (32.1 ± 2.4 h) or at sponge withdrawal (38.2 ± 2.5 h).

Table 4. 4. Least square means (\pm SE) for time to oestrus and the duration of oestrus following oestrous synchronization in BHO ewes

Factor	n	Time to onset of oestrus (h)	Duration of Oestrus (h)
Sponge type		ns	ns
MAP	37	40.0 ± 2.2	46.1 ± 2.4
FGA	40	39.4 ± 2.1	43.9 ± 2.3
Time of PMSG administration		**	ns
-24h	21	$32.1^b \pm 2.4$	45.6 ± 2.7
0h	27	$38.2^b \pm 2.5$	46.6 ± 2.8
Control	29	$48.8^a \pm 2.9$	42.8 ± 3.2
Duration of sponge treatment (days)		ns	ns
9	25	42.8 ± 2.7	45.2 ± 3.0
12	27	35.3 ± 2.5	43.0 ± 2.8
15	25	41.0 ± 2.6	46.8 ± 2.9
BW (kg)		ns	ns
15-20	47	41.4 ± 2.6	45.2 ± 2.9
21-26	30	39.9 ± 2.7	43.5 ± 2.9
BCS		ns	ns
2.0-2.5	13	38.8 ± 4.3	46.3 ± 4.7
2.6-3.0	32	38.7 ± 2.7	44.3 ± 3.0
3.1-3.5	22	35.7 ± 3.4	50.5 ± 3.7
>3.5	10	49.3 ± 5.3	36.2 ± 5.9
Overall mean	77	38.7 ± 3.9	45.1 ± 4.3

^{a, b} Means in a column for the same parameter with different superscripts differ significantly ($P < 0.01$)

** Significant ($P < 0.01$)

n number of ewes exhibiting oestrus

ns not significant

The duration of the induced oestrous period was not significantly affected by the type of progestagen sponge, the duration of its priming, time of PMSG administration, BW or BCS of the ewe at AI. There were also no significant differences in the time from sponge removal to the onset of oestrus and the duration of the induced oestrous period between ewes treated with different oestrous synchronization protocols. Nonetheless, the time from intravaginal progestagen withdrawal to the onset of oestrus was relatively longer for treatment groups 3 (MAP for 9 days with no PMSG), 9 (MAP for 15 days with no PMSG), 12 (FGA for 9 days

with no PMSG) and 18 (FGA for 15 days with no PMSG), compared to the other treatment groups. Regarding the duration of the induced oestrus, in most of the cases it tended to be shorter when the time to onset of oestrus was longer and vice versa (Table 4.5).

Table 4.5. Least square means (\pm SE) for the time to onset of oestrus and the duration of the induced oestrus (h) following oestrous synchronization in BHO ewes

Synchronization treatment	n	Onset of oestrus ^{ns}	Duration of oestrus ^{ns}
1. MAP for 9 days + 300IU PMSG 24h before sponge withdrawal	5	37.0 \pm 6.2	46.2 \pm 6.7
2. MAP for 9 days + 300IU PMSG at sponge withdrawal	5	44.9 \pm 6.4	45.5 \pm 7.0
3. MAP for 9 days with no PMSG	4	53.7 \pm 7.0	38.1 \pm 7.7
4. MAP for 12 days + 300IU PMSG 24h before sponge withdrawal	5	35.0 \pm 6.3	38.6 \pm 6.9
5. MAP for 12 days + 300IU PMSG at sponge withdrawal	4	35.4 \pm 7.1	42.9 \pm 7.8
6. MAP for 12 days with no PMSG	3	40.0 \pm 8.1	56.3 \pm 8.9
7. MAP for 15 days + 300IU PMSG 24h before sponge withdrawal	4	32.2 \pm 7.2	53.2 \pm 7.8
8. MAP for 15 days + 300IU PMSG at sponge withdrawal	4	41.8 \pm 7.2	42.5 \pm 7.9
9. MAP for 15 days with no PMSG	3	50.5 \pm 8.6	39.5 \pm 9.4
10. FGA for 9 days +300IU PMSG 24h before sponge withdrawal	5	29.0 \pm 6.5	50.7 \pm 7.1
11. FGA for 9 days +300IU PMSG at sponge withdrawal	5	47.8 \pm 6.3	41.8
12. FGA for 9 days with no PMSG	1	50.7	48.9 \pm 16.0
13. FGA for 12 days +300IU PMSG 24h before sponge withdrawal	5	28.4 \pm 6.3	37.9 \pm 6.9
14. FGA for 12 days +300IU PMSG at sponge withdrawal;	5	34.4 \pm 6.2	43.4 \pm 6.8
15. FGA for 12 days with no PMSG	5	42.9 \pm 6.3	38.7 \pm 6.9
16. FGA for 15 days +300IU PMSG 24h before sponge withdrawal;	5	34.3 \pm 6.3	45.8 \pm 6.9
17. FGA for 15 days +300IU PMSG at sponge withdrawal	4	38.3 \pm 7.0	47.6 \pm 7.7
18. FGA for 15 days with no PMSG	5	54.7 \pm 6.3	40.6 \pm 6.9
Overall mean	77	38.7 \pm 3.9	45.1 \pm 4.3

n number of ewes exhibiting oestrus

ns not significant

4.3.3. Serum progesterone concentration

The serum progesterone concentration pattern during the intravaginal progestagen sponge treatment and during the 96h post sponge withdrawal period for MAP and FGA treated ewes are depicted in Figure 4.1. No significant differences in the pattern of the serum progesterone concentrations were recorded. In both cases (MAP and FGA), the serum progesterone level increased from the time of sponge insertion to the 8th day of priming, when it reached a peak. The hormone levels declined progressively until a minimum level (0.825ng/ml) at 56h following intravaginal progestagen sponge withdrawal. Thereafter, the serum progesterone levels started to rise slightly until the end of the 96h observation period.

The only noticeable differences in the mean serum progesterone concentration between MAP (60mg) and FGA (40mg) treated ewes was in the magnitude of the serum progesterone levels at day 8 after sponge insertion — being higher in the MAP (3.4ng/ml) compared to the FGA (2.42ng/ml) treated ewes. There was also an increase in the mean serum progesterone level 8h following sponge withdrawal in the MAP treated ewes.

A comparison of the serum progesterone concentrations during the 96h post intravaginal progestagen sponge withdrawal period was also made between ewes treated with progestagen for 9, 12 or 15 days (Figure 4.2). The serum progesterone concentrations were maintained at a higher level in the 9-day primed ewes (throughout the 96h post sponge withdrawal period), followed by the 12 day treated ewes. The mean serum progesterone concentration in the 15-day sponge treated group was maintained at a very low level except at 8h post sponge withdrawal when it showed a peak. In all treatments, the lowest serum progesterone concentration was recorded 56h post intravaginal progestagen sponge withdrawal.

The effect of the progestagen type, duration of sponge treatment and time of PMSG administration relative to intravaginal progestagen withdrawal on the mean serum progesterone concentration during the 96h post sponge withdrawal period is set out in Table 4.6. No significant differences in serum progesterone concentration were observed due to sponge type or time of PMSG administration. However, a significantly ($P < 0.05$) lower progesterone concentration was recorded 56h following sponge withdrawal in ewes primed for 15 days (0.26 ± 0.27 ng/ml), compared to those primed for 9 or 12 days (1.43 ± 0.30 and 0.97 ± 0.25 , respectively).

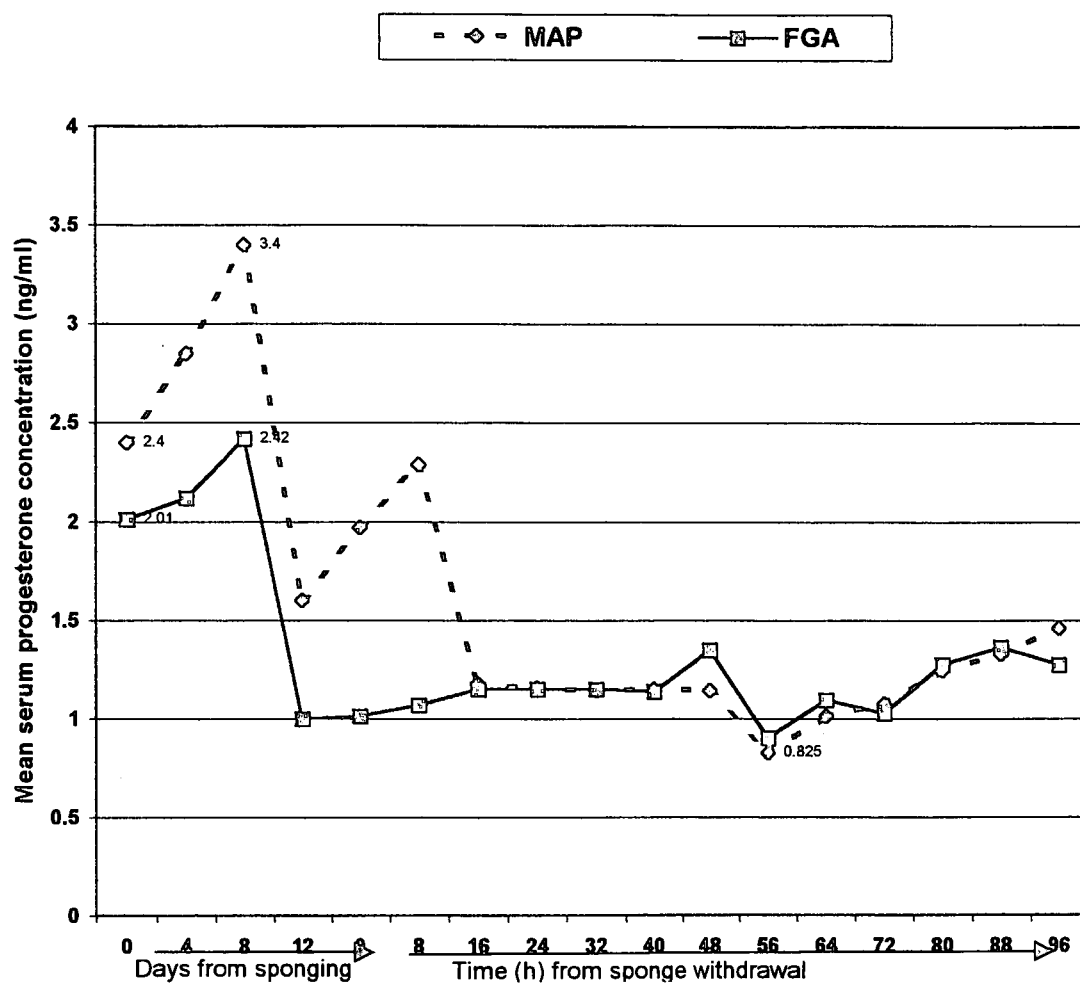


Figure 4.1. Effect of intravaginal progestagen sponge type on the mean serum progesterone concentration in Blackhead Ogaden ewes

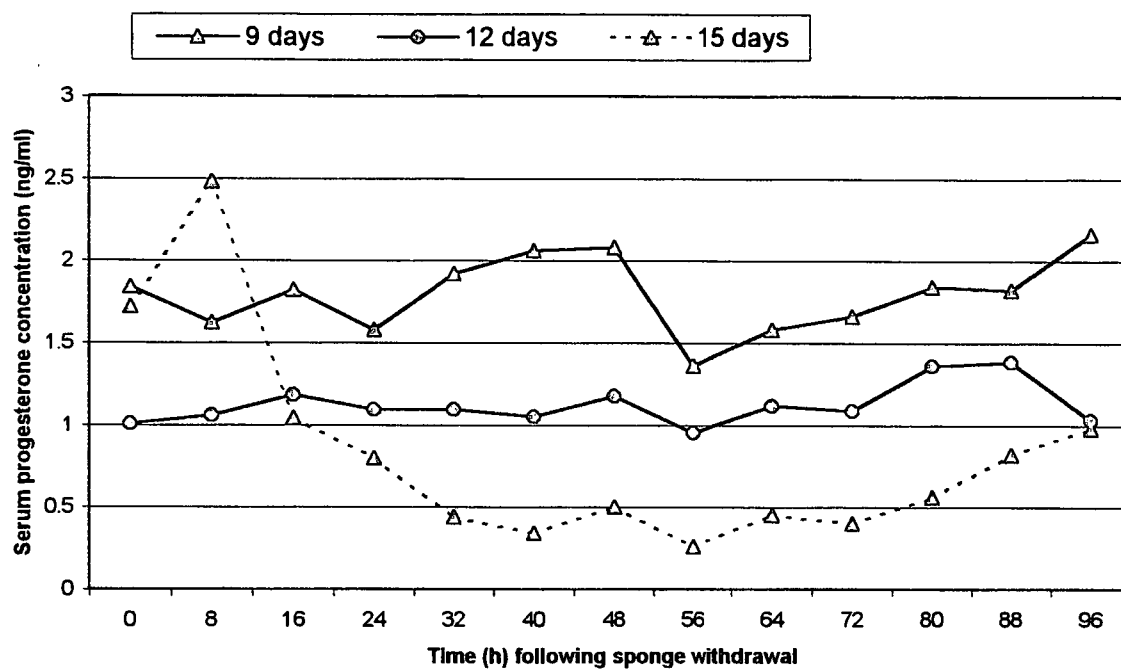


Figure 4.2. Effect of duration of intravaginal progestagen treatment on the post withdrawal mean serum progesterone concentration in Blackhead Ogaden ewes

Table 4. 6. Effect of the type and duration of intravaginal progestagen treatment and time of PMSG administration on the mean serum progesterone concentration in BHO ewes

Time (h) from sponge withdrawal	Mean progesterone (P ₄) concentration (ng/ml)							
	Sponge type		Duration of treatment (days)			Time of PMSG administration (h) in relation to sponge withdrawal		
	ns		*			ns		
	MAP	FGA	9	12	15	-24	0	+24
0	1.93±0.80	1.08±0.65	1.76 ^a ±0.91	0.96 ^a ±0.76	1.79 ^a ±0.82	1.72±0.70	1.45±1.36	1.35±0.67
8	2.03±1.27	1.13±1.03	1.41 ^a ±1.44	0.85 ^a ±1.20	2.48 ^a ±1.30	2.37±1.11	1.12±2.15	1.25±1.06
16	0.72±0.41	1.56±0.33	1.64 ^a ±0.47	0.96 ^a ±0.39	0.82 ^a ±0.42	1.81±0.36	0.48±0.69	1.14±0.34
24	0.93±0.34	1.20±0.27	1.49 ^a ±0.38	0.99 ^a ±0.32	0.71 ^a ±0.35	1.36±0.29	0.77±0.57	1.06±0.28
32	0.97±0.49	1.27±0.40	2.06 ^a ±0.56	1.01 ^a ±0.46	0.29 ^a ±0.50	1.26±0.43	1.02±0.83	1.07±0.41
40	0.97±0.49	1.27±0.40	2.06 ^a ±0.56	1.01 ^a ±0.46	0.29 ^a ±0.50	1.26±0.43	1.02±0.83	1.07±0.41
48	0.96±0.55	1.41±0.45	2.01 ^a ±0.62	1.14 ^a ±0.52	0.42 ^a ±0.56	1.23±0.48	0.99±0.93	1.35±0.46
56	0.78±0.26	0.99±0.21	1.43 ^a ± 0.30	0.97 ^a ± 0.25	0.26 ^b ± 0.27	0.88±0.23	0.97±0.45	0.81±0.22
64	0.98±0.35	1.21±0.28	1.69 ^a ±0.39	1.14 ^a ±0.33	0.46 ^a ±0.35	1.11±0.30	1.24±0.59	0.94±0.29
72	1.11±0.12	0.78±0.12	1.19 ^a ±0.15	1.10 ^a ±0.16	0.50 ^a ±0.18	0.80± 0.12	0.77±0.14	1.26±0.13
80	1.11±0.40	1.41±0.32	1.92 ^a ±0.45	1.33 ^a ±0.38	0.53 ^a ±0.41	1.46± 0.35	1.28±0.67	1.04±0.33
88	1.15±0.41	1.47±0.33	1.84 ^a ±0.47	1.32 ^a ±0.39	0.77 ^a ±0.42	1.58±0.36	1.21±0.69	1.14±0.34
96	1.18±0.36	1.41±0.29	2.09 ^a ±0.41	0.90 ^a ±0.34	0.89 ^a ±0.37	1.74±0.32	0.98±0.61	1.16±0.30

^{a, b} Means in a row and under the same parameter with different superscripts differ significantly (P<0.05)

* Significant (P<0.05)

ns not significant

A comparison in the serum progesterone concentration during the trial period was also made between ewes that eventually conceived from AI and those, which failed to conceive (Figure 4.3). No definite difference or pattern in serum progesterone concentration between the two groups could be observed, except that the peak at day 8 of priming was higher in those ewes that failed to become pregnant. Furthermore, the mean serum progesterone concentration during the first 8h post sponge withdrawal was also higher in ewes that failed to become pregnant.

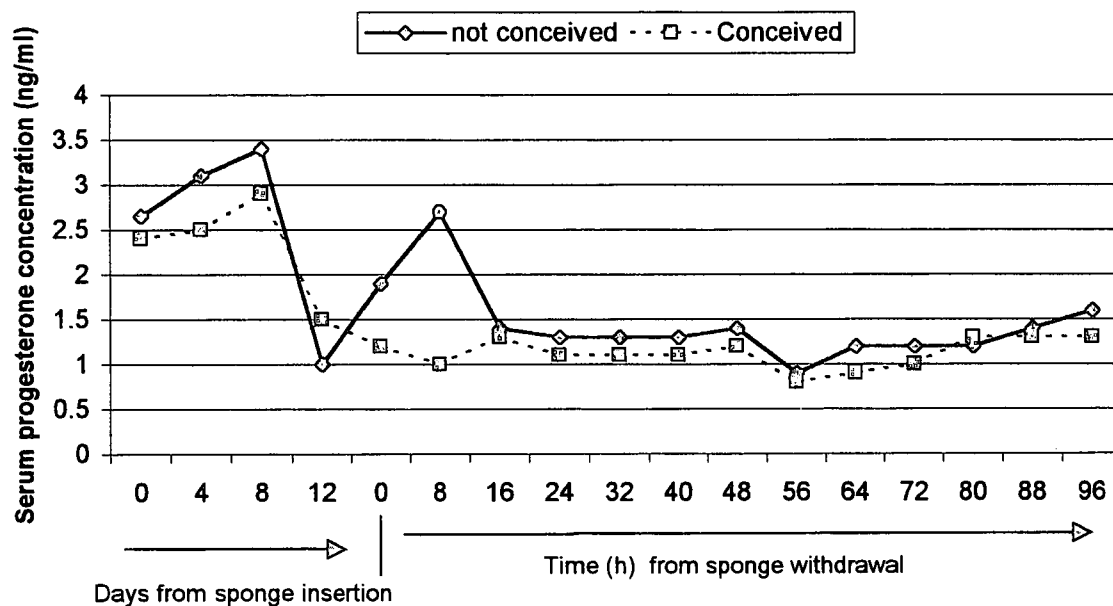


Figure 4.3. The mean serum progesterone concentrations of ewes conceiving and not conceiving following oestrous synchronization and AI

4.3. 4. Serum LH concentration in Blackhead Ogaden ewes

The percentage of ewes exhibiting a pre-ovulatory LH peak, the interval from progestagen withdrawal and time from the onset of oestrus to the LH peak and from the LH peak to the end of oestrus are depicted in Table 4.7. Seven out of 16 (43.8%) ewes exhibited a pre-ovulatory LH peak in this trial. The percentage of ewes demonstrating a LH peak was higher in the MAP (62.5%) treated, compared to FGA (25%) treated ewes. There were no differences in the interval from progestagen withdrawal to LH peak; from onset of oestrus to LH peak and time from the LH peak to the end of induced oestrus between MAP and FGA-treated ewes. The amplitude of the LH peak was higher in the FGA-treated, compared to the MAP-treated group of ewes (Figure 4.4).

Similarly, the duration of the progestagen treatment did not affect the percentage of ewes exhibiting a LH peak; the interval from progestagen withdrawal to the LH peak; time from the onset of oestrus to LH peak and time from LH peak to the end of the induced oestrus. The amplitude of the LH peak was higher in the 12-day, compared to the 9 or 15-day progestagen treated ewes (Figure 4.5)

The time of PMSG administration in relation to progestagen withdrawal did not have any significant influence on the proportion of ewes exhibiting a LH peak; the interval from progestagen withdrawal to LH peak; time of onset of oestrus to LH peak and the time from LH peak to the end of the induced oestrus. The LH peak occurred a bit earlier in PMSG administered ewes, compared to in the control ewes. The amplitude of the LH peak was also higher in ewes administered PMSG 24h prior to progestagen withdrawal, compared to those administered PMSG at sponge withdrawal or those not treated with PMSG (Figure 4.6).

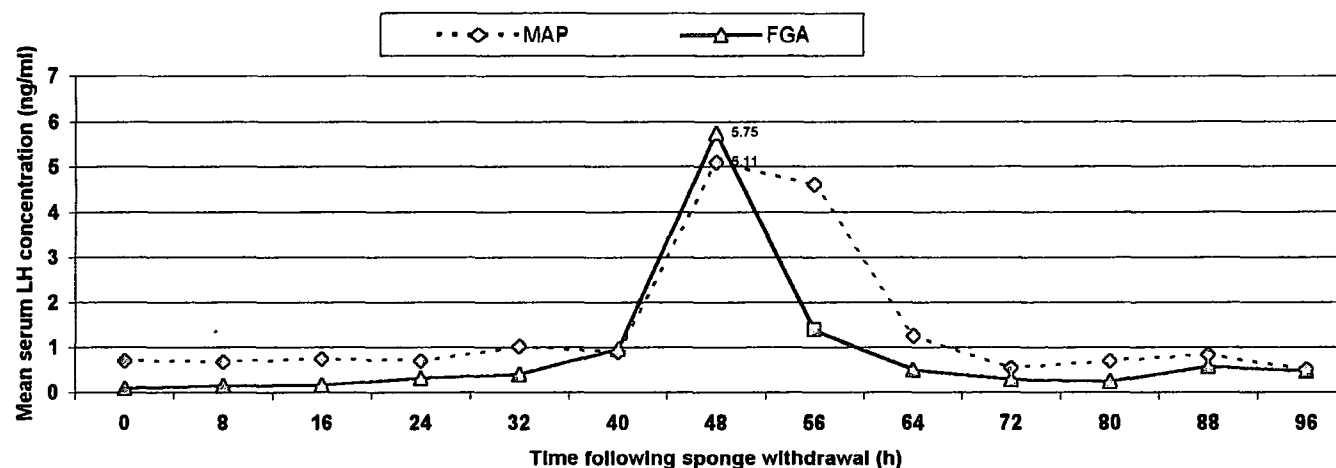


Figure 4.4. Effect of sponge type on post withdrawal serum LH concentration in BHO ewes

Table 4.7. Effect of progestagen type, duration of progestagen sponge treatment and time of PMSG administration on the proportion of ewes showing a LH peak, the position of LH peak and mean serum LH concentration

Response	Parameter							
	Sponge Type		Duration of treatment (days)			Time of PMSG administration		
	MAP	FGA	9	12	15	-24h	0h	Control
Number (and%) of ewes exhibiting LH peak	5/8 (62.5%)	2/8 (25%)	2/5 (40%)	3/6 (50%)	2/5 (40%)	3/7 (43%)	1/2 (50%)	3/7 (43%)
Time from progestagen withdrawal to LH Peak (h)	52.8±2.0	48.0±0.0	52.0±4.0	50.7±2.7	52.0±4.0	48.0	48.0	56.0
Interval from onset of oestrus to LH Peak (h)	16.0±2.5	16.0±8.0	12.0±4.0	16.0±4.6	20.0±4.0	18.7±5.3	8.0	16.0
Time from LH peak to end of oestrus (h)	30.4±3.9	24.0±0.0	32.0	29.3±5.3	24.0±0.0	24.0	24.0	34.7±5.3
Mean serum LH concentration (ng/ml)	1.1±0.1	0.9±0.1	1.0±0.1	1.1±0.1	0.8±0.1	1.1±0.2	0.8±0.3	1.1±0.2

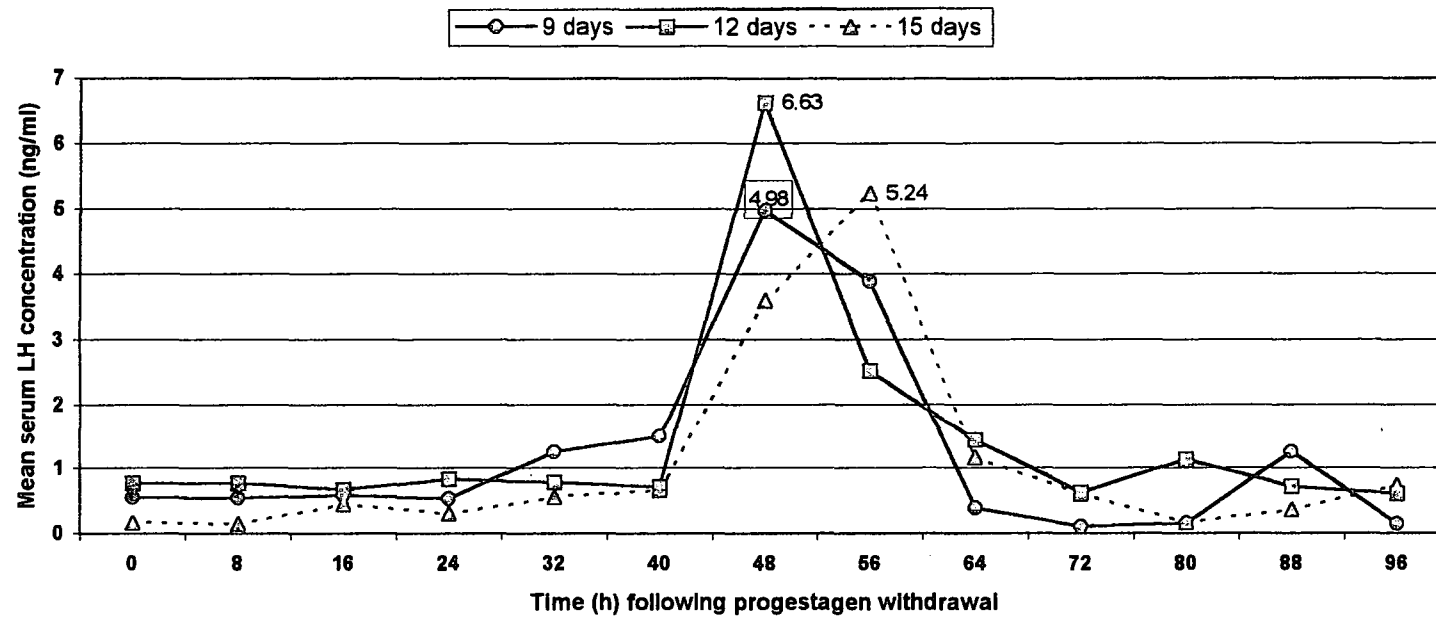


Figure 4.5. Effect of duration of progestagen treatment on post withdrawal serum LH concentration in Blackhead Ogaden ewes

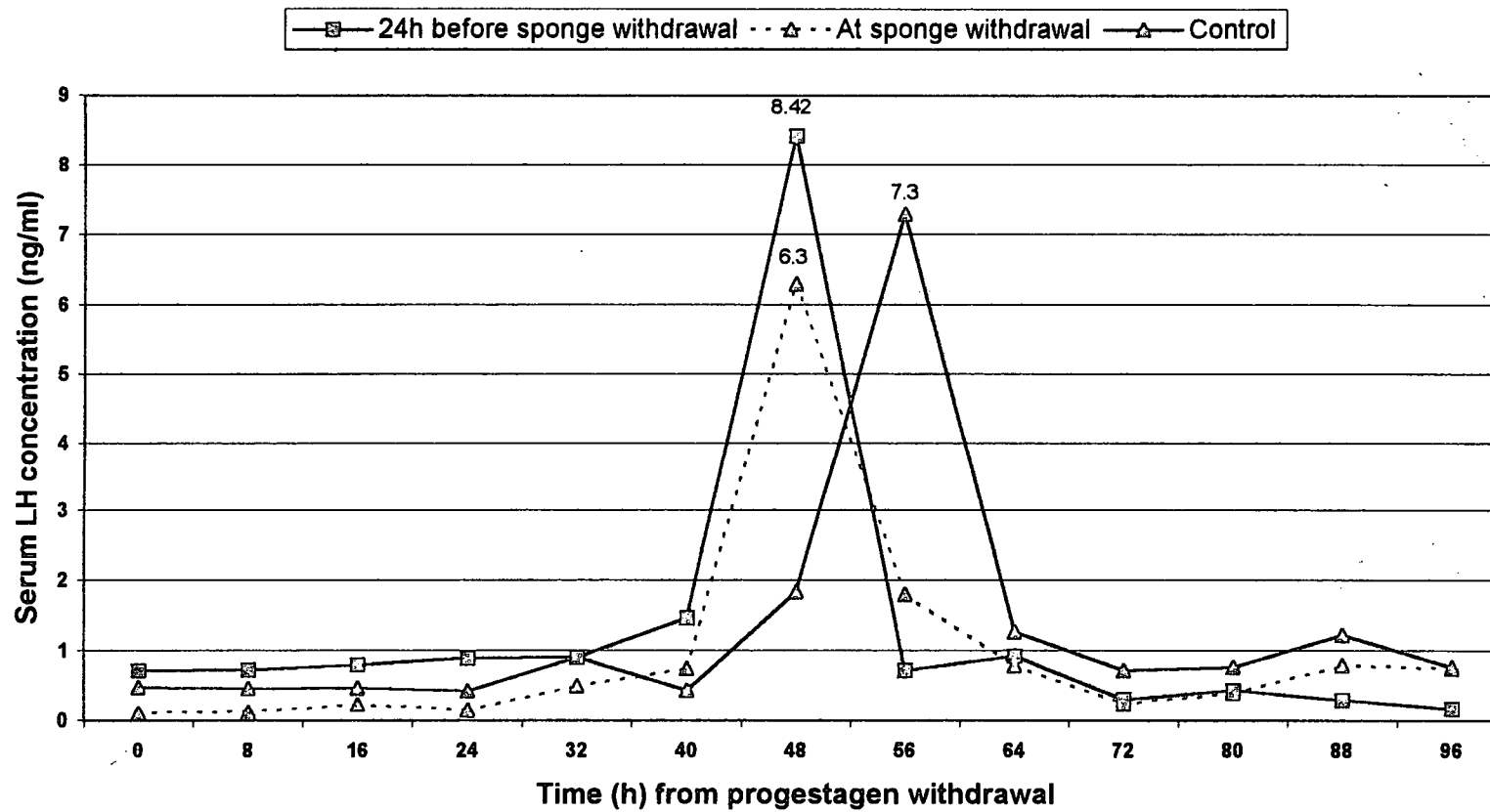


Figure 4.6. Effect of time of PMSG administration relative to progestagen sponge withdrawal on serum LH concentration in BHO ewes

4.3.5. Reproductive performance following synchronization and AI

The overall pregnancy rate and the non-return rate recorded in the BHO ewes following oestrous synchronization and artificial insemination with fresh diluted semen was 63.1% and 73.8%, respectively (Table 4.8). Neither the type of intravaginal progestagen sponge used nor the duration of the sponge treatment significantly affected the pregnancy rates obtained. However, the time of PMSG administration relative to sponge withdrawal and the BCS of the ewes at the time of AI significantly ($P < 0.01$) influenced the pregnancy rate. For instance, the pregnancy rate recorded was significantly lower in the control ewes (46.4%). Furthermore, PMSG administration at the time of sponge withdrawal resulted in a significantly higher pregnancy rate (74.1%), compared to the administration of PMSG 24h prior to sponge withdrawal (69.0%). Similarly, the non-return rate recorded was significantly ($P < 0.05$) lower in the control group (57.1%), compared to ewes administered PMSG 24h before sponge withdrawal (82.8%) or at sponge withdrawal (81.5%). There was, however, no significant difference in the non-return rates between ewes administered PMSG at sponge withdrawal and 24h prior to sponge withdrawal.

The BCS at the time of AI significantly ($P < 0.01$) affected the pregnancy rates. Ewes with a BCS of 3.1 to 3.5 recorded significantly ($P < 0.01$) higher pregnancy and non-return rates (82.6% vs. 87.0%, respectively), compared to those with a BCS of > 3.5 (41.7% vs. 50.0%, respectively). No significant difference in pregnancy rates between ewes with BCS of 2.0 to 2.5 and 2.6 to 3.0 were observed. There was no significant effect in pregnancy rates recorded due to the BW of the ewes at AI.

The overall lambing rate (lambs born/ewes inseminated) and fecundity rates (lambs born/ewes lambing) in this study were 64.3% (54/84) and 101.9% (54/53), respectively. Only one out of 53 ewes lambing gave birth to twin lambs. There were no significant differences in both the lambing and the fecundity rates obtained between ewes primed with MAP or FGA sponges. In almost all treatments, the pregnancy and lambing rates were similar. The non-return rates obtained were higher than pregnancy rates (63.1% vs. 73.8%).

Table 4.8. Reproductive performance of BHO ewes following oestrous synchronization and AI

Factor	n	Pregnancy rate (%)	Non-return rate (%)	Lambing rate (%)	Fecundity rate (%)
Sponge type		ns	ns	ns	ns
MAP	41	63.4	78.0	63.4(26/41)	100.0(26/26)
FGA	43	62.8	69.8	65.1(28/43)	104.0(28/27)
Time of PMSG administration		*	*	*	ns
-24h	29	69.0 ^{ab}	82.8 ^a	72.4(21/29) ^a	105.0(21/20)
0h	27	74.1 ^a	81.5 ^a	74.1(20/27) ^a	100.0(20/20)
Control	28	46.4 ^b	57.1 ^b	46.4(13/28) ^b	100.0(13/13)
Duration of sponge treatment (days)		ns	ns	ns	ns
9	29	62.1	72.4	62.1(18/29)	100.0(18/18)
12	29	58.6	75.9	58.6(17/29)	100.0(17/17)
15	26	69.2	73.1	73.1(19/26)	105.6(19/18)
BW (kg)		ns	ns	ns	ns
15-20	52	61.5	69.2	61.5(32/52)	100.0(32/32)
21-26	32	65.6	81.3	68.8(22/32)	104.8(22/21)
BCS		**	*	**	ns
2.0-2.5	14	57.1 ^{cd}	78.6 ^{ab}	57.1(8/14) ^{cd}	100.0(8/8)
2.6-3.0	35	60.0 ^{cd}	71.4 ^{ab}	60.0(21/35) ^{cd}	100.0(21/21)
3.1-3.5	23	82.6 ^c	87.0 ^a	87.0(20/23) ^c	105.3(20/19)
>3.5	12	41.7 ^d	50.0 ^b	41.7(5/12) ^d	100.0(5/5)
Overall mean	84	63.1	73.8	64.3(54/84)	101.9(54/53)

^{a, b} Means in a column for the same parameter with different superscripts differ significantly (P<0.05)

^{c, d} Means in a column for the same parameter with different superscripts differ significantly (P<0.01)

* Significant (P<0.05)

** Significant (P<0.01)

ns not significant

The effect of the oestrous synchronization treatment on the reproductive performance of the BHO ewes is set out in Table 4.9. Synchronization treatment had a highly significant (P<0.01) effect on pregnancy, non-return and lambing rates. The highest pregnancy rates were achieved in synchronization treatments 1 (MAP for 9 days + 300IU PMSG 24h before sponge withdrawal), 8 (MAP sponges for 15 days + PMSG at sponge withdrawal), 10 (FGA sponges for 9 days + 300IU PMSG 24h before sponge withdrawal) and 14 (FGA sponges for 12 days + 300IU PMSG at sponge withdrawal) (100.0%), whereas the lowest rates (0.0%) were recorded in treatment 12 (FGA sponges for 9 days with no PMSG).

Table 4.9. Effect of synchronization treatment on pregnancy, non-return, lambing and fecundity rates in Blackhead Ogaden ewes following oestrous synchronization and AI with fresh diluted semen

Synchronization treatment	n	Pregnancy rate (%)	Non-return rate (%)	Lambing rate (%)	Fecundity rate (%)
1. MAP for 9 days + 300IU PMSG 24h before sponge withdrawal	5	100.0 ^a	100.0 ^a	100.0(5/5) ^a	100.0(5/5) ^a
2. MAP for 9 days + 300IU PMSG at sponge withdrawal	5	60.0 ^{ab}	100.0 ^a	60.0(3/5) ^{abc}	100.0(3/3) ^a
3. MAP for 9 days with no PMSG	5	60.0 ^{ab}	60.0 ^{ab}	60.0(3/5) ^{abc}	100.0(3/3) ^a
4. MAP for 12 days + 300IU PMSG 24h before sponge withdrawal	5	60.0 ^{ab}	100.0 ^a	60.0(3/5) ^{abc}	100.0(3/3) ^a
5. MAP for 12 days + 300IU PMSG at sponge withdrawal	4	75.0 ^{ab}	75.0 ^{ab}	75.0(3/4) ^{ab}	100.0(3/3) ^a
6. MAP for 12 days with no PMSG	5	40.0 ^{abc}	60.0 ^{ab}	40.0(2/5) ^{abc}	100.0(2/2) ^a
7. MAP for 15 days + 300IU PMSG 24h before sponge withdrawal	4	25.0 ^b	25.0 ^b	25.0(1/4) ^b	100.0(1/1) ^a
8. MAP for 15 days + 300IU PMSG at sponge withdrawal	4	100.0 ^a	100.0 ^a	100.0(4/4) ^a	100.0(4/4) ^a
9. MAP for 15 days with no PMSG	4	50.0 ^{abc}	75.0 ^{ab}	50.0(2/4) ^{abc}	100.0(2/2) ^a
10. FGA for 9 days +300IU PMSG 24h before sponge withdrawal	5	100.0 ^a	100.0 ^a	100.0(5/5) ^a	100.0(5/5) ^a
11. FGA for 9 days +300IU PMSG at sponge withdrawal	5	40.0 ^{abc}	40.0 ^{abc}	40.0(2/5) ^{abc}	100.0(2/2) ^a
12. FGA for 9 days with no PMSG	4	00.0 ^o	00.0 ^c	0.0 ^o	0.0 ^b
13. FGA for 12 days +300IU PMSG 24h before sponge withdrawal	5	40.0 ^{abc}	80.0 ^{ab}	40.0(2/5) ^{abc}	100.0(2/2) ^a
14. FGA for 12 days +300IU PMSG at sponge withdrawal;	5	100.0 ^a	100.0 ^a	100.0(5/5) ^a	100.0(5/5) ^a
15. FGA for 12 days with no PMSG	5	40.0 ^{abc}	40.0 ^{abc}	40.0(2/5) ^{abc}	100.0(2/2) ^a
16. FGA for 15 days +300IU PMSG 24h before sponge withdrawal;	5	80.0 ^{ab}	80.0 ^{ab}	100.0(5/5) ^a	125.0(5/4) ^a
17. FGA for 15 days +300IU PMSG at sponge withdrawal	4	75.0 ^{ab}	75.0 ^{ab}	75.0(3/4) ^{ab}	100.0(3/3) ^a
18. FGA for 15 days with no PMSG	5	80.0 ^{ab}	80.0 ^{ab}	80.0(4/5) ^{ab}	100.0(4/4) ^a
Overall	84	63.10	73.8	64.3(54/84)	101.9(54/53)

^{a, b, o} Values in a column with different superscripts differ significantly (P<0.01)

n number of ewes per treatment

4.3.6. Gestation length

The gestation length in BHO ewes following oestrous synchronization and AI are set out in Table 4.10. The type of intravaginal progestagen sponge did not significantly affect the gestation length of the ewes. Similarly, the time of PMSG administration, the duration of sponge treatment, BW and BCS of the ewe at AI, litter size and sex of the lamb did not significantly affect the gestation length in all ewes.

Table 4. 10. Least square means (\pm SE) for gestation length in Blackhead Ogaden ewes following oestrous synchronization and AI

Factor	n	Gestation length (days)
Sponge type		ns
MAP	24	147.5 \pm 3.4
FGA	29	149.0 \pm 3.3
Time of PMSG administration		ns
-24h	19	148.3 \pm 3.5
0h	20	147.8 \pm 3.6
Control	14	148.8 \pm 4.7
Duration of sponge treatment (days)		ns
9	17	148.1 \pm 3.5
12	19	148.2 \pm 3.6
15	17	148.6 \pm 3.6
BW (kg)		ns
15-20	32	148.0 \pm 3.3
21-26	21	148.6 \pm 3.4
BCS		ns
2.0-2.5	8	146.8 \pm 4.1
2.6-3.0	21	147.0 \pm 3.5
3.1-3.5	19	148.2 \pm 2.9
>3.5	5	151.1 \pm 4.3
Litter size		ns
1	52	149.2 \pm 1.0
2	1	147.3
Sex of the foetus	n ¹	ns
Male	28	148.9 \pm 3.3
Female	26	147.7 \pm 3.3
Overall mean	54	148.6

n¹ number of lambs

ns not significant

The gestation length was not significantly affected by the synchronization treatment (Table 4.11). The overall mean value for gestation length was 141.9 ± 4.5 days with a range of 141.9 ± 4.5 to 152.9 ± 5.2 days.

Table 4. 11. Least square means (\pm SE) for gestation length in BHO ewes corresponding to their respective synchronization treatments

Synchronization treatment	n	Gestation length (days) ^{ns}
1. MAP for 9 days + 300IU PMSG 24h before sponge withdrawal	4	147.0 \pm 4.3
2. MAP for 9 days + 300IU PMSG at sponge withdrawal	2	147.1 \pm 5.7
3. MAP for 9 days with no PMSG	3	148.0 \pm 4.7
4. MAP for 12 days + 300IU PMSG 24h before sponge withdrawal	3	148.4 \pm 4.6
5. MAP for 12 days + 300IU PMSG at sponge withdrawal	3	151.0 \pm 5.4
6. MAP for 12 days with no PMSG	2	152.9 \pm 5.2
7. MAP for 15 days + 300IU PMSG 24h before sponge withdrawal	1	145.0
8. MAP for 15 days + 300IU PMSG at sponge withdrawal	4	148.8 \pm 5.3
9. MAP for 15 days with no PMSG	2	145.2 \pm 6.1
10. FGA for 9 days +300IU PMSG 24h before sponge withdrawal	4	149.4 \pm 4.5
11. FGA for 9 days +300IU PMSG at sponge withdrawal	2	146.0 \pm 5.4
12. FGA for 9 days with no PMSG	3	148.9 \pm 4.7
13. FGA for 12 days +300IU PMSG 24h before sponge withdrawal	2	150.8 \pm 4.8
14. FGA for 12 days +300IU PMSG at sponge withdrawal;	4	147.9 \pm 5.3
15. FGA for 12 days with no PMSG	2	146.3 \pm 6.0
16. FGA for 15 days +300IU PMSG 24h before sponge withdrawal;	4	151.1 \pm 3.6
17. FGA for 15 days +300IU PMSG at sponge withdrawal	4	146.1 \pm 5.1
18. FGA for 15 days with no PMSG	4	141.9 \pm 4.5
Overall mean	53	148.6

n number of ewes lambing

ns not significant

4.3.7. Lamb birth weight

The overall mean birth weight of all lambs born from a synchronized oestrus and AI was 2.4 ± 0.5 kg (Table 4.12). This birth weight was significantly ($P < 0.05$) affected by the BCS of the ewes at the time of AI. Ewes with a BCS greater than 3.5 produced significantly heavier lambs (3.1 ± 0.4 kg), compared to those with a BCS of lower than 3.5. The type of intravaginal progestagen sponge used, the time of PMSG administration relative to sponge withdrawal, the duration of intravaginal progestagen treatment and the BW of ewes at the time of AI did not significantly affect the birth weight of the lambs. Neither litter size nor sex of the lambs significantly affected the birth weight of the lambs.

Table 4. 12. Least square means (\pm SE) for birth weight in Blackhead Ogaden lambs born following synchronization and AI

Factor	n	Lamb birth weight (kg)
Sponge type		ns
MAP	24	2.8 \pm 0.3
FGA	30	2.6 \pm 0.3
Time of PMSG administration		ns
-24h	20	3.0 \pm 0.3
0h	20	2.5 \pm 0.3
Control	14	2.6 \pm 0.5
Duration of sponge treatment (days)		ns
9	17	2.8 \pm 0.3
12	19	2.6 \pm 0.3
15	18	2.8 \pm 0.3
BW (kg)		ns
15-20	32	2.8 \pm 0.3
21-26	22	2.7 \pm 0.3
BCS		*
2.0-2.5	10	2.4 ^b \pm 0.4
2.6-3.0	22	2.5 ^b \pm 0.3
3.1-3.5	19	2.8 ^b \pm 0.3
>3.5	5	3.1 ^a \pm 0.4
Litter size		ns
1	52	2.4 \pm 0.1
2	2	2.97 \pm 0.54
Sex of lamb		ns
Male	27	2.65 \pm 0.30
Female	27	2.75 \pm 0.30
Overall mean	54	2.38

^{a, b} Means in a column for the same parameter with different superscripts differ significantly ($P < 0.05$)

* Significant ($P < 0.05$)

n number of lambs born

ns not significant

The synchronization treatment used significantly ($P < 0.05$) affected the birth weight of the lambs (Table 4.13). Lambs born from synchronization treatments 7 (MAP for 15 days + 300IU PMSG 24h before sponge withdrawal), 14 (FGA for 12 days + 300IU PMSG at sponge withdrawal) and 15 (FGA for 12 days with no PMSG) were significantly ($P < 0.05$) heavier than those born from the other treatments. The lowest birth weights were recorded from oestrous synchronization treatment 6 (MAP for 12 days with no PMSG).

Table 4.13. Least square means (\pm SE) for birth weight of BHO lambs born following synchronization and AI

Synchronization treatment	n	Lamb birth weight (kg)
1. MAP for 9 days + 300IU PMSG 24h before sponge withdrawal	4	2.5 ^b \pm 0.4
2. MAP for 9 days + 300IU PMSG at sponge withdrawal	2	2.6 ^b \pm 0.6
3. MAP for 9 days with no PMSG	3	3.0 ^b \pm 0.5
4. MAP for 12 days + 300IU PMSG 24h before sponge withdrawal	3	2.1 ^b \pm 0.5
5. MAP for 12 days + 300IU PMSG at sponge withdrawal	3	2.5 ^b \pm 0.5
6. MAP for 12 days with no PMSG	2	1.6 ^c \pm 0.5
7. MAP for 15 days + 300IU PMSG 24h before sponge withdrawal	1	3.3
8. MAP for 15 days + 300IU PMSG at sponge withdrawal	4	2.6 ^b \pm 0.5
9. MAP for 15 days with no PMSG	2	2.9 ^b \pm 0.6
10. FGA for 9 days +300IU PMSG 24h before sponge withdrawal	4	2.9 ^b \pm 0.4
11. FGA for 9 days +300IU PMSG at sponge withdrawal	2	2.6 ^b \pm 0.5
12. FGA for 9 days with no PMSG	3	2.6 ^b \pm 0.5
13. FGA for 12 days +300IU PMSG 24h before sponge withdrawal	2	2.8 ^b \pm 0.5
14. FGA for 12 days +300IU PMSG at sponge withdrawal;	4	3.4 ^a \pm 0.5
15. FGA for 12 days with no PMSG	2	3.7 ^a \pm 0.6
16. FGA for 15 days +300IU PMSG 24h before sponge withdrawal;	5	2.5 ^b \pm 0.3
17. FGA for 15 days +300IU PMSG at sponge withdrawal	4	2.8 ^b \pm 0.5
18. FGA for 15 days with no PMSG	4	2.4 ^b \pm 0.4
Overall mean	54	2.4 \pm 0.5

a, b, c Means in a column with different superscripts differ significantly ($P < 0.05$)

n number of lambs born

4.3.8. Perinatal mortality rate in Blackhead Ogaden lambs

The perinatal mortalities in BHO lambs born following oestrous synchronization and AI are set out in Table 4.14. The overall mortality rate recorded within 24h of birth was 11.1%. The perinatal mortality rate was not significantly affected by the type of intravaginal progestagen sponge, time of PMSG administration, duration of progestagen treatment, BW or BCS of the ewes at the time of AI. The perinatal mortality rate was, however, significantly ($P < 0.05$) affected by the birth weight of the lambs — being higher in lambs with a birth weight of 3.1 to 4 kg (37.5%), compared to in lambs with a birth weight of 1.0 to 2.0kg and 2.1kg to 3.0kg (0.0 and 7.5%, respectively).

Table 4.14. The perinatal mortality rate of lambs in BHO sheep

Factor	n	Perinatal mortality (%)
Sponge type		ns
MAP	24	16.7
FGA	30	6.7
Time of PMSG administration		ns
-24h	20	5.0
0h	20	15.0
Control	14	14.3
Duration of sponge treatment		ns
9	17	11.8
12	19	0.0
15	18	22.2
Body weight (kg)		ns
15-20	32	15.6
20-26	22	4.6
BCS		ns
2.0-2.5	8	25.0
2.6-3.0	21	0.0
3.1-3.5	20	20.0
>3.5	5	0.0
Birth weight of lambs (kg)		*
1-2	8	0.0 ^b
2.1-3	38	7.5 ^b
3.1-4	8	37.5 ^a
Litter size		ns
1	52	11.5
2	2	0.0
Sex of lamb		ns
Male	27	7.4
Female	27	14.8
Overall	54	11.1

^{a, b} Means in a column for the same parameter with different superscripts differ significantly (P<0.05)

* Significant (P<0.05)

n number of lambs born

ns not significant

Similarly, there were no significant differences regarding perinatal mortality rates in lambs within 24h of birth, due to the type of oestrous synchronization treatments used (Table 4.15).

Table 4.15. Perinatal mortality rates in oestrous synchronized and artificially inseminated Blackhead Ogaden sheep following different synchronization treatments

Synchronization treatment	n	Perinatal mortality (%) ^{ns}
1. MAP for 9 days + 300IU PMSG 24h before sponge withdrawal	4	25.0
2. MAP for 9 days + 300IU PMSG at sponge withdrawal	2	00.0
3. MAP for 9 days with no PMSG	3	00.0
4. MAP for 12 days + 300IU PMSG 24h before sponge withdrawal	3	00.0
5. MAP for 12 days + 300IU PMSG at sponge withdrawal	3	00.0
6. MAP for 12 days with no PMSG	2	00.0
7. MAP for 15 days + 300IU PMSG 24h before sponge withdrawal	1	00.0
8. MAP for 15 days + 300IU PMSG at sponge withdrawal	4	50.0
9. MAP for 15 days with no PMSG	2	50.0
10. FGA for 9 days +300IU PMSG 24h before sponge withdrawal	4	00.0
11. FGA for 9 days +300IU PMSG at sponge withdrawal	2	00.0
12. FGA for 9 days with no PMSG	3	00.0
13. FGA for 12 days +300IU PMSG 24h before sponge withdrawal	2	50.0
14. FGA for 12 days +300IU PMSG at sponge withdrawal;	4	00.0
15. FGA for 12 days with no PMSG	2	00.0
16. FGA for 15 days +300IU PMSG 24h before sponge withdrawal;	5	00.0
17. FGA for 15 days +300IU PMSG at sponge withdrawal	4	25.0
18. FGA for 15 days with no PMSG	4	00.0
Overall	54	11.1

n number of lambs born

ns not significant

4.4. DISCUSSION

4.4.1. Oestrous response

Four ewes were removed from the trial 5 days after intravaginal progestagen sponge insertion as they were found to be suffering from pneumonia. Thus, the experiment was conducted on 84 ewes. The overall oestrous response of the ewes during the 96h-observation period after sponge withdrawal was 91.7% (Table 4. 2). Only 7 out of the 84 ewes failed to exhibit overt oestrus. Three of these 7 animals had lost their sponges at one stage of the progestagen treatment, although these were immediately replaced with the same type of sponge as soon as the loss was detected. It seems that these ewes never responded to the treatment. The oestrous response rate could possibly have been higher than the current value had these sponges not been lost. Nonetheless, the oestrous response obtained in this trial was comparable to the values reported in other sheep breeds in the literature (Greyling & Brink, 1987; Crosby *et al.*, 1991; Greyling *et al.*, 1997; Rosado *et al.*, 1998; Zarakawi *et al.*, 1999). However, this response was lower than that (100%) reported by Greyling *et al.* (1994) with MAP (60mg)

and 300IU PMSG in Merino ewes outside the natural breeding season. In this trial, the response to oestrus was not significantly affected by the type of progestagen sponge, BW or BCS of ewes at AI. The absence of any significant effect of the type of progestagen used on oestrous response was expected, as most researchers have reported an equal efficiency of MAP (60mg) and FGA (40mg) sponges (Gordon, 1974; Greyling *et al.*, 1988; Al-Kamali *et al.*, 1990; Crosby *et al.*, 1991; Romano *et al.*, 1996; Selvaraju & Kathiresan, 1997; Romano, 1998).

Many studies have been carried out to evaluate the effect of the duration of intravaginal progestagen treatment (priming period) on oestrous response (Greyling *et al.*, 1985; Corteel *et al.*, 1988; Amoah & Gelay, 1990; Pintato *et al.*, 1996). The percentage of ewes exhibiting oestrus in this trial was higher ($P < 0.01$) in the 12 and 15-day sponge treatment groups than the 9-day treatment group (Table 4.2). This finding is in agreement with the work of Vinales *et al.* (2001), who recorded significantly higher oestrous response in 12-day progestagen sponge treatment, compared to 6-day progestagen treatment in cyclic Polwarth ewes. The low oestrous response observed in the short-term sponge treated ewes was expected, as the natural CL could still be functional at the end of the progestagen treatment period in some of the ewes. Ungerfeld and Rubianes (1999) and Rubianes *et al.* (1998) reported short-term (5 to 6-day) treatment with different progestagen devices during the non-breeding season to be as effective as long-term treatment (18 day) to induce oestrus in ewes and does. These females were in seasonal anoestrus and may not have had a CL to interfere with the terminal growing phase of the pre-ovulatory follicle and to inhibit the oestrous response.

Although cyclic ewes or does synchronized can be expected to demonstrate oestrus shortly after intravaginal progestagen withdrawal without any exogenous gonadotrophin, a low dose of PMSG (375IU) can result in a more predictable and compact synchronization of oestrus and ovulation — which can have a favourable effect on the outcome of fixed time AI (Colas *et al.*, 1973; Jennings & Quirke, 1976; Zhang & Yuan, 1988; Knight, *et al.*, 1992; Artiningsih, *et al.*, 1996; Cordova, *et al.*, 1999; Cline, 2001). In the current trial, regardless of the time of PMSG application, a significantly ($P < 0.01$) higher percentage (100%) of PMSG injected ewes exhibited oestrus during the 96h monitoring-period, compared to the control ewes (75%). These results disagree with the suggestion of Robinson (1988) that intravaginal progestagen sponges alone (FGA or MAP) are adequate in inducing oestrus in cyclic ewes during the

breeding season. In sheep, there is presumably a surge of gonadotrophin from the anterior pituitary sufficient to initiate the sequence of hormonal events that results in oestrus and ovulation. Perhaps the time of the synchronization trial (June — beginning of rainy season) was not the peak breeding season for BHO sheep, as farmers in that area normally practice natural mating from October to November to get a lamb crop from April to mid-May (Girma, 1990). The time of PMSG injection relative to intravaginal sponge withdrawal did not really influence the oestrous response in the ewes. In a previous study by Zhang and Yuan (1988) an oestrous synchronization rate of 100% in does treated with PMSG 48h prior to sponge withdrawal was reported, compared to 66.7% in does treated with the same amount of PMSG but at sponge removal.

The BW and BCS of ewes at AI did not seem important in affecting the oestrous response of the BHO ewes in this trial. The variation in BW (from 15 to 26kg) and that of the BCS (from 2.0 to 3.5) may not have been large enough to incur a significant effect on the ewes showing oestrus. The good pastures at the beginning of the rainy season could have had an overriding effect on these factors.

The specific oestrous synchronization protocol had a significant effect on the oestrous response of BHO ewes. The lowest oestrous response was observed in ewes primed with FGA sponges for a period of 9 days, without PMSG. This indicates that the duration of FGA priming in this group was shorter than the life span of the natural CL, and the sponges were removed before natural regression of the CL. At sponge withdrawal, the natural CL present in some ewes might have prevented follicle development and ovulation thus had a poor efficiency. Results revealed that this use of only FGA (40mg) sponges without PMSG for a period of 9 days results in a significantly ($P < 0.01$) lower oestrous response (Table 4.3). The second lowest oestrous response was recorded in groups, which were primed with MAP (60mg) sponges without PMSG for a period of 12 days. The rest of the oestrous synchronization treatments induced oestrus in an acceptable proportion of ewes. The reasons for the low oestrous response from 12-day MAP sponge primed ewes with no PMSG remains unclear.

4.4.2. Time to onset and the duration of induced oestrus

Several factors may influence the length of the interval between the end of the progestagen treatment and the onset of the induced oestrus. Generally, oestrus starts about 36h after progestagen withdrawal, although some ewes may start showing oestrus as early as 24h or as late as 48h after progestagen withdrawal (Gordon, 1997). The overall mean interval between intravaginal progestagen sponge withdrawal and the onset of oestrus in the present trial (38.5h) is in agreement with the findings of Gordon (1997) and Vancleef *et al.* (1998), who reported the mean time to oestrus to be 36h in oestrous synchronized ewes. Similarly, Godfrey *et al.* (1999) recorded the time to oestrus in CIDR synchronized ewes to be 31.6h, which is in line with the results of the current study. Godfrey *et al.* (1997) also reported the time to oestrus to be 33.6 to 40.8h in ewes, which is in compliance with the present results. These results are also fairly comparable to the findings of Greyling *et al.* (1997) with MAP (60mg) synchronized Merino ewes during the natural breeding season (30.5h) and Greyling *et al.* (1994) in MAP (60mg) and 300IU PMSG synchronized Merino ewes during the non-breeding season (43.0 ± 7.4 h). However, the interval observed in this trial was shorter than those results reported by Greyling and Brink (1987) with MAP (60mg) treated Karakul ewes (62.5 ± 18.7 h). This discrepancy may be due to breed, nutritional and/or seasonal differences. There have been some suggestions that the time of the day (morning or evening) at which the intravaginal sponges are withdrawn may influence the interval to oestrus (Robinson, 1980). This aspect was overlooked by most of the literature sources consulted.

The type of progestagen sponges used (MAP or FGA) did not significantly influence the time interval from the sponge removal to the commencement of oestrus (Table 4.4). This is in agreement with the results of Romano *et al.* (1995) and Romano (1996), but disagrees with Romano (1998) who reported the onset of oestrus to be earlier in FGA than in MAP primed does. The duration of progestagen priming was not important in inducing the onset of oestrus in this trial, which disagrees with Vinales *et al.* (2001) who found the time to onset of oestrus to be significantly earlier in long-term (12 day) sponge treatment, compared to short-term (6 day) treatment. Neither BW nor BCS of ewes at AI affected the interval from the withdrawal of sponges to the onset of oestrus.

The interval from sponge withdrawal to the onset of oestrus was significantly ($P < 0.01$) shorter in ewes injected with 300IU PMSG, compared to the control ewes (Table 4.4). The results are in line with the literature (Botha *et al.*, 1975; Zhang & Yuan, 1988; Eppleston, 1991; Knight *et al.*, 1992; Artiningsih *et al.*, 1996), which stated the use of PMSG in combination with progestagen sponges to shorten the response time. Unlike the reports of Zhang and Yuan (1988), Eppleston (1991) indicated that the time to oestrus is significantly reduced when PMSG was administered 24h or 48h prior to sponge withdrawal. The difference between ewes injected 24h prior to sponge withdrawal and at sponge withdrawal was not significant in the present study although there was a tendency for oestrus to start earlier in ewes injected 24h prior to sponge withdrawal.

The mean duration of the induced oestrous period in this experiment was 45.1 ± 4.3 h, which is longer when compared to the periods reported in other studies (Greyling *et al.*, 1994; Greyling *et al.*, 1997; Godfrey *et al.*, 1999). Breed can markedly influence the duration of oestrus (Gordon, 1997). Neither the synchronization treatments nor the body weight and body condition at AI significantly affected the duration of the induced oestrus in this trial (Table 4.4). It seems that the interval from progestagen sponge withdrawal to oestrus and the duration of the induced oestrous are negatively related. It was noted that the earlier the onset of oestrus, the longer the duration of the induced oestrus. There may be a possibility of predicting the duration of oestrus based on the interval between sponge withdrawal and the onset of oestrus, without having to observe the entire oestrous period.

4.4.3. Serum Progesterone concentrations

In the current trial, serum progesterone levels increased to a maximum at 4 days after sponge insertion (Figure 4.1). These results are similar to those reported by Hamra *et al.* (1989) using ovariectomized ewes treated with progestagen sponges. This indicates that the intravaginal delivery of progestagen in the sponges to be effective. The elevation in serum progesterone concentration after insertion of intravaginal progestagen sponges, suggests that the endogenous progesterone levels were augmented with the exogenous sources of progestagen from the inserted sponges. The decline in the level of serum progesterone level after day 8 of insertion indicates the gradual regression of CL and/or possible depletion of progestagen from the exogenous source. The lower progesterone values from the time of sponge withdrawal

until 72h post sponge withdrawal suggests that the abrupt removal of sponges resulted in an effective cessation of the inhibitory effect of progesterone over the hypothalamus, thus allowing follicular development. The minimum serum progesterone level (0.83ng/ml) achieved 56h after sponge withdrawal may be indicative of conducive environment for the follicular growth and maximum oestradiol secretion from the mature follicles. A gradual elevation in the level of serum progesterone level 72h after sponge withdrawal indicates the formation of a new CL. The reasons for an elevation in serum progesterone level 8h after sponge withdrawal in MAP treated ewes were unclear. There might have been a recovery of the natural CL in some ewes, which were not completely regressed during the progestagen treatment or that had not responded to the synchronization treatment. With the exception of this elevation in serum progesterone level 8h after sponge withdrawal in the MAP treated ewes, there were no other noticeable differences in the pattern of serum progesterone secretion between the FGA and MAP treated ewes. This is in agreement with the findings of Motlomelo (2000) in Boer and Nguni does in South Africa. The absence of visible differences in the pattern of serum progesterone level between MAP and FGA primed ewes indicates equal efficiency of these sponges in controlling the hormonal profiles.

On the other hand, the level of serum progesterone concentration after sponge withdrawal varied depending on the duration of progestagen priming (Figure 4.2 and Table 4.6). Fifteen-day progestagen treatment maintained the lowest level of serum progesterone after progestagen withdrawal. In this trial, the shorter the duration of sponge treatment the higher was the level of serum progesterone concentration following sponge withdrawal (Figure 4.2). This suggests that progestagen sponge priming for a period of 15 days induced complete luteolysis of the CL whereas, 9 and 12-day treatments may not have allowed the completion of natural luteolysis in some of the ewes as the duration of progestagen priming was shorter than the duration of the natural luteal phase in ewes. The lowest serum progesterone level (0.26ng/ml) attained approximately 56h after sponge withdrawal in the 15-day progestagen treatment group is also indicative of better conditions for follicular activity, compared to groups primed for 9 or 12 days.

Absence of a clear-cut difference in serum progesterone concentration, both during priming and following sponge withdrawal, between ewes conceiving from AI and those which failed to conceive could imply a difficulty in predicting the pregnancy outcome based on serum

progesterone profiles during this period. However, the pattern of serum progesterone concentration of ewes conceiving and those failing to conceive differs. The pattern of serum progesterone concentration in ewes that failed to conceive was more irregular (Figure 4.3). A sharp drop in serum progesterone level on day 8 after sponge insertion may be due to shortage of exogenous source of progesterone or higher follicular activity at that time. The increase in progesterone level after 8h post sponge withdrawal can only have endogenous origin from a new CL being formed. It seems that endogenous endocrine activity was not completely eliminated in some of the ewes. With the long inter-sampling period (8h), it is difficult to get a clear picture of the progesterone profile (and CL activity).

4.4.4. Serum Luteinizing hormone concentration

The number of ewes used for serum LH concentration determinations was not large enough to allow for a more meaningful conclusion. The numbers were limited by the high costs of the hormone laboratory analyses. The number of ewes that exhibited a LH peak varied among treatments, and a valid statistical comparison regarding the occurrence of the LH peak relative to sponge withdrawal and onset of oestrus was not possible. Nonetheless, this preliminary information could help as a springboard for further studies on controlled reproduction in BHO sheep.

In this trial 7/16 (43.8%) of ewes exhibited a pre-ovulatory LH peak (≥ 5 ng/ml) following synchronization treatment (Table 4.7). The percentage of ewes demonstrating the LH peak was higher in the MAP synchronized (62.5%), compared to the FGA synchronized ewes (25%). MAP progestagen priming was presumably more effective in regulating the hormonal milieu and inducing follicular activity in most of the synchronized ewes. However, the occurrence of the LH peak relative to progestagen withdrawal and onset of oestrus were not different between the two progestagen sponge types. The response of higher level for the LH peak in the FGA compared to MAP treated ewes is unclear (Figure 4.4).

The duration of the progestagen priming period did not affect either the proportion of ewes exhibiting LH peak or the position of LH peak relative to time to progestagen withdrawal or the time to onset of oestrus. This suggests that 9, 12 or 15-day progestagen priming were equally effective in initiating follicular activity in BHO sheep. The higher LH peak in 12-days

progestagen primed, compared to 9 or 15-days progestagen primed ewes suggests that 12-days is an optimum duration of treatment to enhance follicular activity in BHO ewes. The peak values measured in this trial are relative due to the pulsatile nature of LH secretion and the long inter-sampling periods.

4.4.5. Reproductive performance following oestrous synchronization and AI

The main objective of controlled reproduction focuses on acceptable fertility following synchronized oestrus and AI. The overall mean pregnancy rate confirmed after lambing (63.1%) in the present trial (Table 4.8) is comparable to the results obtained by Hill *et al.* (1998), who reported the mean pregnancy rate following Map (60mg) treatment and AI in Merino ewes to be 64.6%. The current results are also in line with those of Greyling *et al.* (1988), who recorded a pregnancy rate of 63.5% in MAP and FGA treated Merino ewes. However, this pregnancy rate is lower than the 79.3% of Greyling and Brink (1987) in MAP synchronized Karakul ewes and that of Vinales *et al.* (2001), who recorded a pregnancy rate of 87% in short-term (6 day) progestagen primed ewes. Nonetheless, the pregnancy rate obtained in this experiment was not discouraging, as this experiment serves as the baseline for further oestrous synchronization studies in the BHO ewes.

The difference between the actual pregnancy rate and that indicated by the non-return rate was large (63.1% vs. 73.8%). This big variation between the pregnancy and the non-return rates suggests the probable occurrences of high embryonic resorption in some of the experimental animals due to handling stress during heat detection and blood sampling. Besides, these ewes were kept out side their natural habitat, which might have exacerbated an additional stress on animals eventhough an adaptation period was given to them. Had the pregnancy rate been the same as the non-return rate obtained in the present study, it would have been more acceptable. The high non-return rate suggests that more care has to be taken to limit possible embryonic resorption.

In this experiment, the two intravaginal progestagen sponges (MAP and FGA) did not play a role in the pregnancy, the non-return to oestrus, lambing or fecundity rates (Table 4.8). These results demonstrate that either one of the two intravaginal progestagen sponges can be used, based on their availability and cost effectiveness for oestrous synchronization purposes in

BHO sheep. Similar fertility rates of MAP and FGA sponges following synchronization and AI has also been reported by Al-Kamali *et al.* (1990), Crosby *et al.* (1991), Romano *et al.* (1996) and Romano (1998), which are in agreement with the present results. However, the superiority of FGA over MAP sponges has also been reported in some instances (Gordon, 1974; Eppleston & Roberts, 1986; Greyling *et al.*, 1988; Hill *et al.*, 1998).

The duration of progestagen priming did not affect the pregnancy, non-return, lambing and fecundity rates (Table 4.8). Similar results in ewes (Ungerfeld & Rubianes, 1999) and does (Rubianes *et al.*, 1998) have been reported for short-term priming (5 to 6 days) with different progestagen devices in the non-breeding season and found to be as effective as long-term priming (18 days) in inducing a fertile oestrus. This is contradictory to Moore and Appleton (1979) who reported the duration of progestagen treatment to play a critical role in affecting fertility in Angora does. It was also stated that treatment with progestagen pessaries for more than 16 days tended to decrease the fertility rate achieved. In fact, in the current trial the longest duration of progestagen priming was 15 days, which may not have been long enough to compromise fertility. Vinales *et al.* (2001) also reported the pregnancy rate to decrease by 9 to 21% in long-term progestagen treatment (12 days), compared to short-term treatment (6 days) in cyclic ewes. Lower pregnancy rates were also recorded by Robinson *et al.* (1970) following long-term priming with progestagen in sheep. The reasons for the lower fertility following long-term progestagen priming was probably due to the ovulation of aged follicles, which reduces fertility and embryo survival (Sirois & Fortune, 1990; Savio *et al.*, 1993; Revah & Butler, 1996). In cyclic ewes, the administration of eCG or PMSG when progestagen treatment is terminated could compensate for the deleterious effect of long-term progestagen treatment on follicular dynamics by promoting the recruitment of new follicles (Noel *et al.*, 1994). This could overcome the problem of depressed fertility (Boland *et al.*, 1978). The reasons for the absence of a significant difference in pregnancy rate among 9, 12 and 15-day treatments in the present study could thus be due to the compensatory effects of PMSG.

Robinson (1988) stated that intravaginal progestagen treatment alone (FGA or MAP) to be adequate in inducing oestrus in cyclic ewes during the breeding season. After progestagen withdrawal in such sheep, there may be a sufficient surge of gonadotrophin from the anterior pituitary to initiate the sequence of complex hormonal events that result in oestrus and ovulation. However, for a progestagen treatment to be effective for induction of oestrus during

the non-breeding season, there may be a need to supplement with endogenous gonadotrophins to initiate these pre-ovulatory events (Robinson, 1988). In the present experiment, achievement of significantly higher ($P < 0.05$) fertility rates (pregnancy, lambing and non-return rates) in ewes injected with PMSG at sponge withdrawal (74.1%), compared to control (46.4%) ones indicate the importance of PMSG administration. The higher fertility rate achieved from PMSG injected groups is in line with most of the literature sources (Zhang & Yuan, 1988; Eppleston *et al.*, 1991; Knight *et al.*, 1992; Artiningsih *et al.*, 1996; Cordova *et al.*, 1999; Cline, 2001). The present findings, however, contradict the report of Romano *et al.* (1996), who recorded similar fertility rates for ewes injected with 250IU PMSG or no PMSG. Perhaps, 250IU PMSG may have been below the threshold level to significantly affect fertility rate in that experiment. Unlike the previous reports of Zhang and Yuan (1988) who indicated an increase in fertility when PMSG is administered 24h prior to pessary removal (compared to PMSG administration at sponge withdrawal), there were no significant differences in fertility rates between the 2 groups in the current trial. However, the results of the present study are in agreement with Eppleston *et al.* (1991), who stated the time of PMSG treatment could not yield constant improvement in fertility, apart from reducing the time of ovulation.

The BW of ewes in this experiment had no significant effect on pregnancy, non-return, lambing or fecundity rates. The differences in BW (15 to 26kg) may have been too small to affect fertility in this group of ewes. Unlike BW, BCS at AI significantly affected the pregnancy ($P < 0.01$) and the lambing rates ($P < 0.05$) (Table 4.8). The optimum BCS at AI in these ewes appears to be between 3.1 and 3.5, for which the highest pregnancy and lambing rates were obtained (82.6 and 87.0%, respectively). This suggests that a BCS higher than 3.5 or lower than 3.0 could negatively affect fertility. This is in agreement with the findings of Mellado *et al.* (1996) and Gonzalez, *et al.* (1999), who observed that too high or too low BCS at breeding affects the fertility in does negatively. Rhind *et al.* (1989) reported BCS to affect directly the hypothalamic activity and GnRH secretion, and these effects on the reproductive performance are mediated by way of changes in ovarian hormones or in the hypothalamic-pituitary sensitivity to ovarian hormones.

From the 18 oestrous synchronization treatments compared in this experiment, the highest pregnancy and lambing rates were obtained in ewes synchronized in treatments 1 (MAP for 9 days +PMSG 24h prior to sponge removal), 8 (MAP for 15 days + PMSG at sponge

withdrawal) and 14 (FGA for 12 days +300IU PMSG at sponge withdrawal). None of the ewes synchronized with FGA sponges for 9 days without PMSG conceived (Table 4.9). This could indicate the importance of the exogenous source of gonadotrophin following priming with FGA sponges for a period of 9 days. Unfortunately, the number of ewes per treatment was not large enough to draw a conclusive recommendation for the choice of the best synchronization treatment. Thus, based on fertility rates, synchronization treatments 1, 8 and 14 were found to be superior to the rest of the treatments.

4.4.6. Gestation length

The length of gestation varies among sheep breeds and ranges between 144 and 147 days in the early maturing improved mutton breeds and 149 to 151 days in the late maturing fine-wool breeds (Gordon, 1997). It is generally accepted that the duration of the gestation period within a particular breed is stable (Forbes, 1967). Actually, the duration of pregnancy within a breed can also vary as a result of other factors. These include: the number of foetuses, the sex of the lambs, the sire breed, the breed of ewe and its age (Gordon, 1997). The overall mean gestation length of BHO sheep obtained in this study (148.6 days) falls within the range of that for late maturing fine-woolled sheep breeds. The length of the gestation period was not affected by any of the factors considered in this experiment (Table 4.10). In fact there was only a tendency for an increase in gestation period in single fetus carrying ewes (149.2 ± 1.0 days), compared to the twin-carrying ones (147.3 ± 6.1 days). Similarly, male lambs were carried on average a day longer, compared to female lambs although these differences were not significant. The effect of litter size on gestation length was reported by Gordon (1983) and Osinowo *et al.* (1994) in that a day's difference exists between twin and single pregnancies. As could be expected, none of the oestrous synchronization treatments used in this experiment affected gestation length (Table 4.11). The literature on the combined effects of sponge type, duration of treatment, and time of PMSG administration relative to progestagen withdrawal on gestation length is scarce.

4.4.7. Lamb birth weight

In this experiment, the overall mean birth weight of lambs was 2.4kg (Table 4.12), which is far below than the birth weight values reported by Olivier *et al.* (1984), Schoeman (1990), Ingyangala *et al.* (1991; 1992) and Schoeman and Van der Merwe (1994) for other sheep breeds. The difference in birth weight of lambs of different breeds of sheep is expected, as different breeds also differ in mature body weights. Unfortunately, literature on the birth weight of BHO sheep is not available to compare with the present results.

The type and the duration of sponge treatment, time of PMSG administration, BW, litter size and sex of the lambs did not significantly affect the birth weight. The only factor that significantly ($P < 0.05$) affected the birth weight of lambs was BCS of the ewes at AI. Heavier lambs were born from ewes with a BCS of >3.5 (3.1 ± 0.4 kg), compared to lambs born from ewes with a BCS of <3.5 (Table 4.12). This may be due to a more favourable uterine environment for growth and development of the foetus during pregnancy.

4.4.8. Perinatal lamb mortality

Perinatal lamb mortality is a major cause of reduced productivity in sheep, with 10 -20% deaths being recorded in the literature (Gordon, 1997). According to Egan (1984), it is not unusual to find that 20-25% of pregnant ewes fail to rear a lamb to marketing age in Australia. Most lamb deaths occur within the first few days of life and it is recognized that the major causes are nutritional, behavioural and physiological rather than infectious (Gordon, 1967). The occurrence of 11.1% (6/54) lamb losses within 24h of birth observed in this trial is indicative of the importance of perinatal management in BHO sheep (Table 4.13). The occurrence of significantly ($P < 0.01$) higher perinatal mortality rates in heavier lambs (3 to 4kg), compared to lambs with lighter birth weights (1-3kg) is contradictory to most of the other reports (Mtenga *et al.*, 1994; Rattner *et al.*, 1994; Awemu *et al.*, 1999). In general, the incidence of perinatal mortalities are said to be higher in lighter lambs, compared to lambs with heavier birth weights. Most of the incidences of perinatal mortalities (4/6) in the present trial were due to difficulties at birth (dystocia). This may be due to the small body size of the BHO sheep. Gordon (1997) stated that as lamb birth weight increases within a particular breed type, mortality rate declines to a minimum for lambs of average size or for lambs with slightly

higher birth weights than average, and then, mortality rises again for a very high birth weights as a result of difficult births. So increasing the birth weight of lambs beyond 3kg in the BHO sheep would have a great disadvantage, as the perinatal mortality would increase mainly due to dystocia.

4.5 CONCLUSIONS

Either MAP (60mg) or FGA (40mg) progestagen sponges can successfully be used to synchronize oestrus in BHO sheep under traditional management conditions in Ethiopia. They are equally effective in inducing oestrus with no significant differences in subsequent fertility. Administration of 300IU PMSG either 24h prior to progestagen withdrawal or at progestagen withdrawal results in a more effective synchronization of oestrus and higher pregnancy rate. Furthermore, maintaining the BCS of ewes at 3.1 to 3.5 prior to AI is vital to achieve acceptable fertility rates from controlled breeding and AI. To achieve the best reproductive performance in BHO sheep, synchronizing either with MAP sponges for 9 days +300IU PMSG administration 24h before sponge withdrawal, MAP sponges for 15 days + 300IU PMSG at sponge withdrawal, FGA sponges for 9 days + 300IU PMSG 24h before sponge withdrawal or FGA sponges for 12 days + 300IU PMSG at sponge withdrawal can be recommended. It is important to limit the lamb birth weight to 3kg in future selection programs, as heavier lambs result in dystocia and a higher rate of perinatal mortalities. Besides, increasing body mass of the ewes before breeding is important to minimize incidence of distocia. Further studies on the effect of season of synchronization and doses of PMSG under different feeding management are warranted in BHO sheep breed under Ethiopian conditions.

CHAPTER 5

EFFECT OF TYPE AND DURATION OF INTRAVAGINAL PROGESTAGEN TREATMENT ON EFFICIENCY OF OESTROUS SYNCHRONIZATION AND FERTILITY IN SOMALI DOES

5.1. INTRODUCTION

In Ethiopia, agriculture in general and livestock production in particular plays a pivotal role in the country's economy. The majority of the population depends on small-scale agriculture for their livelihood, and livestock farming is integral part of most farming systems. Among the livestock, the goat is a valuable and major source of milk, meat, and immediate source of income for the resource poor rural farmers. Goat production also plays a role in the form of savings and investment assets, particularly where land is intensively cultivated, natural pastures are limited and nutrient resources are insufficient to sustain milk or meat production from large stock. Besides their direct contribution as a source of food and cash income to the producers, the goat also contributes to Ethiopia's foreign income earnings by providing skins for the tanning industry and the exports of live animals to neighboring countries is a significant source of revenue.

In contrast to the large number of goats farmed in Ethiopia and the vital role that goats play in the livelihood of resource-poor farmers, the present productivity per head is very low. For instance, the annual meat production per animal slaughtered is 8 to 10kg and milk production per animal from the indigenous goat is less than 0.5kg/day. Pre-weaning mortality rates of kids are also as high as 10 to 22% (FAO, 1995). The reason for this low productivity in goats is that little attention has been given to maintaining and improving them. In the last decade, efforts have been made by FARM-Africa, in collaboration with the Ministry of Agriculture, Alemaya University and Awassa College of Agriculture to introduce a goat with better productive capabilities to the smallholder farming areas of Ethiopia (Abebe, 1996). Their objective is to improve the milk and meat production by improving the genetic potential of the

local Somali goats by crossbreeding them with the Anglo-Nubian, an exotic breed. More recently, a collaborative project between Langston University (USA) and Alemaya University (Ethiopia) has begun distributing local and crossbred goats to nearby rural poor farmers with the intention of helping farmers to improve their livelihood and to generate knowledge regarding the on-farm productivity of the local Somali and crossbred goats.

The attempts being made by these institutions to improve the genetic potential and then the productivity of goats are facing certain challenges. Among the challenges faced are: (1) difficulties to import and maintain large number of exotic pure breed bucks for cross breeding purposes as the purchasing price and overall maintenance and transportation costs of these animals are very high. (2) adaptation problems, as these animals are being imported to a new environment and (3) difficulties to obtain large number of offspring of uniform age and season of birth to draw a valid comparisons regarding their productivity under local farming conditions. To mitigate the bottlenecks for the genetic improvement of local goats either by selection or crossbreeding, the use of artificial insemination (AI) seems the best option. The use of AI is more economical than the use of natural mating as the semen from few bucks can be used on a large number of does and purchasing, transportation and maintenance costs of bucks will be generally low. If need be, semen alone can be imported without having to import the live animals. AI facilitates the selection of superior animals among local breeds by producing a large number of progeny simultaneously and eliminating the confounding effect of season of kidding.

For the successful use of AI in goats, oestrous synchronization is an important pre-requisite. The synchronization of oestrus minimizes the time and the labour to be spent on oestrous detection (enabling the use of fixed time AI), facilitates controlled breeding and general reproductive management. There are many oestrous synchronization protocols implemented in goats in other parts of the world. However, the success of these protocols varies depending on genetic and environmental factors, (breed of goat, management conditions, season and geographical location). The objective of this trial was, therefore, to compare type of intravaginal progestagen sponge, time of PMSG administration relative to progestagen sponge withdrawal, and the combined effects of progestagen sponge type and its duration of treatment on synchronization efficiency and fertility of Somali goats at the beginning of the rainy (summer) season in Eastern Ethiopia.

5.2. MATERIALS AND METHODS

5.2.1. Study site

The experiment was conducted at the Dairy Goat Cross Breeding Station at Alemaya University, located 25km from the town of Harar and 42km from Dire-Dawa, Eastern Ethiopia. The site is located at 9°24'N latitude and 41°5'E longitude, and at an altitude of 1980m above sea level. The mean annual rainfall and mean maximum and minimum temperature of the area are 870mm, 22.9°C and 7.8°C, respectively (Heluf, 1982).

5.2.2. Experimental animals, their description and management

The Somali goat breed, also known as the *Deghier*, *Deg yer* or *Dighi yer*, is found in Somalia, Ethiopia and North-east Kenya (Mason, 1996). The breed is used primarily for meat production. These goats are predominantly white in colour, but some individuals have colored spots or patches. The Somali goat has short hair and ears, the males are horned and the females are either horned or polled.

One hundred and twenty local Somali female goats were selected from a total flock of 200 kept at the station for crossbreeding purposes. Selection was based on availability of non-pregnant female goats. The initial body weight of the selected does ranges from 14.5 to 49 kg. The age of the does was 1 year (n=72), 6 years (n=25) and 9 years (n=23). The animals were allowed to graze 8h a day (8:00-12:00 and 14:00-18:00) on legume/grass-mixed cultivated pastures. In addition to grazing, goats were provided with 1.3kg brewer's grain per head per day. When brewer's grain was not available, goats were given approximately 200g wheat bran per head per day.

Prior to commencement of the actual trial, goats were checked for internal and external parasites, drenched with a broad-spectrum antihelminthic and dipped with a standard acaricide solution.

5.2.3. Intravaginal progestagen treatment

Two types of intravaginal progestagen sponges were used in this study. Experimental does ($n=120$) were divided into two balanced (in terms of age and body weight) groups of 60 animals each. Half of the animals ($n=60$) received medroxyprogesterone acetate (MAP; 60mg) and the remaining half received fluorogesterone acetate (FGA; 40mg) intravaginal sponges. Sponges were inserted deep into the vagina with the aid of applicator (Plate 5.1). The applicator was rinsed with clean warm water before each insertion and a small quantity of antiseptic cream was applied to the applicator with each insertion to lubricate it and prevent reproductive tract from infection. The experimental does in each progestagen treatment group were again randomly subdivided into 4 groups of 15 animals each and these groups were treated with intravaginal progestagen sponges for 9, 12, 15 or 18 days (Table 5.1).

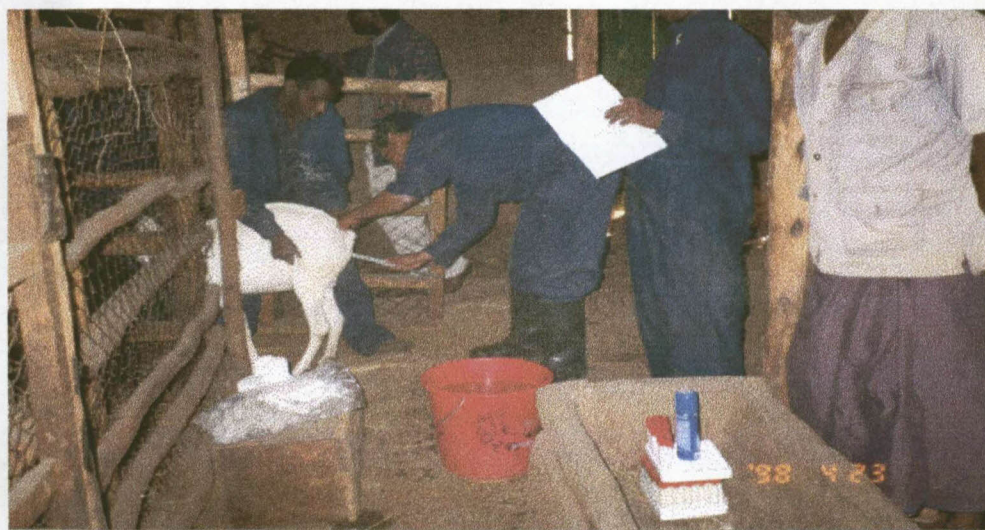


Plate 5.1. Sponging of the Somali goats in Ethiopia

5.2.4. PMSG administration

Regardless of the type of progestagen sponge used and the duration of its treatment period, all does were randomly allocated to 3 PMSG treatment groups of 40, 38 and 39 animals. The first group was injected with 300IU PMSG 24h prior to sponge withdrawal; the second group was injected with the same dose of PMSG at sponge withdrawal, while the third group, which served as the control, received no PMSG.

5.2.5 AI procedures

Semen from 5 healthy and fertile Anglo-Nubian bucks was collected with the aid of the artificial vagina. The bucks had been trained for a period of 2 weeks prior to AI to mount teaser does and ejaculate in the artificial vagina (Plate 5.2). Viable semen with progressive forward motility was diluted with sterile skimmed cow milk (30°C) at a ratio of 1:2. The viability and motility of sperm was microscopically evaluated following each collection and prior to insemination. Care was taken to avoid cold shock and thus injury to the sperm. This was done by (1) keeping the semen containing tubes in a temperature-controlled water bath (34°C) while avoiding a direct contact of semen with water (2) by warming the tip of the insemination gun in slide warmer prior to sucking the semen from the tube in to the insemination gun and (3) by minimizing the time gap between sucking of semen into the insemination gun and depositing it in the cervix. Then, does were inseminated 48 and 60h following sponge withdrawal with 0.1ml of fresh diluted semen (approximately 150×10^3 sperm/insemination) (Plate 5.3).

Table 5.1. Treatment allocation

Treatment number	Progestagen sponge type	Duration of sponge treatment (days)	No. of goats
1	MAP (60mg)	9	15
2		12	15
3		15	15
4		18	15
5	FGA (40mg)	9	15
6		12	15
7		15	15
8		18	15



Plate 5.2. Semen Collection from Anglo-Nubian bucks using the artificial vagina



Plate 5.3 Artificial insemination of Somali does using diluted fresh semen from Anglo-Nubian bucks

5.2.6. Blood sampling

Five does were randomly selected from each progestagen treatment group for blood sampling. Blood samples for serum progesterone concentration determinations were collected at 3-day intervals starting from the day of progestagen sponge insertion until progestagen sponge withdrawal, and at 8h intervals from the time of progestagen sponge withdrawal until 96h post progestagen sponge withdrawal. For serum LH concentration determinations blood samples were collected at 8h intervals starting from the time of progestagen sponge withdrawal for a total period of 96h. Blood samples were taken from the jugular vein by veni-puncture into 10ml plain (no anticoagulant) vacutainers (Plate 5.4). The blood was allowed to stand for an hour to clot and was then centrifuged at a speed of 1500 rpm for 15 minutes. The serum was aspirated and stored at -20°C until assayed for serum progesterone and LH concentrations.

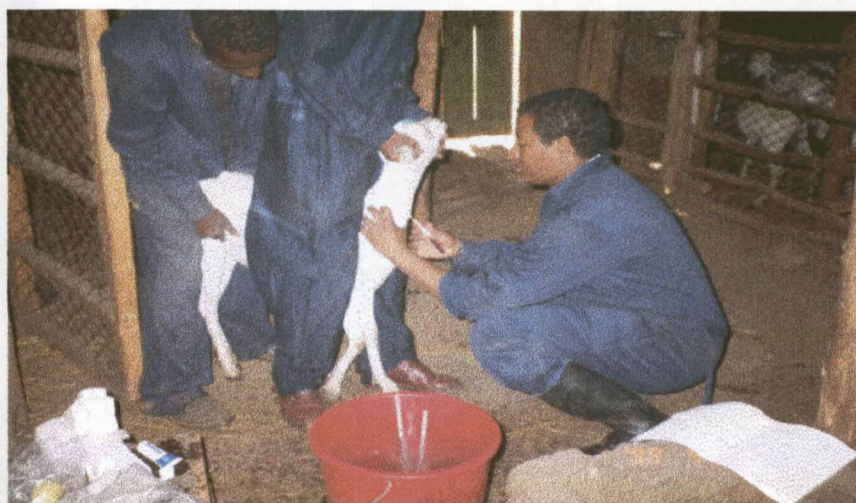


Plate 5.4. Blood sampling from Somali goats at the Dairy Goat crossbreeding Station, Alemaya University

5.2.7. Serum progesterone assay

Serum progesterone concentrations were assayed using the DRG progesterone direct solid phase enzyme immunoassay (ELISA KIT) (Kat. / Cat #: EIA-1561, DRG Instruments GmbH DRG International, Inc. Germany USA). The test is based on a competition principle and microplate separation method. An unknown concentration of progesterone present in the blood sample and a fixed amount of progesterone conjugated to horse-radish peroxidase

compete for the binding sites of polyclonal progesterone antiserum, coated to the wells. After incubation for an hour, the microtiter plate was washed to terminate the competition reaction. Having added the substrate solution, the concentration of progesterone was inversely proportional to the optical density measured. A microwell reader capable of determining the absorbance at $450 \pm 10 \text{ nm}$ is used to quantify the progesterone present. The progesterone value of each blood sample was then obtained, using linear-linear or semi log graph paper after constructing a standard curve by plotting the average absorbance (Y) of each reference standard against its corresponding concentration (X) in ng/ml. The lowest detectable level of serum progesterone that could be measured from the zero standard was 0.05 ng/ml, at the 95% confidence level. The inter- and intra coefficients of variation were 13.8% and 8.7%, respectively.

5.2.8. Serum Luteinizing hormone (LH) assay

The serum LH concentration assay was done using a solid phase enzyme linked immunosorbent technique. The assay system utilizes one anti-LH antibody for the solid phase (microtiter wells) immobilization, and another mouse monoclonal anti-LH anti-body in the anti-body-enzyme (horseradish peroxidase) conjugate solution. The test sample was allowed to react simultaneously with the antibodies, resulting in the LH molecules being sandwiched between the solid phase and enzyme-linked anti-bodies. A solution of TMB (tetramethylbenzidine) was added and incubated for 20 minutes, resulting in the development of a blue colour. The colour change was stopped with the addition of 2N HCL. The colour changed to yellow and was measured spectrophotometrically at 450nm. The concentration of LH was directly proportional to the color intensity of the test sample. The LH concentration was determined by calculating the mean absorbance value (A_{450}) for each set of reference standards. A standard curve was constructed by plotting the mean absorbance value on the Y-axis and concentration on the X-axis. The mean absorbance values were used for each sample to determine the corresponding concentration of LH in ng/ml from the standard curve. The minimal detectable concentration of serum LH by this assay was estimated to be 0.08ng/ml (Diagnostic Automation, Inc, 23961 CraftsmanRd. Suite E/F, Calabasas. California 91302, USA). The inter- and intra- coefficients of variation were 8.4% and 14.3%, respectively.

5.2.9. Oestrous observations

After withdrawal of the intravaginal sponges, signs for overt oestrus were monitored at 8h intervals for 96h. Does were arbitrarily grouped into 4 groups of 30 animals each to facilitate the process of oestrous detection. Approximately 30 minutes was allowed in each group for oestrous detection. Intact bucks fitted with aprons were used to tease the does (Plate 5.5). Similarly, oestrus was monitored for about 15 days, starting from day 13 following the last AI, to detect does returning to oestrus (not conceiving). During this time, 6 intact fertile bucks were introduced to the entire flock. The detection of oestrous was performed twice daily, in the morning (7:00) and in the late afternoon (18:00). Does that exhibited oestrus following the initial AI were hand-mated and considered not pregnant for the purpose of this trial.



Plate 5.5. An Anglo-Nubian buck fitted with an apron for the purpose of oestrous detection

5.2.10. Body weight (BW) and body condition score (BCS)

The individual BW of all experimental does was measured and recorded at the onset of the treatment (sponging), before AI and fortnightly thereafter until kidding. The body condition score (BCS) of all does was done prior to AI. This BCS was done according to the method used in USA for small ruminants (Russel, 1991). The BCS system was made based on a scale of 1 to 5 (1 for emaciated, 2 for thin, 3 for average, 4 for fat and 5 for obese).

5.2.11. Kidding performance

Kidding data was recorded for a period of 15 days, starting from 140 days from the time of AI. Birth weight, litter size, sex and perinatal mortality rate of kids were recorded.

5.2.12. Statistical analysis

The general linear model (GLM) procedures of SAS (1999) were used to do an analysis of variance to test the effect of progestagen type, duration of progestagen treatment, time of PMSG administration, BW, BC and age of does on the time to oestrus, duration of induced oestrus, litter size, lambing weight, gestation length and serum progesterone and LH concentrations as continuous variables.

The categorical modeling (CATMOD) procedures of SAS were used to test the effect of progestagen type, duration of progestagen treatment, time of PMSG administration, BW, BCS and age of does on pregnancy rate, oestrous response and perinatal kid mortalities, as discrete variables. The treatment means were compared by Duncan's multiple range test (DMRT), as described in Gomez and Gomez (1984).

5. 3.RESULTS

5.3.1. Oestrous Response

Three does were excluded from the experiment a day after progestagen withdrawal due to sickness, unrelated to the trial. The overall mean oestrous response of the Somali does following all the synchronization treatments was 97.4% (114/117). Only 3 of the experimental does failed to exhibit oestrus during the monitoring period. One doe from each of treatment group 2 (MAP for 12 days), 4 (MAP for 18 days) and 8 (FGA for 18 days) did not show overt oestrus. The oestrous response of the does was not significantly affected by the type or the duration of intravaginal progestagen sponge treatment and the time of PMSG administration

relative to intravaginal progestagen sponge withdrawal (Table 5.2). Furthermore, oestrous response was not significantly affected by age, BW or BCS of the does at AI.

The effect of oestrous synchronization treatment (combined effect of sponge type and duration of priming period) on the oestrous response is set out in Table 5.3. The oestrous response was slightly lower in treatment group 4 (MAP sponges for 18 days), 6 (FGA sponges for 12 days) and 7 (FGA sponges for 15 days), compared to the other synchronization treatments.

Table 5.2. The overall effect of sponge type, time of PMSG administration on oestrous response of Somali does following different synchronization treatments

Factor	n	Oestrous response (%)
Sponge type		ns
MAP	58	98.3
FGA	59	96.6
Time of PMSG administration		ns
-24h	40	100.0
0h	38	92.1
Control	39	100.0
Doe age (years) at AI		ns
1	72	93.5
6	24	99.9
9	39	100.0
Duration of sponge treatment (days)		ns
9	34	100.0
12	27	96.3
15	32	96.9
18	24	95.8
Doe BW (kg) at AI		ns
15-20	61	96.7
21-30	27	96.7
31-40	17	100.0
41-50	12	100.0
Doe BCS at AI		ns
2.0-2.5	76	96.1
2.6-3.0	32	100.0
3.1-3.50	9	100.0
Overall	117	97.4

n number of does used

ns not significant

Table 5.3. Effect of different oestrous synchronization treatments on oestrus response in Somali goats

Treatment group	n	Oestrous response (%) ^{ns}
1. MAP sponges for 9 days	15	100.0
2. MAP sponges for 12 days	14	100.0
3. MAP sponges for 15 days	15	100.0
4. MAP sponges for 18 days	14	92.9
5. FGA sponges for 9 days	15	100.0
6. FGA sponges for 12 days	15	93.3
7. FGA sponges for 15 days	15	93.3
8. FGA sponges for 18 days	14	100.0
Overall mean	117	97.4

n number of does used

ns not significant

5.3.2. Time to onset and the duration of the induced oestrous period

The overall mean time interval from intravaginal progestagen sponge withdrawal to the onset of oestrus and the duration of the induced oestrus in all synchronized does was 33.3 ± 2.7 h and 35.5 ± 4.2 h, respectively (Table 5.4). Both the time to onset and the duration of oestrus were not significantly affected by the type of progestagen and time of PMSG administration. The time to onset and the duration of the induced oestrus were, however, significantly ($P < 0.05$) affected by the duration of the intravaginal progestagen sponge priming. Oestrus commenced significantly earlier (28.2 ± 4.4 h) in does primed for 9 days, compared to those primed for 12, 15 and 18 days (38.0 ± 5.7 , 35.9 ± 4.9 and 35.6 ± 5.0 h, respectively). No significant difference in time to the onset of oestrus was recorded for does primed for 12, 15 or 18 days. Regarding the duration of the induced oestrous period, it was significantly ($P < 0.05$) longer (42.3 ± 7.7 h) in does primed with intravaginal progestagen sponges for the period of 15 days, compared to does primed for 9, 12 or 18 days (Table 5.4). Does primed for 9 days also stayed in oestrus significantly ($P < 0.05$) longer (34.0 ± 6.8 h), compared to those primed for a period of 12 or 18 days. No significant difference regarding the duration of induced oestrus was recorded between does primed for a period of 12 or 18 days.

The time to onset of oestrus and its duration were not significantly affected by the age and the BCS of the does at AI. However, BW at AI significantly ($P < 0.05$) affected the time to onset of oestrus relative to progestagen sponge withdrawal. For instance, the time to onset of oestrus

was shorter in does weighing between 15 and 20kg and between 41 and 50kg (30.6 ± 3.0 h and 33.6 ± 2.4 h, respectively), compared to does weighing 31 to 40kg (38.4 ± 2.6 h). There were no significant differences regarding this parameter between the groups weighing 15 to 20kg and 41 to 50kg. The duration of the induced oestrus was also significantly ($P < 0.05$) affected by the BW of the does at AI. Does weighing between 15 and 20kg stayed in oestrus significantly ($P < 0.05$) longer (37.3 ± 4.6 h), compared to does weighing between 21 and 30kg and 31 and 40kg at sponge withdrawal (27.9 ± 3.8 and 25.3 ± 4.4 , respectively)

The relationship between the onset of oestrus and the duration of oestrus with BW at AI in all does is illustrated in Figure 5.1. The time to onset of oestrus showed an increasing trend as the BW of does increased from 15 to 40kg, and then declined again when the BW exceeded 40kg.

Both the time to oestrus and the duration of the induced oestrous period were not significantly affected by the duration of progestagen priming (Table 5.4). The longest time to onset of oestrus (41.5h) was recorded in does primed with MAP sponges for a period of 9 days (irrespective of PMSG treatment), compared to those in the other treatment groups. The shortest time to the onset of oestrus was recorded in does primed with MAP sponges for 12 days. Similarly, the shortest mean duration of the induced oestrous period was recorded in does primed with MAP sponges for 15 days, whereas the longest induced oestrous period was observed in does treated with FGA sponges for 18 days.

Table 5.4. The mean (\pm SE) overall effect of progestagen sponge type, the duration of the priming period, time of PMSG administration, age, BW and BCS on the time to onset and duration of the induced oestrous period

Factor	n	Onset of oestrus (h)	Duration of Oestrus (h)
Sponge type		ns	ns
MAP	57	34.4 \pm 1.1	33.5 \pm 1.8
FGA	57	32.1 \pm 1.1	37.5 \pm 1.8
Time of PMSG administration		ns	ns
-24h	40	33.5 \pm 1.9	29.6 \pm 2.8
0h	35	35.6 \pm 1.7	30.6 \pm 2.6
Control	39	34.2 \pm 1.8	33.5 \pm 2.7
Duration of sponge treatment (days)		*	*
9	34	28.2 ^b \pm 4.4	34.0 ^b \pm 6.8
12	26	38.0 ^a \pm 5.7	26.2 ^c \pm 8.9
15	31	35.9 ^a \pm 4.9	42.3 ^a \pm 7.7
18	23	35.6 ^a \pm 5.0	22.3 ^c \pm 7.7
Doe age (years) at AI		ns	ns
1	69	32.0 \pm 1.0	32.3 \pm 4.1
6	24	36.0 \pm 1.7	29.6 \pm 3.2
9	21	34.3 \pm 1.8	31.8 \pm 3.6
Doe BW (kg) at AI		*	*
15-20	59	33.6 ^b \pm 2.4	37.3 ^a \pm 4.6
21-30	26	35.1 ^{ab} \pm 2.5	27.9 ^b \pm 3.8
31-40	17	38.4 ^a \pm 2.6	25.3 ^b \pm 4.4
41-50	12	30.6 ^b \pm 3.0	34.5 ^{ab} \pm 5.2
Doe BCS at AI		ns	ns
2.0-2.5	73	33.2 \pm 2.0	31.6 \pm 3.0
2.6-3.0	32	34.0 \pm 1.9	31.4 \pm 2.9
3.1-3.5	9	36.1 \pm 4.3	30.7 \pm 6.7
Overall mean	114	33.3 \pm 2.7	35.5 \pm 4.2

^{a, b, c} Means in a column for the same parameter with different superscripts differ significantly ($P < 0.05$)

* Significant ($P < 0.05$)

n number of does exhibiting oestrus

ns not significant

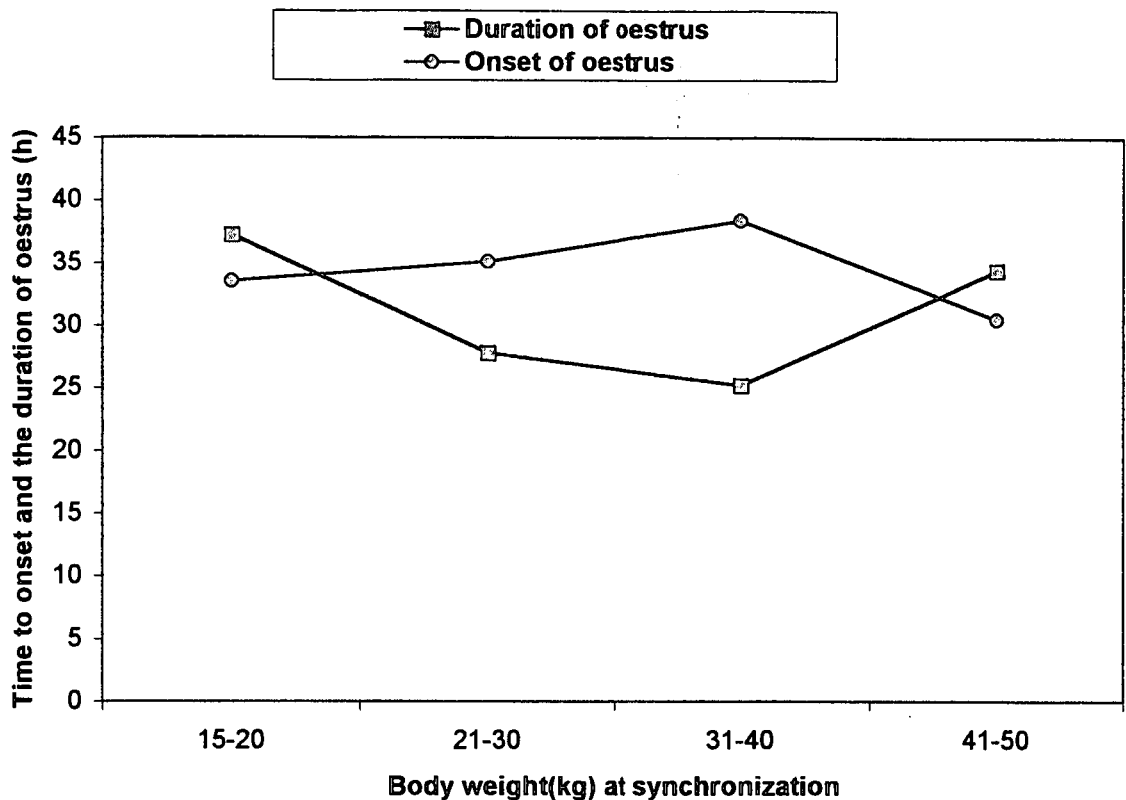


Figure 5.1. Effect of body weight at synchronization on the time to oestrus and the duration of induced oestrus in Somali does

Table 5.5. Effect of Synchronization treatment (irrespective of PMSG administration) on the time to oestrus and the duration of induced oestrus in Somali does

Oestrous synchronization treatment	n	Onset of oestrus (h) (Mean±SE) ^{ns}	Duration of oestrus (h) (Mean±SE) ^{ns}
1. MAP sponges for 9 days	15	41.5±4.7	28.4±7.1
2. MAP sponges for 12 days	14	29.1±6.5	36.9±10.2
3. MAP sponges for 15 days	14	34.6±5.5	22.0±8.6
4. MAP sponges for 18 days	15	35.0±5.1	36.4±7.8
5. FGA sponges for 9 days	14	40.1±4.7	25.5±7.2
6. FGA sponges for 12 days	14	31.2±5.3	37.1±8.4
7. FGA sponges for 15 days	14	30.2±5.7	24.5±8.9
8. FGA sponges for 18 days	14	33.8±4.1	38.9±6.3
Overall mean	114	33.3±2.7	35.5±4.2

n number of does exhibiting oestrus

ns not significant

5.3.3. Intravaginal sponge losses

During the synchronization period, 10 does (8.3%) in a total lost their sponges. From the total of 10 losses, 60% (6/10) were recorded for MAP sponges and the remaining 40% for the FGA sponges. The percentage of sponge losses were also found to be higher in the 9-year-old does (50%), compared to in the 1 and 6-year old does (30 and 20%, respectively).

5.3.4. Serum progesterone concentrations

The effect of intravaginal progestagen sponge type on the mean serum progesterone concentration during sponge treatment and for the 96h period following sponge withdrawal is illustrated in Figure 5.2. No significant differences in the serum progesterone levels between does treated with MAP or FGA sponges were recorded. The mean serum progesterone concentration for both sponge types increased from 1.89ng/ml at sponge insertion to 2.23ng/ml on day 3 of sponge treatment. The mean concentration dropped to below 1ng/ml during the 80h period following intravaginal sponge removal, and then increased again to above 1ng/ml (Figure 5.2). The lowest overall serum progesterone level (0.5ng/ml) was recorded 32h after intravaginal progestagen sponge withdrawal.

Figure 5.3 illustrates the effect of the duration of intravaginal progestagen sponge treatment on the serum progesterone concentration pattern following sponge withdrawal. In does treated with progestagen sponges for a period of 18 days, the mean serum progesterone concentration remained below 1ng/ml throughout the 96h period post sponge withdrawal. Unlike the 18-day sponge treated groups, the mean serum progesterone concentration in the 9, 12 and 15-day sponge treated does started to increase by 32h following sponge withdrawal. There were no obvious differences in the pattern of the mean serum progesterone concentration for does treated with intravaginal progestagen sponges for a period of 9, 12 or 15 days.

The effect of the type and the duration of intravaginal progestagen sponge treatment and the time of PMSG administration in relation to intravaginal progestagen sponge withdrawal on serum progesterone concentration are depicted in Table 5.6. No significant differences in serum progesterone concentration between MAP and FGA sponge treated does at 0h, 8h, 16h,

24h, 32h, 48h, 56h, 64h, 72h and 88h following sponge withdrawal were recorded. The mean serum progesterone concentration at 40h, 80h and 96h was, however, significantly higher ($P < 0.05$) in the MAP treated does (0.91 ± 0.10 ng/ml, 1.22 ± 0.11 ng/ml and 1.80 ± 0.16 ng/ml, respectively) compared to the FGA treated ones (0.59 ± 0.10 ng/ml, 0.76 ± 0.11 ng/ml and 1.05 ± 0.16 ng/ml, respectively).

Regarding the duration of intravaginal progestagen sponge treatment (MAP and FGA) on serum progesterone concentration following sponge withdrawal, significant differences ($P < 0.05$) were recorded at 40h, 72h and 96h post sponge withdrawal (Table 5.6). The overall mean serum progesterone concentration was significantly lower in the 18-day progestagen treated groups (0.34 ± 0.15 ng/ml), compared to the 9, 12 and 15-day treated groups (0.84 ± 0.13 ng/ml, 0.95 ± 0.13 ng/ml and 0.88 ± 0.12 ng/ml, respectively). No significant differences in the serum progesterone concentration were recorded between the 9, 12 and 15-day sponge (FGA and MAP) treated groups, while the mean serum progesterone concentration 72h post sponge withdrawal was found to be significantly ($P < 0.05$) lower in the 18-day sponge treated group (0.42 ± 0.17 ng/ml), compared to the 9, 12 and 15-day treatment groups. Furthermore, the serum progesterone level 96h post sponge withdrawal was significantly ($P < 0.05$) lower in 18-day treated groups (0.38 ± 0.24 ng/ml), compared to the 9, 12 and 15-day sponge treated groups.

Besides the type of sponge and the duration of the intravaginal progestagen treatment, time of PMSG administration in relation to sponge withdrawal significantly affected ($P < 0.05$) the mean serum progesterone concentration at 72h, 80h and 96h post sponge withdrawal. In all cases, PMSG administration at sponge withdrawal (irrespective of sponge type) resulted in significantly ($P < 0.05$) lower serum progesterone concentration, compared to PMSG administration at 24h before or 24h after intravaginal progestagen withdrawal.

Table 5.6. The effect of the type and duration of intravaginal progestagen impregnated sponge treatment and time of PMSG administration relative sponge withdrawal on subsequent serum progesterone concentration of Somali does

Time (h) from sponge withdrawal	Serum progesterone concentration (ng/ml)								
	Type of sponge		Duration of progestagen treatment (days)				Time of PMSG administration (h) relative to sponge withdrawal		
	*		*				*		
	MAP	FGA	9	12	15	18	-24h	0	24
0	0.64±0.10	0.68±0.10	0.71±0.13	0.64±0.14	0.65±0.13	0.65±0.15	0.59±0.10	0.58±0.12	0.81±0.11
8	0.56±0.07	0.68±0.07	0.61±0.09	0.58±0.09	0.60±0.09	0.69±0.11	0.56±0.07	0.71±0.08	0.59±0.08
16	0.56±0.06	0.58±0.06	0.58±0.08	0.61±0.08	0.54±0.08	0.56±0.09	0.59±0.06	0.57±0.07	0.56±0.07
24	0.56±0.06	0.58±0.06	0.58±0.08	0.61±0.08	0.54±0.08	0.56±0.09	0.59±0.06	0.57±0.07	0.56±0.07
32	0.63±0.06	0.56±0.06	0.62±0.07	0.64±0.08	0.64±0.07	0.47±0.09	0.65±0.06	0.58±0.07	0.55±0.06
40	0.65±0.10	0.59±0.10	0.84±0.13 ^a	0.95±0.13 ^a	0.88±0.12 ^a	0.34±0.15 ^b	0.76±0.10	0.72±0.11	0.76±0.11
48	0.96±0.13	0.71±0.13	0.91±0.17	1.07±0.18	0.93±0.16	0.42±0.20	0.77±0.13	0.78±0.15	0.95±0.15
56	1.02±0.12	0.75±0.12	1.05±0.15	1.00±0.16	0.96±0.15	0.52±0.18	0.71±0.12	0.83±0.14	1.10±0.13
64	1.02±0.13	0.76±0.13	1.00±0.16	1.02±0.17	0.98±0.15	0.54±0.19	0.74±0.13	0.76±0.14	1.16±0.14
72	1.11±0.12	0.78±0.12	1.19±0.15	1.10±0.16	0.98±0.15	0.50±0.18	0.80±0.12 ^a	0.77±0.14 ^b	1.26±0.13 ^a
80	1.22±0.11 ^a	0.76±0.11 ^b	1.26±0.14 ^a	1.30±0.15 ^a	0.98±0.14 ^b	0.42±0.17 ^c	0.88±0.12 ^b	0.81±0.13 ^b	1.29±0.12 ^a
88	1.42±0.17	1.09±0.17	1.63±0.21	1.32±0.22	1.37±0.21	0.71±0.25	1.05±0.17	1.11±0.19	1.61±0.19
96	1.80±0.16 ^a	1.05±0.16 ^b	1.66±0.20 ^a	2.06±0.21 ^a	1.61±0.20 ^a	0.38±0.24 ^b	1.13±0.16 ^b	1.30±0.18 ^b	1.85±0.18 ^a

^{a, b, c}, Means in a row and for the same parameter with different superscripts differ significantly (P<0.05)

* Significant (P<0.05)

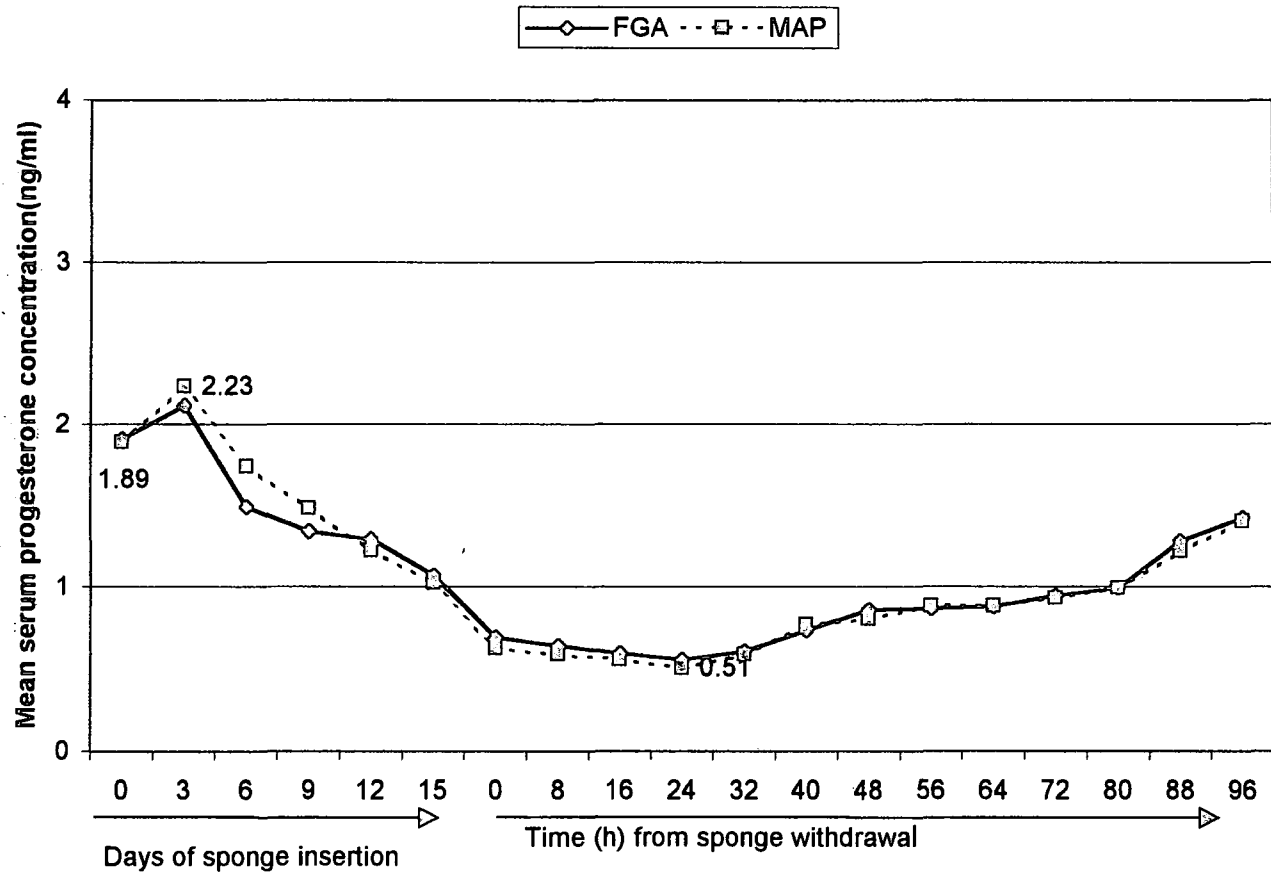


Figure 5.2. Effect of intravaginal progestagen sponge type on serum progesterone concentration during and following progestagen withdrawal in Somali does

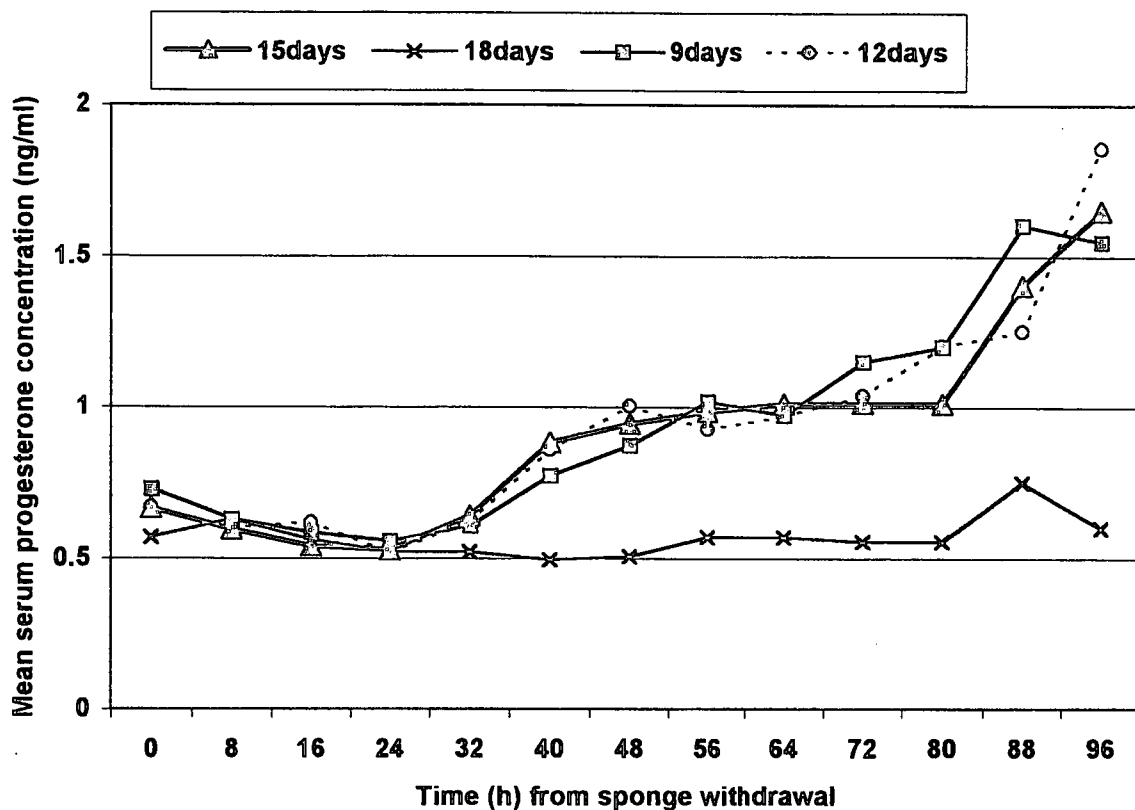


Figure 5.3. Effect of duration of progestagen treatment on serum progesterone concentration following sponge withdrawal in Somali does

5.3.5. Serum LH concentrations

The pre-ovulatory LH peak (>5ng/ml) was observed in only 32.5% (13/40) of does. The effect of synchronization treatment on the percentage of does exhibiting the pre-ovulatory LH peak, the interval from sponge withdrawal to the LH peak and from the onset of oestrus to the LH peak is set out in Table 5.7. The proportion of does exhibiting the pre-ovulatory LH surge was variable and inconsistent across treatment groups. The percentage of does showing the pre-ovulatory LH peaks was higher in treatment group 3 (MAP + 15 days), 5 (FGA + 9 days) and 6 (FGA+12 days), compared to the rest of the treatment groups (Table 5.7). The lowest percentage of ewes

exhibiting the pre-ovulatory LH surge was observed in treatment group 1 (MAP + 9days). The pre-ovulatory LH peak was observed between 32h and 56h post progestagen sponge withdrawal in all does that exhibited a pre-ovulatory LH surge. Similarly, in most of the does (17.5%) that exhibited the LH peak, the onset of oestrus and the LH peak occurred at approximately the same time (Figure 5.5)

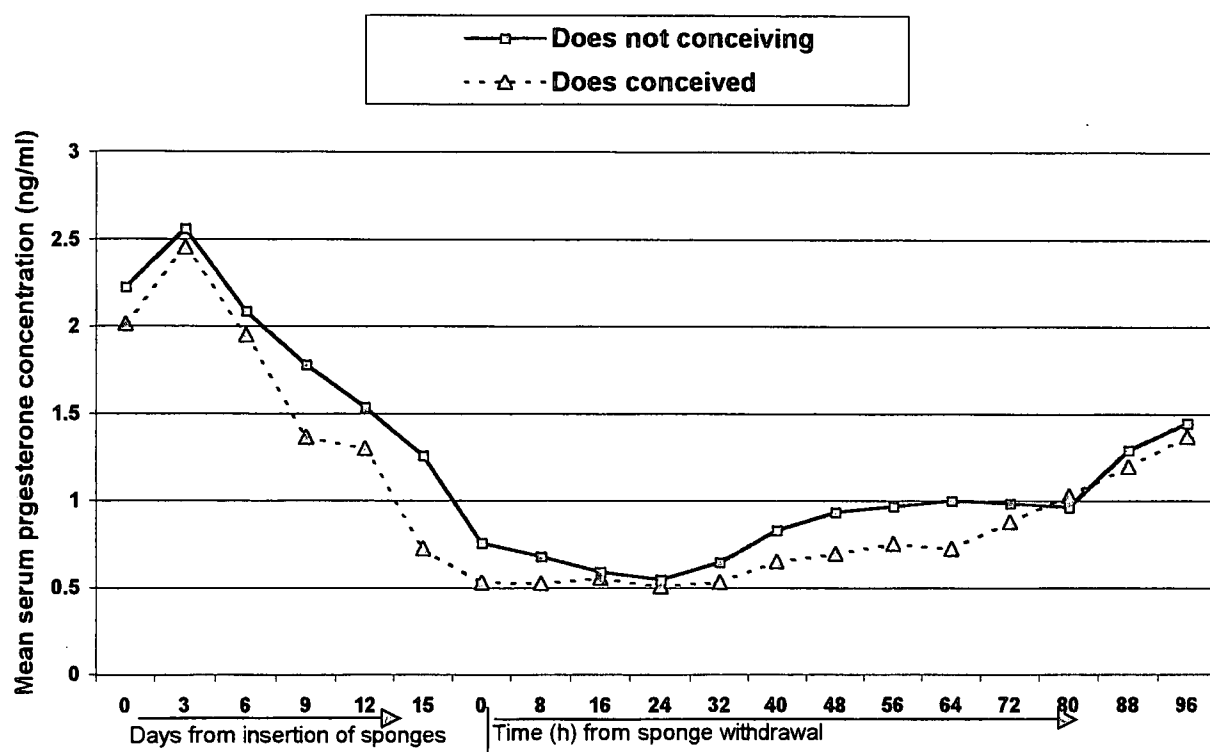


Figure 5.4. Mean serum progesterone concentrations in does that conceived and failed to conceive at the induced oestrus

The occurrence of the pre-ovulatory LH peak relative to progestagen sponge withdrawal was variable. The incidence of the LH peak ranged from 32h to 56h from the time of sponge withdrawal. There were no significant difference in the proportion of does exhibiting a LH peak between the MAP and FGA treated groups. The time from progestagen withdrawal to the LH peak, onset of oestrus to the LH peak and the LH peak to the end of oestrus were not significantly different between the MAP and FGA treated groups. The patterns of serum LH concentration in MAP and FGA treated does are presented in Figure 5.6.

Similarly, no significant variation was recorded between the 9, 12 and 15-day progestagen treatment groups regarding the percentage of does exhibiting a LH peak, the interval from sponge withdrawal to LH peak and onset of oestrus to LH peak (Table 5.8 and Figure 5.8). No difference in the proportion of does exhibiting a LH peak, the interval from progestagen withdrawal to LH peak and mean serum LH concentration was noted between does administered PMSG 24h prior to progestagen withdrawal, at progestagen withdrawal or the control group (Table 5.8 and Figure 5.7).

Table 5.7. Effect of synchronization treatment (irrespective of PMSG) on the interval from progestagen withdrawal to LH peak and onset of oestrus to LH peak

Synchronization treatment	% does exhibiting a LH peak	Progestagen withdrawal to LH peak (h)	Onset of oestrus to LH peak (h)	Mean (mean±SE) Serum LH (ng/ml)
1. MAP for 9 days	1/7 (14.3)	40	0	0.86±0.21
2. MAP for 12 days	3/8 (37.5)	48	10.7	1.23±0.16
3. MAP for 15 days	2/5 (40.0)	40	4	1.22±0.35
4. MAP for 18 days	1/3(33.3)	56	0	0.97±0.26
5. FGA for 9 days	2/5 (40.0)	40	0	0.91±0.32
6. FGA for 12 days	2/5(40.0)	45.3	13.3	1.47±0.23
7. FGA for 15 days	1/4 (25.0)	32	0	1.25±0.24
8. FGA for 18 days	1/3 (33.3)	32	0	0.82±0.40
Overall mean	13/40(32.5)	41.7	3.5	1.10±0.22

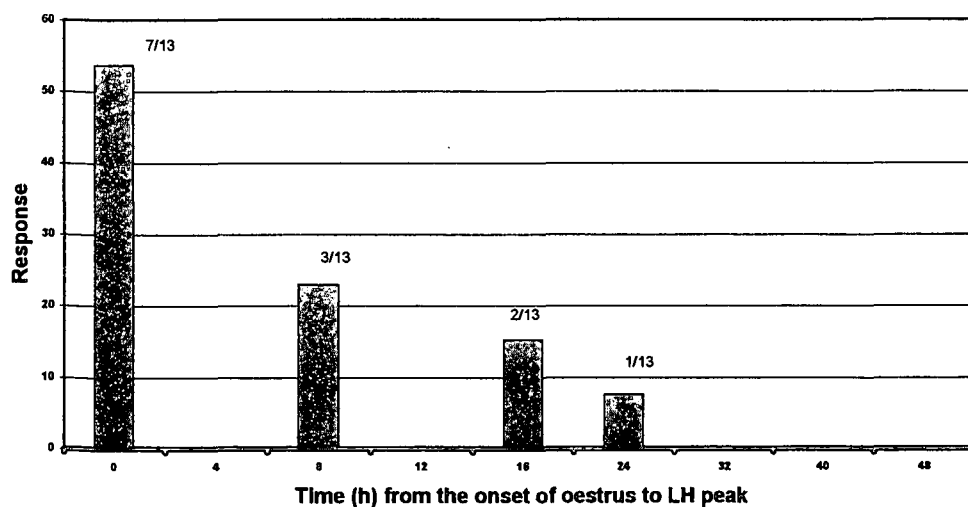


Figure 5.5. Distribution of the occurrence of a LH peak after the onset of synchronized oestrus in Somali does

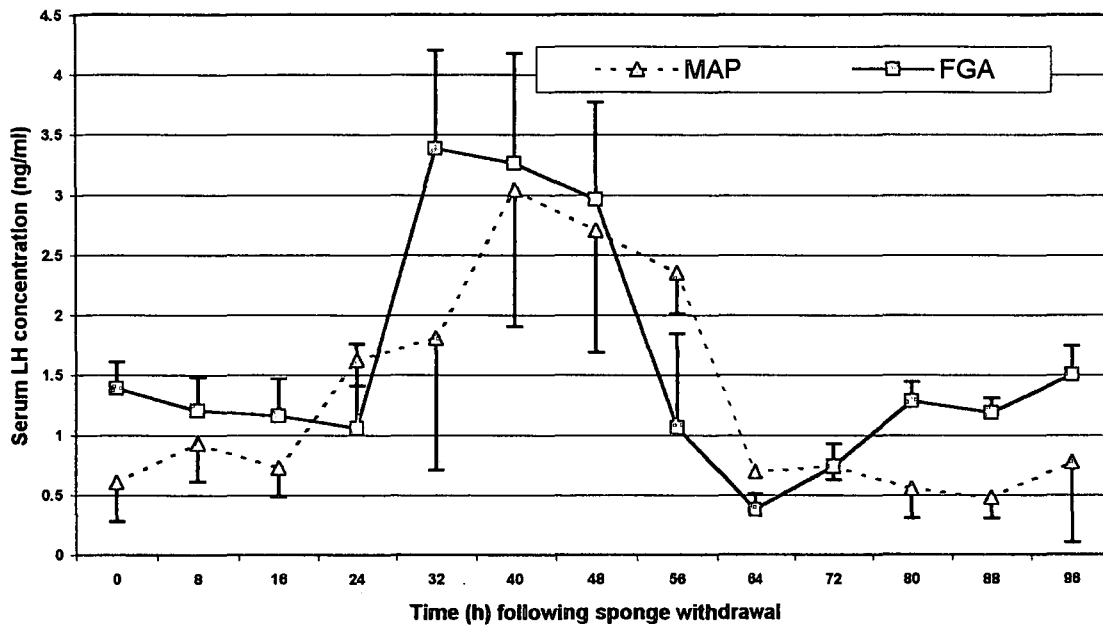


Figure 5.6. Effect of progestagen type on post sponge withdrawal mean serum LH concentrations in Somali does

The effect of type of progestagen sponge, duration of progestagen priming and time of PMSG administration on the number of does exhibiting a LH peak, the interval from progestagen withdrawal to LH peak, the onset of oestrus to LH peak, and the LH peak to the end of oestrus are shown in Table 5.8.

Table 5.8. The effect of sponge type, duration of progestagen treatment and time of PMSG administration on the proportion of does exhibiting a pre-ovulatory LH peak and on the position of LH Peak

Response	Sponge type		Duration of treatment (days)				Time of PMSG administration		
	ns		ns						
	MAP	FGA	9	12	15	18	-24h	0h	Control
Number of ewes exhibiting LH peak	7/20 (35%)	6/20 (30%)	3/10 (30%)	2/10 (20%)	4/10 (40%)	4/10 (40%)	2/15 (13.3%)	6/12 (50%)	5/13 (38.5%)
Time of sponge withdrawal to LH peak (h)	45.7±3.4	40.0±2.9	37.3±2.7	44.0±4.0	40.0±4.6	50.0±3.8	44.0±12.0	44.0±3.4	41.6±3.0
Onset of oestrus to LH peak (h)	5.7±3.4	6.7±3.2	na	12.0±4.0	6.0±3.8	8.0±5.7	na	8.0±4.1	6.4±3.0
LH peak to end of oestrus (h)	28.6±7.9	30.7±4.8	na	24.0±8.0	38.0±9.5	18.0±8.3	na	26.7±7.9	25.6±3.0
Mean serum LH concentration (ng/ml)	1.0±0.2	1.2±0.2	1.1±0.3	0.8±0.2	1.0±0.2	1.6±0.2	0.9±0.1	1.1±0.1	1.3±0.1

ns not significant

na Signs of oestrus not observed

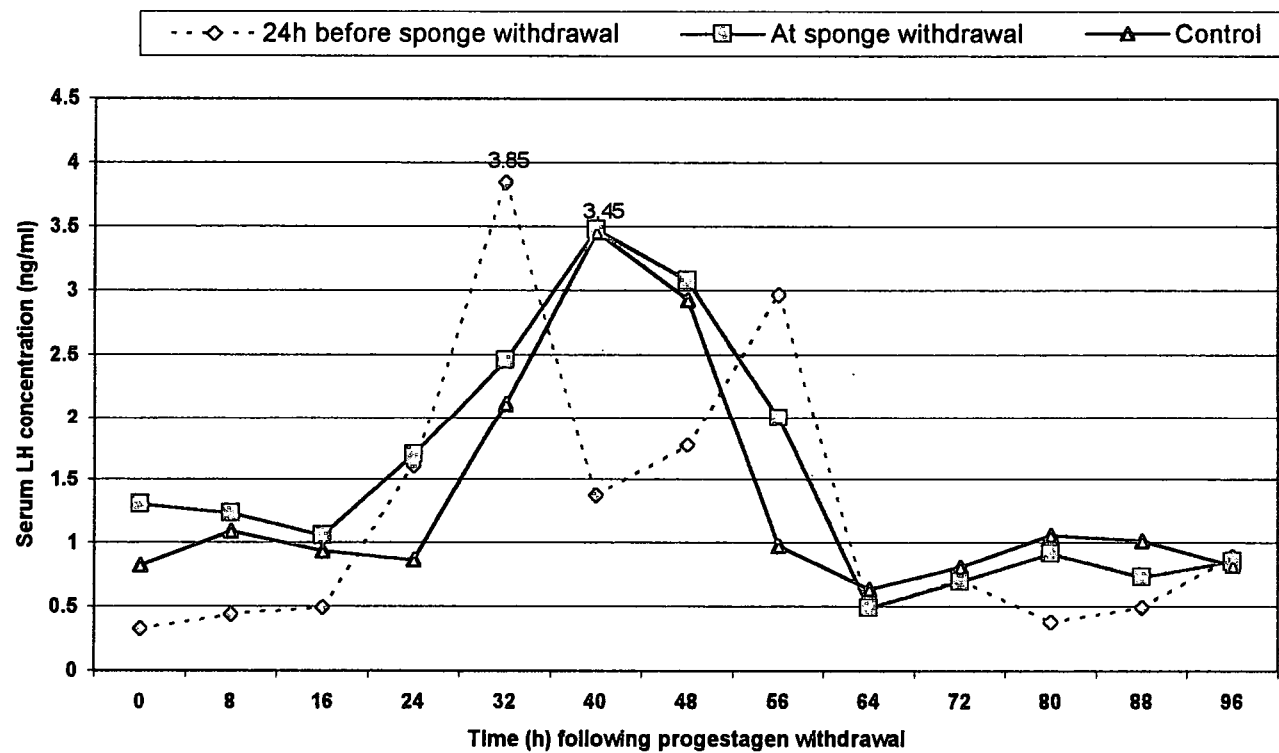


Figure 5.7. Effect of time of PMSG administration on serum LH concentration in Somali does

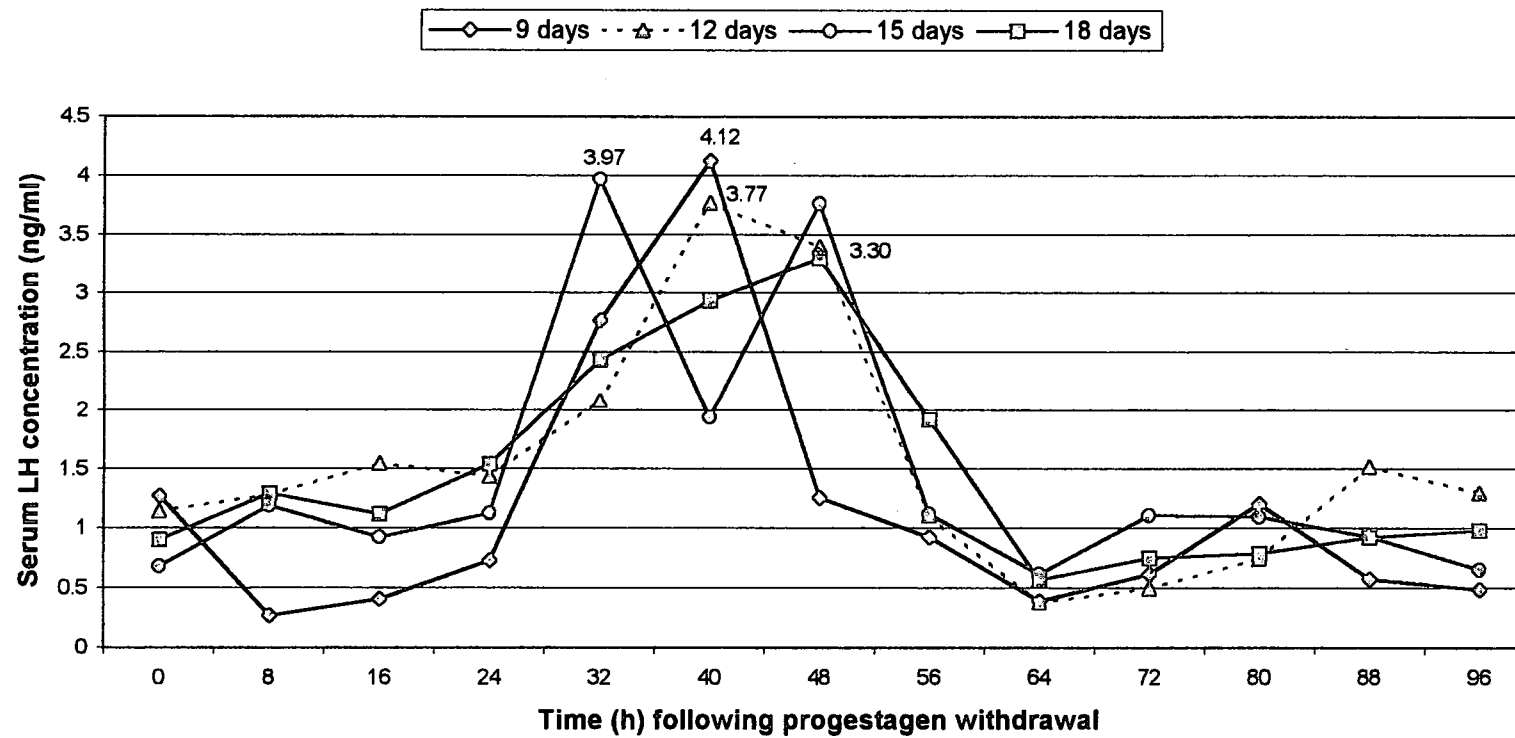


Figure 5.8. Effect of duration of progestagen treatment period on post withdrawal serum LH concentration in Somali does

5.3.6. Reproductive performance following oestrous synchronization and AI

The overall pregnancy and non-return rates for all oestrous synchronized and artificially inseminated does were 31.5% and 62.4%, respectively (Table 5.9). The type and the duration of intravaginal progestagen sponge priming did not significantly affect the pregnancy rate. The pregnancy rate, however, tended to increase in does primed for 15 days (40.0%). The lowest pregnancy rates were recorded in the 9-day and 18-day primed groups (25.8% and 27.3%, respectively), irrespective of the time of PMSG administration.

However, when the time of PMSG administration relative to intravaginal progestagen sponge withdrawal is taken into account, it significantly ($P < 0.05$) affected the pregnancy rate, with pregnancy rate being higher in the control does (39.5%), compared to does administered PMSG either at 24h before sponge withdrawal (25.7%) or at sponge withdrawal (28.6%).

Age, BW and BCS of does at AI significantly ($P < 0.05$) affected the pregnancy rate (Table 5.10). The pregnancy rate was higher in the 6-year-old does (60.9%) compared to 1 and 9-year-old does (25.8% and 17.7%, respectively). The pregnancy rate was also significantly ($P < 0.05$) higher in does weighing between 21 and 30kg at AI (40.7%), compared to those weighing between 15 and 20 kg (24.6%), but not different between does with a BW of 21 to 30kg and 41 to 50kg. Furthermore, a higher pregnancy rate was achieved in does with a BCS between 2.6 and 3.0 (44.8%), compared to does below or above this BCS at AI (Table 5.10). Does with a BCS of 3.1 to 3.5 also resulted in a significantly ($P < 0.05$) higher pregnancy rate (37.5%), compared to those with a BCS of 2.0 to 2.5 at AI (25.4%).

The overall non-return rate was not significantly affected by the type and the duration of intravaginal progestagen sponge treatment or the time of PMSG administration relative to sponge withdrawal (Table 5.9). The non-return rate was also not significantly affected by the age of does, however, it was significantly ($P < 0.05$) affected by the BW and BCS at AI. The non-return rate was significantly higher ($P < 0.05$) in does weighing between 41 and 50kg (91.7%), compared to does weighing between 15 and 20kg; 21 and 30kg or 31 and 40kg (Table 5.10). The non-

return rate (100%) was significantly ($P<0.05$) higher in does with a BCS of 3.1 to 3.5, compared to does with other BCS's.

Unlike both the non-return and the pregnancy rates, kidding rate as such was not significantly affected by any of the factors considered in this trial (Tables 5.9 and 5.10) except for the time of PMSG injection and age of the does. The kidding rate was significantly ($P<0.05$) higher in the control does (44.7%), compared to all the does administered PMSG regardless of the time of administration. Furthermore, the kidding rate was higher ($P<0.05$) in the 6-year-old does (60.9%) compared to 1 and 9-year old does (27.9% and 29.4%, respectively). Fecundity was not affected by any of the factors considered in this trial (Table 5.9 and 5.10). The type of progestagen treatment showed no significant effect on the pregnancy rate (Table 5.11). There was no a clear-cut difference in the kidding and fecundity rates in does receiving the different synchronization treatments.

Table 5.9. Effect of progestagen sponge type, duration of sponge treatment and time of PMSG administration on the reproductive performance of Somali does

Sponge type	n	Pregnancy rate (%)	Non-return rate (%)	Kidding rate (%)	Fecundity (%)
		ns	ns	ns	ns
MAP	58	30.8	65.5	32.7(17/52)	106.3(17/16)
FGA	59	32.1	59.3	37.5(21/56)	116.7(21/18)
Time of PMSG administration		*	ns	*	ns
-24h	40	25.7 ^b	62.5	31.4(11/35) ^b	122.2(11/9)
0h	38	28.6 ^b	63.2	28.6(10/35) ^b	100.0(10/10)
Control	39	39.5 ^a	61.5	44.7(17/38) ^a	113.3(17/15)
Duration of sponge treatment (days)		ns	ns	ns	ns
9	34	25.8	58.8	29.0(9/31)	112.5(9/8)
12	27	32.0	63.0	36.0(9/25)	112.5(9/8)
15	32	40.0	56.3	43.3(13/30)	108.3(13/12)
18	24	27.3	75.0	31.8(7/22)	116.7(7/6)
Overall	117	31.5	62.4	35.2	112

^{a, b} Means in a column for the same parameter with different superscripts differ significantly ($P<0.05$)

* Significant ($P<0.05$)

n number of does at kidding

ns not significant

Table 5.10. Effect of age, body weight and body condition score on the reproductive performance of does following oestrous synchronization and AI

Factor	n	Pregnancy rate (%)	Non-return rate (%)	Kidding rate (%)	Fecundity (%)
Age (years)		*	ns	*	ns
1	72	25.8 ^b	58.3	27.9(19/68) ^b	111.8(19/17)
6	24	60.9 ^a	75.0	60.9(14/23) ^a	100.0(14/14)
9	21	17.7 ^b	61.9	29.4(5/17) ^b	166.7(5/3)
BW (kg)		*	*	ns	ns
15-20	61	24.6 ^b	57.4 ^b	26.3(15/57)	107.1(15/14)
21-30	27	40.7 ^a	63.0 ^{ab}	44.4(12/27)	109.1(12/11)
31-40	17	42.9 ^a	58.8 ^{ab}	50.0(7/14)	116.7(7/6)
41-50	12	30.0 ^{ab}	91.7 ^a	40.0(4/10)	133.3(4/3)
BCS		*	*	*	ns
2.0-2.5	76	25.4 ^c	59.2 ^b	26.8(19/71) ^b	105.6(19/18)
2.6-3.0	32	44.8 ^a	59.4 ^b	51.7(15/29) ^a	115.4(15/13)
3.1-3.5	9	37.5 ^b	100.0 ^a	50.0(4/8) ^a	133.3(4/3)
Overall	117	31.5	62.4	35.2	112

^{a, b, c} Means in a column for the same parameter with different superscripts differ significantly ($p < 0.05$).

* Significant ($P < 0.05$)

ns not significant

n number of does at kidding

Table 5.11. Reproductive performance of Somali does following oestrous synchronization with MAP or FGA, irrespective of the PMSG treatment

synchronization treatment	n	Pregnancy rate (%) ^{ns}	Non-return rate (%) ^{ns}	Kidding rate (%) ^{ns}	Fecundity rate (%) ^{ns}
1. MAP sponges for 9 days	15	38.5	66.7	53.9(7/13)	140.0(7/5)
2. MAP sponges for 12 days	14	46.2	57.1	46.2(6/13)	100.0(6/6)
3. MAP sponges for 15 days	15	30.8	60.0	30.8(4/13)	100.0(4/4)
4. MAP sponges for 18 days	14	21.4	78.6	28.6(4/14)	133.3(4/3)
5. FGA sponges for 9 days	15	14.3	53.3	21.4(3/14)	150.0(3/2)
6. FGA sponges for 12 days	15	14.3	66.7	14.3(2/14)	100.0(2/2)
7. FGA sponges for 15 days	15	42.9	53.3	42.9(6/14)	100.0(6/6)
8. FGA sponges for 18 days	14	46.2	64.3	46.2(6/13)	100.0(6/6)
Overall mean	117	31.5	62.4	35.2	111.8

n number of does at kidding

ns not significant

5.3.7. Litter size of Somali goats following oestrous synchronization and AI

The mean litter size recorded in Somali does following oestrous synchronization and AI with fresh diluted semen is set out in Table 5.12. The overall mean litter size recorded in this study was 1.1 ± 0.1 . No significant differences in litter size were observed due to sponge type, duration of treatment, time of PMSG administration, BW or BCS at the time of AI. However, a significant ($P < 0.01$) difference in litter size was observed in does of the different age groups. The 9-year-old does yielded a significantly ($P < 0.01$) higher litter size (1.7), compared to 1 to 6-year-old does (1.1 ± 0.1 and 1.0 ± 0.1 , respectively).

Although not significantly different, relatively higher litter size was obtained from does in the synchronization treatment group 5 (FGA sponges for 9 days) and 1 (MAP sponges for 9 days) compared to other treatment groups (Table 5.13).

Table 5. 12. The effect of type of progestagen and duration of sponge treatment, time of PMSG administration, age, body weight and body condition score of does on litter size

Parameter	n	Litter size (Mean±SE)
Sponge type		ns
MAP	17	1.1±0.1
FGA	17	1.2±0.1
Duration of sponge treatment (days)		ns
9	7	1.3±0.2
12	9	1.2±0.1
15	12	1.2±0.1
18	6	1.2±0.2
Time of PMSG administration		ns
-24h	9	1.3±0.2
0h	10	1.1±0.2
Control	15	1.2±0.1
Doe age (years) at AI		**
1	17	1.1±0.1 ^b
6	14	1.0±0.1 ^b
9	3	1.7±0.2 ^a
Doe BW (kg) at AI		ns
15-20	14	1.1±0.1
21-30	11	1.1±0.1
31-40	6	1.2±0.1
41-50	3	1.3±0.2
Doe BCS at AI		ns
2.0-2.5	18	1.1±0.1
2.6-3.0	13	1.1±0.1
3.1-3.5	3	1.4±0.2
Overall mean	34	1.1±0.1

^{a, b} Means in a column for the same parameter with different superscripts differ significantly

* Significant (P<0.05)

n number of does kidded

ns not significant

Table 5.13. Effect of synchronization treatment (irrespective of PMSG administration) on litter size from induced oestrus and AI in Somali does

Synchronization treatment	n	Litter size ^{ns}
1. MAP sponges for 9 days	5	1.4±0.1
2. MAP sponges for 12 days	6	1.0±0.1
3. MAP sponges for 15 days	4	1.0±0.2
4. MAP sponges for 18 days	3	1.3±0.2
5. FGA sponges for 9 days	2	1.5±0.2
6. FGA sponges for 12 days	2	1.0±0.2
7. FGA sponges for 15 days	6	1.0±0.1
8. FGA sponges for 18 days	6	1.0±0.1
Overall mean	34	1.1±0.1

n number of does kidded

ns not significant

5.3.8. Gestation length following oestrous synchronization and AI in Somali does

The mean gestation length (days) in oestrous synchronized and artificially inseminated Somali does are set out in Table 5.14. The overall mean gestation length for all does was 149.4 days. In this study, gestation length of the does was not significantly affected by the type and duration of intravaginal progestagen sponge treatment, time of PMSG administration, age, BW, BCS of does at AI and sex of the kids. Gestation length was, however, significantly ($P<0.01$) affected by litter size. Single fetuses were carried for a longer period (149.9 ± 0.5 days), compared to twin fetuses (143.5 ± 1.4 days).

Table 5.14. The effect of type and duration of intravaginal progestagen treatment, time of PMSG administration, age body weight and body condition score, litter size and sex of the kids on gestation length in Somali does

Parameter	n	Gestation length (days)
Sponge type		ns
MAP	17	149.2±1.1
FGA	17	149.5±1.0
Duration of sponge treatment (days)		ns
9	7	149.3±1.5
12	9	150.1±1.5
15	12	148.7±1.2
18	6	149.4±1.6
Time of PMSG administration		ns
-24h	9	146.4±1.0
0h	10	145.7±1.2
Control	15	148.0±0.9
Doe age (years) at AI		ns
1	17	148.2±1.4
6	14	150.2±1.0
9	3	147.7±2.0
Doe BW (kg) at AI		ns
15-20	14	150.8±1.6
21-30	11	147.8±1.2
31-40	6	147.6±1.6
41-50	3	148.7±2.1
Doe BCS at AI		ns
2.0-2.5	18	150.0±0.9
2.6-3.0	13	148.6±1.0
3.1-3.5	3	149.5±2.2
Litter size		**
1	30	149.9±0.5 ^a
2	4	143.5±1.4 ^b
Sex of the kids		ns
Male	19	146.7±0.9
Female	15	146.7±0.9
Overall mean	34	149.4

^{a, b} Means in a column for the same parameter with different superscripts differ significantly (P<0.01)

** Significant (P<0.01)

n number of does kidded

ns not significant

5.3.9. Kid birth weight and total litter weight of Somali goats born following oestrous synchronization and AI

The mean birth weight and the total litter weight of the Somali goat kids born following oestrous synchronization and AI are set out in Table 5.15. The overall mean kid birth weight and total litter weight of the Somali goats were recorded as 2.7 ± 0.1 and 3.2 ± 0.2 kg, respectively. The type and the duration of the intravaginal progestagen sponge treatment; the litter size or the sex of the kids had no significant effect on the birth weight of kids. However, the time of PMSG administration relative to intravaginal progestagen sponge withdrawal, age and BCS of does at AI incurred a significant ($P<0.05$) effect on kid birth weight. Kids born from the PMSG treated does at sponge withdrawal were significantly lighter (2.4 ± 0.3 kg) than kids born from does injected with PMSG 24h prior to sponge withdrawal (3.0 ± 0.3 kg) or the control group (2.8 ± 0.2 kg). Similarly, 1-year-old does produced significantly lighter (2.6 kg) kids, compared to 6 and 9-year-old does (3.1 ± 0.2 kg and 3.4 ± 0.4 kg, respectively).

Regarding BCS at the time of AI, it was found that does with a BCS of 2.0 to 2.5 produced lighter kids (2.1 ± 0.2 kg) than does with a BCS of 3.1 to 3.5 (3.3 ± 0.4 kg). The birth weight of kids born from does with BCS of 2.6 to 3.0 did not differ significantly from those born from does with a BCS of 2.0 to 2.5 or 3.1 to 3.5.

The total litter weight was not significantly affected by the type and the duration of intravaginal progestagen sponge treatment, time of PMSG administration relative to sponge withdrawal or sex of the kids (Table 5.15). On the other hand, age, BW and BCS of the does at AI did significantly ($P<0.01$) affected the total litter weight. In general, 9-year-old does produced heavier litters (5.5kg) than the 1 and 6-year-old does (3.5 and 3.2kg, respectively). Similarly, the heavier does (41-50kg) produced heavier ($P<0.01$) litter weights than the lighter groups. As it was the case with BW at the time of AI, there was an apparent increase in the total litter weight as the BCS of does increased from 2.0 to 3.5 (Figure 5. 9). Does with a BCS of 3.1 to 3.5 produced the heaviest ($P<0.05$) litters (4.9kg), compared to those with a BCS of 2.0 to 2.5 or 2.6 to 3.0 at AI (Table 5.15).

Table 5.15. Effect of sponge type, duration of treatment, time of PMSG administration, age, body weight and body condition of does, litter size and sex of kids on kid birth weight in Somali does

Parameter	n	Kid birth weight (Mean±SE)	Total litter weight(Mean±SE)
Sponge type		ns	ns
MAP	18	2.8±0.2	4.1±0.3
FGA	20	2.6±0.2	4.0±0.3
Duration of sponge treatment (days)		ns	ns
9	8	2.7±0.3	4.2±0.4
12	10	2.7±0.3	3.9±0.4
15	13	2.5±0.3	3.7±0.3
18	7	2.9±0.3	4.5±0.4
Time of PMSG administration		*	ns
-24h	11	3.0±0.3 ^a	4.3±0.4
0h	10	2.4±0.3 ^b	3.8±0.4
Control	17	2.8±0.2 ^a	4.1±0.3
Doe age (years) at AI		*	**
1	19	2.6±0.3 ^b	3.5±0.3 ^d
6	14	3.1±0.2 ^a	3.2±0.3 ^d
9	5	3.4±0.4 ^a	5.5±0.4 ^c
Doe BW (kg) at AI		ns	**
15-20	15	2.4±0.3 ^b	2.8±0.4 ^e
21-30	12	3.0±0.2 ^a	3.6±0.3 ^d
31-40	7	3.3±0.3 ^a	4.7±0.4 ^c
41-50	4	3.4±0.4 ^a	5.0±0.5 ^c
Doe BCS at AI		*	*
2.0-2.5	19	2.1±0.2 ^b	3.3±0.3 ^e
2.6-3.0	15	2.7±0.3 ^{ab}	4.0±0.3 ^b
3.1-3.5	4	3.3±0.4 ^a	4.9±0.5 ^a
Litter size		ns	**
1	30	2.3±0.2	3.1±0.2 ^d
2	8	2.4±0.3	5.0±0.4 ^c
Sex of kid		ns	ns
Male	22	2.9±0.2	4.4±0.3
Female	16	2.6±0.2	3.7±0.3
Overall mean	38	2.7±0.1	3.2±0.2

^{a, b} Means in a column for the same parameter with different superscripts differ significantly (P<0.05)

^{a, d, e} Means in a column for the same parameter with different superscripts differ significantly (P<0.01)

** Significant (P<0.05)

* Significant (P<0.01)

n number of kids born

ns not significant

Besides the effect of BW and BCS of does at the time of AI, larger litters were significantly ($P<0.01$) heavier, compared to single births ($3.1\pm 0.2\text{kg}$).

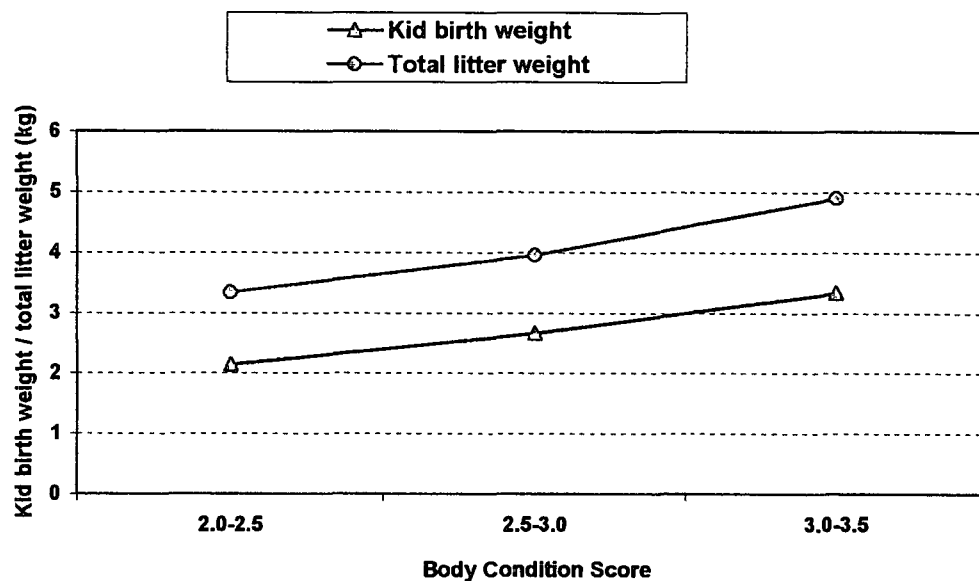


Figure 5.9. The effect of body weight and body condition score at the time of AI on kid birth weight and total litter weight in Somali does

5.3.10. Perinatal kid mortality rates in Somali goats

The perinatal mortality rates in kids born following oestrous synchronization and AI are set out in Table 5.16. The overall mortality rate (within 10 days of birth) was 29.0%. This was not significantly influenced by the type and duration of intravaginal progestagen treatment, time of PMSG administration, BW and BCS of does at the time of AI, or by the sex of the kids. However, the perinatal kid mortality rate was found to be significantly ($P<0.01$) related to the age of the dams and litter size. A higher ($P<0.01$) incidence of kid mortalities was recorded in kids born from 9-year-old does (80.0%), compared to kids born from 1-year-old (31.6%) or 6-year-old does (7.1%). Similarly, the kid mortality rate was significantly higher in twin born kids (75.0%) than in kids born as singletons (16.7%).

Table 5.16. Mortality rate of Somali goat kids born following synchronized oestrus and AI

Parameter	n	Perinatal mortality (%)
Sponge type		ns
MAP	18	33.3
FGA	20	25.0
Duration of sponge treatment (days)		ns
9	8	25.0
12	10	50.0
15	13	23.1
18	7	14.3
Time of PMSG administration		ns
-24h	11	27.3
0h	10	20.0
Control	17	35.3
Doe age (years) at AI		**
1	19	31.6 ^b
6	14	7.1 ^b
9	5	80.0 ^a
Doe BW (kg) at AI		ns
15-20	15	33.3
21-30	12	16.7
31-40	7	28.6
41-50	4	50.0
Doe BCS at AI		ns
2.0-2.5	19	26.3
2.6-3.0	15	26.7
3.1-3.5	4	50.0
Litter size		**
1	30	16.7 ^b
2	8	75.0 ^a
Sex of kids		ns
Male	22	31.8
Female	16	25.0
Overall	38	29.0

^{a, b} Means in the same column for the same parameter with different superscripts differ significantly ($P < 0.01$)

** Significant ($P < 0.01$)

n number of kids born

ns not significant

5.4. DISCUSSION

5.4.1. Oestrous response

In this study, an attempt was made to synchronize oestrus efficiently in order to facilitate the use of AI and accelerate genetic progress in Somali goats. Oestrus was efficiently induced by the use of intravaginal progestagen sponges (both MAP and FGA) and PMSG in 97.4% of all does in the 96h observation period following the withdrawal of intravaginal progestagen sponges (Table 5.2). The remaining 2.6% does, which did not exhibit overt oestrus signs were those which had lost their intravaginal progestagen sponges although replaced with the same type of sponges as soon as the loss was observed. The response to oestrus obtained in this experiment is comparable to the results reported by Corteel (1975) and Freitas *et al.* (1997) in goats. However, the present oestrous response is slightly lower than the findings of El-El-Amrawi *et al.* (1993), Ishwar and Pandey (1992), Artingsih *et al.* (1996) and Zarakawi *et al.* (1999), who reported a 100% response in goats following progestagen treatment. On the other hand, the present results are higher than those obtained in Nubian (Ahmed *et al.*, 1998), Boer (Greyling & Van der Nest, 2000) and tropical (Rosnina *et al.*, 1992) goat breeds.

The lack of significant differences in the percentage of does exhibiting overt signs of oestrus between FGA and MAP progestagen treatment indicate similar efficiency of these intravaginal progestagen sponges in inducing oestrus in Somali does. This is in agreement with Al-Kamali *et al.* (1990), Crosby *et al.* (1991) and Romano (1998a). No significant difference in the percentage of does showing overt signs of oestrus was recorded among does treated with intravaginal progestagen sponges for a period of 9, 12, 15 or 18 days irrespective of progestagen type and PMSG administration (Table 5.2), which is in line with Greyling *et al.* (1985) in goats and Romano (1998a) in sheep. PMSG administration, either 24h prior, at or 24h after sponge withdrawal had no significant effect on the percentage of does exhibiting oestrus. PMSG treated does also showed a lower response to oestrus, although the difference between the control and PMSG injected does was not significant (Table 5.2). Literature on the effect of PMSG and the time of its administration relative to sponge withdrawal in farm animals is contradictory. For instance, Zhang and Yuan (1988) claimed a higher oestrous

response (100%) in dairy goats administered PMSG at sponge withdrawal, compared to 66.7% in goats given the same dose of PMSG 48h prior to sponge withdrawal during the non-breeding season. Similarly, Greyling and Van Niekerk (1991) obtained a 100% and 53.5% oestrous response in Boer goats given 500IU PMSG and no PMSG, respectively, during the non-breeding season. On the contrary, Robinson (1988) found intravaginal progestagen treatment alone to be adequate to induce oestrus in cyclic ewes during the natural breeding season. It was suggested that after progestagen withdrawal in sheep, there is presumably a surge of gonadotrophin secretion from the anterior pituitary, sufficient to initiate a sequence of hormonal events that result in the manifestation of oestrus and ovulation. However, for progestagen treatment to be effective in inducing oestrus in the non-breeding season in does, there is a need for sufficient gonadotrophin hormones to be available to initiate the pre-ovulatory events. This necessitates the augmentation of endogenous gonadotrophin secretion with a certain amount of PMSG. Therefore, in the Somali goat which is known as a tropical goat breed, the effect of PMSG injection to induce oestrus may not be as important as it would be in the more temperate goat breeds to initiate the induction of oestrus.

Similar to the effect of oestrous synchronization treatments, age, BW and BCS of the does at AI had no significant effect on the percentage of does exhibiting oestrus (Table 5.2). Therefore, oestrus in Somali does can be successfully induced by applying progestagen sponges (FGA or MAP) for a period of 9, 12, 15 or 18 days. Similarly, difference in age (1 to 9 years), BW (15 to 50kg) and BCS (2 to 3.5) were not found to affect the artificial induction of oestrus significantly in Somali does.

Differences in the oestrous synchronization protocol did not have any significant influence on the response of does to oestrus (Table 5.3). The oestrous response recorded in this study ranged from 92.9 to 100%, indicating that the use of only intravaginal progestagen sponges (MAP or FGA) is as effective as using a combination of intravaginal progestagen sponges and duration of progestagen priming period.

5.4.2. Time to onset and the duration of the induced oestrous period

The time to onset of oestrus and the duration of the induced oestrous period are important aspects in assisted breeding techniques, as these parameters are crucial in determining the optimal time for AI following oestrous synchronization. Several factors may influence the interval between sponge withdrawal and the onset of the induced oestrous period. The overall mean time to the commencement of oestrus in this trial was 33.3 ± 2.7 h (Table 5.4), which is comparable with the reports of Freitas *et al.* (1996) and Motlomelo (2000), who reported a mean time to commencement of oestrus of 35.5h in dairy goats and 30.1 ± 5.5 h in Boer and Feral goats, respectively. These findings are also in agreement with those of Greyling *et al.* (1997), who recorded the onset of oestrus in sheep following cessation of progestagen treatment to average 30.5h. However, the interval from the cessation of progestagen treatment and the onset of oestrus recorded in this trial tended to be shorter when compared to the results of Ishwar and Pandey (1992) in Black Bengal goats, Doijode *et al.* (1992) in Angora goats, Romano (1998) in dairy goats, Greyling *et al.* (1985), Greyling and Van Niekerk (1991), Greyling and Van der Nest (2000) in Boer goats and Ahmed *et al.* (1998) in Nubian goats. These variations in the interval from sponge withdrawal to the onset of oestrus may be primarily attributed to breed differences, which are known to play a significant role (Ahmed *et al.*, 1998). The interval from sponge withdrawal to the commencement of oestrus in the present study could have been hastened by a factor such as the presence of teaser bucks, as the does were teased regularly at 8-hourly intervals for the 96h period following progestagen sponge withdrawal, and a nutritional status of the animal can also play a role (Romano & Fernandez, 1997).

The intravaginal progestagen sponge type (MAP or FGA) was not different in affecting the interval from sponge withdrawal to the onset of oestrus (Table 5.4). This is in line with the findings of Crosby *et al.* (1991), Selvaraju *et al.* (1997), Selvaraju and Kathiresan (1997) and Hill *et al.* (1998). Romano (1998) reported the interval to the onset of oestrus to be shorter in FGA (30mg) treated does, compared to MAP (60mg) treated ones.

The duration of the intravaginal progestagen sponge treatment significantly ($P < 0.05$) shortened the interval from sponge withdrawal to the onset of oestrus. Does primed with progestagen sponges for a period of 9 days (regardless of sponge type) exhibited oestrus significantly earlier (28.2 ± 4.4 h) when compared to those primed for a period of 12, 15 or 18 days (Table 5.4). These results are in agreement with those reported by Greyling *et al.* (1985) who found a 12-day progestagen priming to induced oestrus significantly earlier (63 ± 19 h) when compared to 14 or 16-day progestagen treatments (81 ± 19 h and 74 ± 18 h, respectively) in Boer goats. The justification for the shortening of the time to oestrus in the 9-day progestagen treatment may be attributed to lower levels of progestagen (residual progestagen) being present at the time of sponge withdrawal in does treated for shorter periods and thus a faster decline in the level of circulating progesterone and a faster removal of a negative feed back effect of progestagen at the hypothalamic-pituitary level. This could result in a faster oestrous response.

The time from sponge removal to the commencement of oestrus was not significantly affected by the time of PMSG administration in relation to intravaginal sponge withdrawal. Furthermore, the PMSG treated groups did not show any significant advantage in terms of time to response when compared to the control animals (Table 5.4) — implying that the administration of 300IU PMSG, regardless of the time of application, did not influence the time to onset of oestrus. The results of the present study are in agreement with those reported by Ahmed *et al.* (1998) who also found the difference in time to the onset of oestrus to be insignificant between PMSG treated and non-treated cyclic Nubian goats in Sudan. Zhang and Yuan (1988) and Artingsih, *et al.* (1996) also recorded the administration of PMSG not to advance the time to onset of oestrus. It has been indicated that an injection of PMSG 24h (Artingsih *et al.*, 1996) or 48h (Zhang and Yuan, 1988) prior to sponge withdrawal shortened the interval to onset of oestrus, compared to administering PMSG at sponge withdrawal. A possible reason for the differences between the present results and some of the previous reports could be ascribed to breed, season and climatic differences. The present trial was conducted on a tropical goat breed with an extended breeding season, and is different from the temperate breeds, which exhibit anoestrus during a non-breeding season.

Age of the does did not have any significant effect on the time to the onset of oestrus in this trial (Table 5.4). These results are in accordance with those of Baril *et al.* (1993) who reported the absence of age effect on the interval from progestagen removal to onset of oestrus in goats. However, these results are contradictory to the findings of Moses *et al.* (1997) who reported the onset of oestrus to be earlier in young ewes.

Both BW and BCS of the does did not influence the interval from intravaginal progestagen sponge withdrawal to the onset of oestrus (Table 5.4). This is contrary to the reports of Mani *et al.* (1992) who reported a poor BCS in sheep to be associated with a delay or suppression in the manifestation of oestrus. In the present trial, the BW and BCS of the experimental does may have been below the threshold level to affect the response time.

The mean duration of the induced oestrous period in all does that exhibited overt oestrus signs was 35.5 ± 4.2 h. This value is comparable to the results of Romano *et al.* (1998) in synchronized dairy goats (36.0 ± 15.7 h and 30.0 ± 7.9 h, for 12 and 14 day FGA treated goats, respectively), Devendra and Burns (1983), Taminić *et al.* (1984) and Van Der Nest (1997). However, a longer oestrous duration than that obtained in the present trial has been reported by Greyling and Van Niekerk (1991) in Boer goats, outside the natural breeding season (40.7 ± 14.5 h), Freitas *et al.* (1996) in Tellicherry goats (45.6 ± 2.3 h), Ahmed *et al.* (1998) and Romano *et al.* (2000) in dairy goats (41.8 ± 9.6 h). The discrepancy between the present values obtained and that of previous work may be attributed to a difference in breed, nutritional regime and season of observation.

As it was the case regarding the time to onset of oestrus, the duration of the induced oestrous period was not significantly affected by the different intravaginal progestagen agents used, the time of PMSG administration, and the age or BCS of the does at AI (Table 5.4). These results are contradictory to those of Selvaraju *et al.* (1997) who recorded a significantly longer duration of oestrus in MAP, compared to FGA synchronized goats. Furthermore, Ahmed *et al.* (1998) recorded a significantly longer oestrus in 300IU PMSG injected Nubian goats, compared to controls (36.6 ± 47.1 and 52 ± 7.8 h, respectively), which is also contrary to the results of the present trial.

The duration of the induced oestrous period was significantly ($P < 0.05$) affected by the duration of the progestagen treatment and the BW of does at the time of sponge withdrawal and AI although there was no definite trend. The duration of the induced oestrus was the shortest ($P < 0.05$) in the 18-day progestagen treatment group followed by the 12 and 9-day treatment groups, respectively (Table 5.4). The longest duration of the induced oestrous period was recorded in the 15-day progestagen treatment group. The significant effect of the duration of intravaginal progestagen treatments on the duration of the induced oestrus is in line with the reports of Romano (1998), who revealed the duration of oestrus to be significantly longer in 12-day compared to 14-day MAP (60mg) sponge treated dairy goats. The reason for the longer duration of induced oestrus in 15-day progestagen treatment compared to 9, 12 or 18 day treatment may be due to the fact that this period is similar to a normal life span of the natural CL, which may enhance the growth of a larger number of oestrogenic follicles capable of secreting more oestrogens which would maintain animals in overt oestrus for a relatively longer period of time.

Besides the duration of intravaginal progestagen treatment, BW of the does at AI significantly ($P < 0.05$) affected the duration of the induced oestrous period (Table 5.4). Does with a BW of 15 to 20kg remained in oestrus for a significantly ($P < 0.05$) longer period of time, compared to those with a BW of 21 to 30kg or 31 to 40kg. The duration of the induced oestrus was, however, not significantly different between the lightest and the heaviest group of does (Figure 5.1). The intermediate BW groups exhibited oestrus for a relatively shorter period of time when compared to the lighter and the heavier groups of does. The reason for this difference remains unclear.

None of the oestrous synchronization treatments compared significantly affected the time to onset of oestrus or the duration of the induced oestrous period (Table 5.5) — indicating that all synchronization treatments were equally efficient.

5.4.3. Intravaginal sponge losses

During the observation period, 10 females (8.3%) lost their sponges and these were replaced with the same type of sponges as soon as the loss was observed. Of the 10 sponges lost, 6 (60%) of the losses were from MAP treated does, indicating that MAP sponges could be more prone to losses than the FGA sponges. This may emanate from the difference in the size and texture of the sponges. FGA sponges are relatively larger and coarser in texture than the MAP sponges. A higher loss of sponges in the 9-year-old does (50%), compared to 1 and 6-year-old does (30 and 20%, respectively) could be attributed to a difference in the size of the reproductive tract, affecting the retention of the sponges. These higher losses encountered in MAP sponges are in agreement with the reports of Boland *et al.* (1979) and Ainsworth and Shrestha (1983). No supporting literature regarding the effect of age of does on sponge retention could be found.

5.4.4. Serum progesterone concentration

The mean serum progesterone concentration for all groups increased from 1.89ng/ml to 2.23ng/ml by the third day of intravaginal progestagen sponge treatment. The progesterone level then dropped after the third day of sponge insertion. The mean serum progesterone concentration was maintained below 1ng/ml in all does for 80h period following the withdrawal of the intravaginal progestagen sponges. This is in agreement with the findings of Leyva *et al.* (1995), who found serum progesterone concentration to remain below 1ng/ml during oestrus in native and crossbred Venezuela goats. As it has been illustrated in Figure 5.2, the absence of any evident difference in the serum progesterone concentration between FGA (40mg) and MAP (60mg) treatments suggest a similar action of these progestagen sponge types in maintaining blood progesterone levels. The increment in serum progesterone concentration from 80h post sponge withdrawal could be attributable to the newly formed corpus luteum after ovulation of the induced follicles, which caused an increase in the endogenous production of progesterone.

The duration of progestagen priming period seemed to have an effect on the mean serum progesterone concentration, especially 32h following sponge withdrawal (Figure 5.3). The mean serum progesterone concentration remained significantly lower during the 96h monitoring period in the 18-day treatment group compared to the 9, 12 and 15-day-treatment groups — which could be attributed to a more effective suppression of ovarian activity. The reason for the lower progesterone concentration in the 18-day treatment group may also be due to a higher follicular activity as a result of presence of aged and persistent follicles in these group of does compared to the other groups. The mean serum progesterone concentration at 40h following sponge withdrawal was also significantly ($P<0.05$) lower in the 18-day progestagen treatment group, compared to the 9, 12 or 15-day progestagen treatment groups (Table 5. 6). These findings are contrary to the results in Boer goat does reported by Greyling *et al.* (1985), who revealed an absence of any significant difference in the mean serum progesterone concentration at oestrus between 12, 14, 16 and 18-day progestagen treatment groups.

The other factor, which may have affected the mean serum progesterone concentration, was the time of PMSG administration relative to intravaginal progestagen withdrawal. The mean serum progesterone concentration at 72h, 80h and 96h following sponge withdrawal were significantly ($P<0.05$) lower in does administered PMSG at sponge withdrawal, compared to in those treated 24h prior to sponge withdrawal (Table 5.6). The reason for this could be that the latter does were still under the suppressing influence of exogenous progesterone on ovarian (follicular) activity.

5.4.5. Serum Luteinizing hormone concentration

In this trial the number of does exhibiting a LH surge was not sufficient to make valid statistical comparisons between treatments groups for parameters such as interval from the onset of oestrus to the LH peak. In some instances, there were cases where none of the does in a group exhibited oestrus. In such cases, it was not possible to compare certain parameters like the interval from the onset of oestrus to the LH peak. Nonetheless, a pre-ovulatory LH peak ($>5\text{ng/ml}$) was recorded in 32% (13/40) of all does used in blood sampling. Due to the

long inter-sampling period (8h) and the pulsatile nature of LH, some of the pre-ovulatory LH peaks might have gone unnoticed. The mean time interval from the withdrawal of progestagen sponges to the LH peak in those does, which exhibited the LH peak, was 41.7h. In agreement with the current results, Greyling and Niekerk (1991) observed the interval from sponge withdrawal to the LH peak to be 40.0 ± 6.0 h in Boer goats synchronized with progestagen sponges and 500IU PMSG. Similarly, Freitas *et al.* (1997) reported the LH peak to occur on average at 45.0 ± 5.6 h from the progestagen sponge withdrawal in goats. In this trial, the occurrence of a LH peak was distributed between 32h and 56h after sponge withdrawal or 0h to 24h after the onset of oestrus. In the majority of does that exhibited the LH peak, this peak was observed at the onset of oestrus (Figure 5.5). Freitas *et al.* (1997) also observed the preovulatory LH peak to occur from 0h to 24h post progestagen withdrawal. The average interval from the onset of oestrus to LH peak in all does exhibiting the LH peak was 3.5h. This interval is comparable to of Greyling and Niekerk (1991) in Boer goat (4.3 ± 3.4 h).

The distribution of the LH peak between treatment groups was inconsistent and variable (Table 5.7). Besides this, the number of does that exhibited the LH peak was too small to draw a valid statistical comparison. More frequent blood samplings for LH would have made possible to record more of the LH peaks and enabled a valid comparison.

5.4.6. Reproductive performance following synchronization of oestrus and AI

The mean non-return and pregnancy rates (confirmed at kidding) in all synchronized goats in this trial were 31.5% and 62.4%, respectively (Table 5.9). The pregnancy rate obtained in this experiment is very low when compared to the pregnancy rates cited in the literature (Bowen, 1988; Greyling *et al.*, 1988; Greyling & Van Niekerk, 1991; El-Amrawi *et al.*, 1993; Selvaraju & Kathiresan, 1997; Ahmed *et al.*, 1998; Zarakawi *et al.*, 1999; Greyling & Van der Nest, 2000; Kusina *et al.*, 2000; Romano *et al.*, 2000). Nonetheless, the pregnancy rate in this experiment is comparable to the value of 36.6% recorded by El-Amrawi *et al.* (1993) from synchronization studies involving the use of FGA sponges and administration of 700IU PMSG during the non-breeding season. The present pregnancy rate is higher than the 20.8% reported by Abebe (1996) for the same breed of goat following oestrous synchronization with

intravaginal progestagen sponges and PMSG. This low pregnancy rate could be ascribed not only to the breed as such but also to the poor nutritional environment under which the goats were maintained, managerial practices, stress induced by frequent handling of the animals for oestrous detection, bleeding and AI. The big difference between non-return rate and actual pregnancy rate leaves a question mark regarding the post AI care of the does (especially nutrition).

As it could be expected, the pregnancy rate was not significantly affected by the type of progestagen sponges used, which indicates an equal efficiency of the two intravaginal sponges in synchronized breeding. This is in agreement with the findings of Crosby *et al.* (1991) Romano *et al.* (1996) and Romano (1998), who reported absence of significant differences in fertility rate between goats synchronized with FGA and MAP sponges. Their findings, however, contradict those of Greyling *et al.* (1988), Selvaraju and Kathiresan (1997) and Hill *et al.* (1998), who indicated the superiority of FGA over MAP sponges in terms of fertility.

Similarly, the duration for which the intravaginal progestagen sponges were left in situ did not affect the pregnancy rate (Table 5.9). A relatively higher pregnancy rate was obtained in the 15-day progestagen sponge treatment group, compared to in the other treatment groups. However, these differences were not significant. The lowest pregnancy rates were obtained in the long-term (18-day) and short-term (9-day) progestagen primed does. It would seem as if both long-term and short-term treatments could have a negative impact on the fertility at the induced oestrus. It may be possible that in the long-term progestagen treatment, the aging of ova or the problem of sperm transport to the site of fertilization could negatively affect fertility (Vinoles *et al.*, 2001). On the other hand, in the short-term progestagen priming, the effect of progesterone prior to ovulation could be too short or resulted in incomplete suppression of the natural CL during treatment — thus resulting in lower pregnancy rates. Absence of a significant difference in pregnancy rate due to the duration of intravaginal progestagen treatment in this experiment is in line with Romano (1998), who compared 12 and 14-day sponge treatment (FGA 30mg and MAP 60mg) in dairy goats. However, the present results disagree with the findings of Vinoles *et al.* (2001), who compared 6 and 12-day sponge treatments in cyclic ewes, and recorded a significantly higher pregnancy rate in the

short-term progestagen treatment. Greyling *et al.* (1985) reported an absence of a significant difference in ovulation rate between 12, 14, 16 and 18-day MAP treated Boer goat does.

In this trial, regardless of the time of administration (relative to intravaginal progestagen sponge withdrawal), overall PMSG administration significantly ($P < 0.05$) decreased the pregnancy rate (28.6% and 25.7% for groups injected at sponge withdrawal and 24h before sponge withdrawal, respectively), compared to those groups, which did not receive PMSG (39.5%). In agreement with this, Ahmed *et al.* (1998) found a reduction in pregnancy rate from 70% (FGA sponges alone) to 55.5%, when 300IU PMSG was injected to Nubian goats. Similarly, Regueiro *et al.* (1999) recorded a decline in kidding rate in dairy goats from 62.5% to 41.0%, when eCG was given to MAP primed does. Furthermore, Abebe (1996) found a significant reduction in fertility of Somali goats from 60.0% when only intravaginal progestagen sponges were used to 20.8% when PMSG was used in combination with the intravaginal progestagen sponges. However, Greyling and Van Niekerk (1991) recorded a conception rate of 73.3% in Boer goats synchronized during the non-breeding season with MAP sponges and 500IU PMSG, compared to the 53.3% obtained with MAP sponges alone. Thus, it could be suggested that the use of PMSG to synchronize oestrus in Somali goats has a negative impact on fertility following induced oestrus and AI. PMSG may disturb the endogenous FSH and LH ratio by over stimulation, thus hindering the normal development of follicles and the complex events leading to ovulation of the dominant follicle. It may also negatively affect the possible movement of the sperm and/or egg to the site of fertilization by disturbing the uterine motility patterns.

The pregnancy rate obtained was significantly ($P < 0.05$) higher in the 6-year-old does (60.9%), compared to 1 or 9-year-old does (25.8 and 17.7%, respectively). It would seem as if both immaturity and old age have a deleterious effect on the pregnancy rate or overall fertility in Somali does following oestrous synchronization and AI. These results are in agreement with those of Dewi *et al.* (1996), who found ovulation rate to be significantly affected by the age of ewe. Moses *et al.* (1997) also found fertility to be higher in mature than in young ewes, with distinct differences in gonadotrophin secretion rate.

Pregnancy rate was also significantly ($P < 0.05$) affected by the BW and BCS of the does at AI. The pregnancy rate was higher in does with a BW of 21 to 40kg, compared to those with a BW of 15 to 20kg. However, there were no significant differences in the pregnancy rate between does with a BW of between 21 to 30 kg, 31 to 40kg or 41 to 50kg. There was also no significant difference between does weighing 15 to 20kg and 41 to 50kg. It would thus seem as if the best pregnancy rate would be achieved in the intermediate BW groups. Both under-weight and over-weight seem to negatively affect the pregnancy rate in these does. These results are in agreement with the findings of Pitono *et al.* (1992) who claim heavy ewes to have a higher ovulation rate than lighter ewes. Regueiro *et al.* (1999) also reported that lighter does have a lower kidding rate, which supports the results of the present trial.

Similarly, the pregnancy rate was significantly ($P < 0.05$) higher in does with a BCS of 2.5 to 3.0, followed by does with a BCS of 3.1 to 3.5. The lowest pregnancy rates observed in does with a lower BCS (< 2.5) in this trial is in agreement with Rhind *et al.* (1989), Mellado *et al.* (1996), Rondon *et al.* (1996) and Gonzalez *et al.* (1999). The lower pregnancy rate from these groups of does may be due to their lower nutritional reserves at AI, which may have indirectly affected normal reproductive processes.

The overall non-return rate following AI was 62.4% (Table 5.9). This was much higher than the overall pregnancy rate confirmed at kidding (31.5%). Ritar *et al.* (1989) and Ahmed *et al.* (1998) also reported a similar pattern, and found that the non-return rates to be much higher than the corresponding conception rates. It can simply be said that the non-return rate is not a reliable indicator of pregnancy rate in Somali does. The non-return method is subjected to human error and failing to observe animals that returned to oestrus could have reduced its accuracy. Furthermore, females that do not return to oestrus may not necessarily be pregnant. Animals may experience silent oestrus or other physiological conditions. There is also the possibility of embryonic resorption in some of the does. Thus, the method is not reliable and not recommended as a possible indicator of reproductive success following AI (Ritar *et al.*, 1989; Ahmed *et al.* 1998).

The non-return rate to oestrus was not affected by the type of progestagen sponges, duration of progestagen treatment, time of PMSG administration or age of the does. The non-return rate was, however, significantly ($P < 0.05$) influenced by the BW of does at AI; and the highest ($P < 0.05$) values were recorded in does with a BW of 41 to 50kg — compared to those with a BW of 15 to 20kg. Similarly, does with a BCS of 3.1 to 3.5 had a higher non-return rate (100%) than those with a BCS of 2.0 to 2.5 or 2.6 to 3.0. The highest non-return rate was recorded in the group of does with the highest BW and BCS, while the highest pregnancy rate was obtained from the intermediate BW and BCS groups. This may lead to the assumption that there might be a higher occurrence of early embryonic loss in the highest BW and BCS groups of does due to higher ovulation rates, which may result from hormonal incompatibility and a competition for uterine space.

The kidding rate (number of kids born/number of does inseminated) was more or less comparable to that of the original pregnancy rate as the numbers of multiple births in this trial were very limited. As it could be expected, the type and the duration of intravaginal progestagen sponge treatment did not really affect the eventual kidding rate. Similar to the pregnancy rate, the kidding rate was affected ($P < 0.05$) by PMSG administration, age and BCS of the does at AI. The administration of 300IU PMSG significantly reduced the kidding rate, compared to control (not injected with PMSG) animals. This indicates that the use of PMSG in the oestrous synchronization protocol for Somali does under similar management condition to have a possible negative effect on kidding rate. This could possibly be related to over stimulation with PMSG of the lighter does. The opposite is also possibly true in the very old does (9-years of age). Both immaturity and old age have a significant and negative effect on kidding rate. The literature also indicates that immature 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; Sarmah *et al.*, 1996; Gootwine *et al.*, 1997; Anwar & Ahmed, 1999). Thus, it would seem as if synchronization of oestrus with the aid of intravaginal progestagen sponges and PMSG is less effective in immature (1-year old) and old (9-years old in this case) does compared to mature does. Does with a low BCS had a lower kidding rate following synchronization treatment and AI, which is in agreement with Rondon *et al.* (1996).

The protocol (combination of progestagen sponge type and duration of progestagen treatment) used for oestrous synchronization did not significantly affect the pregnancy, non-return and kidding rates (Table 5.11). This indicates that all the oestrous synchronization treatments used are equally effective for oestrous synchronization in Somali does.

4.4.7. Litter size of Somali goats following oestrous synchronization and AI

The overall mean litter size in all oestrous synchronized does in this trial was 1.1 ± 0.1 (Table 5.12). This is in agreement with Abebe (1996), who obtained a litter size of 1.01 for the same breed of goat in Ethiopia. It is also comparable to results obtained by Romano *et al.* (1996). The litter size recorded in this trial was lower when compared to more prolific breeds in the literature (El-Aramawi *et al.*, 1993; Zarakawi *et al.*, 1999; Kusina *et al.*, 2000). It would seem as if the Somali goat has gone through a natural selection process aimed at a smaller litter sizes, as this breed of goat is extensively farmed primarily for milk production under traditional extensive rural management systems. Further improvement of this breed of goat for litter size could thus be of paramount importance in increasing the goat meat and milk productions, particularly under better feeding management conditions in Ethiopia.

The litter size was not significantly affected by the type and duration of intravaginal progestagen sponge treatment, the time of PMSG administration relative to sponge withdrawal, BW and BCS of the does at the time of AI. However, litter size was significantly ($P < 0.01$) affected by the age of the does. The 9-year-old does were found to be more prolific, compared to the 1 and 6-year-old does, which is in agreement with findings in the literature (Armstrong & Evans, 1983; Dewi *et al.*, 1996; Sarmah *et al.*, 1996; Gootwine *et al.*, 1997; Anwar & Ahmed, 1999; Notter, 2000). The reasons for this phenomenon could be coincidental or coupled to hormonal and uterine environmental factors. Absence of any significant differences in litter size due to the type of synchronization treatments used demonstrates that any of the current synchronization treatments can be used provided that the cost effective implications are borne in mind.

5.4.8. Gestation length following oestrous synchronization in Somali does

The overall mean gestation length in this trial was found to be 149.4 days (Table 5.13). This period is comparable to the previous reports of Devendra and Burns (1983) in tropical goat breeds (149.9 days), Zarakawi *et al.* (1999) in Damascus goats (148.5±2.3 days) and Motlomelo (2000) in Boer and indigenous South African goats (149.1±4.1 days). The gestation period in this study is longer when compared to the results obtained by Abebe (1996), who recorded a 145.8 days for the same breed of goat. Amoah and Gelaye (1990) recorded even longer gestation length (151 days) than the gestation length recorded in this trial.

The gestation length was not significantly affected by the type and the duration of progestagen sponge treatment, the time of PMSG administration, age, BW, BCS of the does or the sex of the offspring. The absence of a significant effect on gestation length due to synchronization treatment is in agreement with the reports of Oh *et al.* (1971), Abad *et al.* (1982) and Ishwar and Pandey (1992), who found no significant difference in gestation length due to synchronization treatment with progestagen sponges and PMSG or hCG administration.

However, as it could be expected, the gestation length was significantly ($P<0.01$) affected by litter size. Does carrying singletons had relatively longer gestation periods (149.9±0.5 days), compared to those carrying twins (143.5±1.4 days). This could be explained by the lack of uterine space due to the increased total litter weight and size, which induces more stress and earlier kidding in twin-bearing does. Ritar *et al.* (1989) and Amoah and Gelaye (1990) reported a shorter gestation length in does carrying multiple kids, compared to does carrying singletons while some researchers observed the gestation length to be affected by sex of the kids (Shelton, 1960; Amoah & Bryant, 1983), although no effect of sex of the offspring on gestation length was observed in this trial.

5.4.9. Kid birth weight and total litter weight of Somali goats following synchronization

The overall mean birth weight and total litter weight for does in this trial was 2.7 ± 0.1 and 3.2 ± 0.2 kg, respectively (Table 5.14). Both the birth weight of individual kid and total litter weight were not significantly affected by the type and the duration of progestagen treatment. Birth weight was, however, significantly ($P < 0.05$) influenced by the time of PMSG administration relative to progestagen sponge withdrawal, age and BW of the does. The significantly ($P < 0.05$) lighter birth weight observed in does treated with 300IU PMSG at sponge withdrawal, compared to those administered the same dose of PMSG 24h prior to sponge withdrawal remains unclear. It is generally assumed that birth weight is related to litter size and can only be influenced by PMSG stimulation.

The 1-year-old does produced significantly lighter kids at birth (2.6 ± 0.3 kg) than the 6 and 9-year old does (3.1 ± 0.2 and 3.4 ± 0.4 kg, respectively). The justification for heavier kids at birth in the older compared to the immature (1-year old) does emanates from the fact that immature does are still growing and the nutrients are partitioned for growth of the dam and the foetus — as a result the development of the foetus may be slower. Besides the potential nutritional deprivation in the uterine environment, the uterine space in immature does of smaller body size may be limited to allow growth of the foetus.

Significantly heavier kids were born from does with a BCS of 3.1 to 3.5 (3.3 ± 0.4 kg), compared to kids born from does with a BCS of 2.0 to 2.5 (2.1 ± 0.2 kg). This reveals the importance of maintaining the pre-mating BCS (nutritional status) of does in the region of 3.1 to 3.5 and thus obtaining heavier and more viable kids at birth.

The total litter weight was significantly ($P < 0.01$) affected by age and BW of does, and by the litter size. Nine year old does produced significantly ($P < 0.05$) heavier litters when compared to 1 and 6-year-old does. Similarly, does with a BW of 31 to 40kg and 41 to 50kg at AI produced heavier litters, compared to does with a BW of 15 to 20kg and 21 to 30kg at AI. A linear increase in total litter weight was recorded as the BCS of the does increased from 2.0 to 3.5 (Figure 5. 9). The present results are in agreement with those of Michels *et al.* (2000), who

found the BW of ewes at mating to affect lamb birth weight and total litter weight. The reason for the heavier litter weights in the older, heavier, and does in a better BCS could be ascribed to increased litter size in this group of does.

5.4.10. Perinatal kid mortality rate in Somali goats

The overall perinatal mortality rate in Somali goat kids within 10 days of birth was 29.0% (Table 5.16). As it could be expected, none of the synchronization treatments affected the perinatal mortality rate. The perinatal mortality rate was significantly higher ($P < 0.01$) in kids born from 9-year-old does (80.0%), compared to those born from 1 and 6-year-old does (31.6 and 7.1%, respectively). The reasons for the higher mortality rate in kids born from 9-year-old does may be due to problems in mothering ability. The 9-year-old does also had higher litter sizes and this could be an additional reason for a higher mortality rate.

Although multiple births recorded in this experiment were too few to compare with single births, the available information indicates that the mortality rate was higher ($P < 0.01$) in twin kids (75.0%), compared to single kids (16.7%). The higher perinatal mortality in twin born kids compared to single born kids is in agreement with the literature. Kids from multiple births are generally weaker at birth than single born kids as a result of physiological starvation in the uterus and lower body energy reserves at birth. The survival rate of multiple kids is usually lower, as these kids are too weak to suckle and hence the low energy reserves are rapidly depleted (Alexander *et al.*, 1990; Mukasa-Mugerwa & Lahlou-Kassi, 1995; Awemu *et al.* 1999). The mortality rate recorded was unacceptably high and could in part be ascribed to the fact that the experimental animals are unaccustomed to being frequently handled and confined. The short kidding season resulted from oestrous synchronization and AI may have also contributed to the high mortality as many small kids were present in the barn at the same time which may have made the kid-dam bonding more difficult — as a result, some kids were abandoned by their dams (particularly those with twin kids).

5.5. CONCLUSIONS

Induction of synchronized oestrus in Somali does was found to be possible using either MAP (60mg) or FGA (40mg) intravaginal progestagen sponges. Both MAP and FGA sponges were found to be equally effective in inducing overt oestrus, with no significant difference in reproductive performance following AI. The pregnancy rates following AI at the induced oestrus was, however, found to be unacceptably low.

Regarding the duration of intravaginal progestagen treatment, 9, 12, 15 or 18-day applications were equally effective in inducing overt oestrus, with no significant difference on the subsequent reproductive performance. However, the 15-day sponge treatment tended to improve pregnancy rate when compared with other priming periods. Regardless of the time of PMSG administration relative to intravaginal progestagen withdrawal, the injection of 300IU PMSG reduced the pregnancy rate significantly following the induced oestrus and AI. Therefore, the use of PMSG as oestrus-synchronization agent in Somali does during this period of the year and under similar management conditions is not recommended, as it negatively affected the subsequent pregnancy rate.

When a controlled breeding program is designed for Somali goats, age of the female should be taken into account (particularly too young or too old), as age could negatively affect the reproductive performance following synchronized oestrus and AI. The significantly lower pregnancy rate, coupled with the higher perinatal kid mortalities in 9-year-old does, demonstrates the restriction in the use of old does in controlled breeding programs. Culling of old does from flocks should be one of the managerial objectives to achieve better productivity from a goat enterprise. Furthermore, significantly lower pregnancy rates from induced oestrus and AI in 1-year-old female goats warrants further investigation to determine the age of maturity in the Somali goat breed.

The age, BW and BCS of the does at AI were also found to be important factors that could affect the reproductive performance in Somali does. Better pregnancy rates in this trial were achieved in does weighing between 21 to 30kg and with a BCS of 2.6 to 3.0 at AI. Therefore,

maintaining an optimum pre-mating BW (21 to 30kg in this case) and BCS (2.6 to 3.0 out of 5) is crucial for the success of controlled breeding programs in these goats. The importance of nutrition should not also be underestimated.

Further research is warranted to investigate the causes for the low pregnancy and high perinatal kid mortality rates recorded in the Somali goat. Other synchronizing agents as well as synchronization protocols could also be evaluated across seasons and under improved feeding management conditions by using larger number of experimental animals.

CHAPTER 6

GENERAL CONCLUSIONS AND RECOMENDATIONS

As this study consists of 3 independent experiments carried out under different management systems, comparison of treatments across experiments is not possible. In the first experiment, oestrus was successfully induced in 97% of synchronized Dorper ewes kept under natural South African veld condition during the transition period from the breeding to the anoestrous period. The overall pregnancy (72.3%), lambing (91.1%) and fecundity rates (126.0%) obtained in all synchronization protocols tested were above average. Both MAP (60mg) and FGA (40mg) sponges were equally effective in inducing oestrus, with no significant difference in pregnancy rate following the synchronized oestrus and fixed time AI. Administration of 300IU PMSG 24h prior or at sponge removal resulted in a significantly higher pregnancy and lambing rates, compared to the administration of the same dose of PMSG 24h after sponge withdrawal or the control. Furthermore, subcutaneous administration of 300IU PMSG resulted in a significantly higher pregnancy rate when compared to intramuscular administration of the same dose of PMSG. The highest pregnancy rates were achieved by synchronizing Dorper ewes with FGA for 14 days plus the administration of 300IU PMSG (intramuscular) 24h after sponge withdrawal (93.3%) or FGA sponges for 14 days plus the administration of PMSG (subcutaneous) 24h before sponge withdrawal (93.3%). Significantly higher perinatal mortality rates and lower litter size were recorded in the lighter ewes (40 to 50kg). This necessitates improved feeding management practices to increase the body weight of ewes at AI. Increasing fecundity or litter size by improving the body weight of ewes at AI, and the use of PMSG is very important in enhancing the reproductive performance of Dorper ewes under similar management conditions. No negative relationship was recorded between increased litter size and the survival of lambs 24h post lambing.

In the second experiment, response to oestrus and fertility of Blackhead Ogaden ewes maintained under pastoral management conditions of Eastern Ethiopia were evaluated. Most of the ewes responded successfully to the synchronization treatments applied. The overall

oestrous response (91.1%) and pregnancy rate (63.1%) from fixed time AI were acceptable. Both MAP (60mg) and FGA (40mg) progestagen sponges were equally effective in inducing oestrus (90.2% vs. 93.0%, respectively), with no significant difference in subsequent fertility. Regardless of the time of administration relative to progestagen withdrawal, oestrous response was higher in PMSG administered ewes (100.0%), compared to in control ones (75.0%). Pregnancy, non-return and lambing rates were significantly higher in PMSG administered ewes, compared to in control ewes. Furthermore, pregnancy and lambing rates were higher in ewes with BCS between 3.1 and 3.5 (82.6% and 87%, respectively), compared to those with BCS of >3.5 (41.7% and 41.7%, respectively) at AI. Of the 18 combinations of synchronization treatments used in this trial, the best pregnancy rates (100.0%) were recorded in ewes synchronized with MAP sponges for 9 days +300IU PMSG administration 24h before sponge withdrawal, MAP sponges for 15 days + 300IU PMSG at sponge withdrawal, FGA sponges for 9 days + 300IU PMSG 24h before sponge withdrawal and FGA sponges for 12 days + 300IU PMSG at sponge withdrawal.

In Somali does, oestrus was synchronously induced in 97.4% of the does treated. The overall pregnancy rate (31.5%) recorded in this trial was far below an acceptable level. Both MAP (98.3%) and FGA (96.6%) sponges were found to be equally effective in inducing overt oestrus, with no significant difference in reproductive performance following fixed time AI. Regarding the duration of the progestagen priming period, 9, 12, 15 or 18-days were equally effective in inducing overt oestrus, with no significant difference in the subsequent fertility. However, the 15-day sponge treatment tended to improve pregnancy rates, compared to the other treatment periods. Regardless of the time of administration, the administration of 300IU PMSG significantly reduced the pregnancy rates following AI. Therefore, the use of PMSG as an oestrous synchronizing agent in Somali does under similar management conditions is not recommended, as it compromises the subsequent reproductive performance. Significantly lower pregnancy rates coupled with higher kid mortality in 9-year-old does indicate the importance of limiting reproductive age of this breed of does. Furthermore, significantly lower pregnancy rates in 1-year-old female goats, compared to 6-year old does warrants further investigation to determine the optimal reproductive age in the female Somali goat. Significantly higher pregnancy rates were achieved in this trial from does weighing between

21 and 30kg and with a BCS of between 2.6 to 3.0 at AI. So maintaining an optimal pre-mating BW (21 to 30kg in this case) and BCS (2.6 to 3.0 out of 5) is crucial for the success of controlled breeding programs in Somali goats.

In conclusion, either MAP (60mg) or FGA (40mg) progestagen sponges can be used to synchronize oestrus in Dorper, Blackhead Ogaden sheep and Somali goats under their respective managerial conditions. Administration of 300IU PMSG either 24h prior to or at sponge withdrawal is recommended to improve fertility following synchronization treatment and AI in both the Dorper and Blackhead Ogaden ewes. However, administration of 300IU PMSG regardless of time of administration is not recommended in Somali goats as it significantly reduced the induction of oestrus and pregnancy rates. Maintaining an optimal BCS (3.1 to 3.5) prior to AI is important in Blackhead Ogaden ewes. The optimal age to start and the age limit to breed Somali does should be further investigated. The effect of nutritional status, dose of PMSG and season of synchronization on the reproductive performance of BHO ewes warrant further investigation. The use of modern methods (e.g. ultrasound) to effectively perform an early pregnancy diagnosis is important to identify possible embryonic resorption as big differences exist between the non-return rate and the actual pregnancy rate in both Somali goats and Blackhead Ogaden sheep. Further research projects on the response and subsequent fertility of small ruminant breeds to assisted reproductive techniques in Africa are needed. These are essential to foster genetic improvement and livestock productivity in the continent.

ABSTRACT

IMPROVING THE REPRODUCTIVE EFFICIENCY OF SMALL STOCK BY CONTROLLED BREEDING

Zelege Mekuriaw Zelege

Promoter: Prof. J.P.C. Greyling

Co-promoter: Dr. L.M.J. Schwalbach

Department: Animal, Wildlife and Grassland Sciences

University: University of Free State, Bloemfontein

Degree: PhD (Agric) Animal Science

Three independent experiments were conducted in sheep and goats to compare the efficiency of synchronization on induction of oestrus and fertility following a synchronized oestrus and artificial insemination. In experiment 1, oestrous synchronization study was conducted on 224 Dorper ewes kept under extensive veld conditions during the transition period from the natural breeding season to anoestrous period. Two types of intravaginal progestagen sponges (MAP; 60mg and FGA; 40mg), time of PMSG administration relative to sponge withdrawal (24h before, at or 24h after), different routes of PMSG injection (intramuscular, subcutaneous) were evaluated, and the combination of all these factors were compared on oestrous synchronization efficiency (oestrous response, time to onset of oestrus and the duration of induced oestrus) and fertility (pregnancy, lambing and fecundity rates) following AI with 0.1ml fresh diluted semen. No significant differences in terms of oestrous response, time to onset of oestrus and the duration of induced oestrus were recorded due to differences in the type of progestagen sponges used, time and route of PMSG administration or a combination of these factors. The overall pregnancy, lambing and fecundity rates were 72.3%, 91.1% and 126.0%, respectively, with no significant differences in pregnancy, lambing and fecundity rates between MAP and FGA primed ewes (70.6%, 85.3% and 120.8% vs. 74.0%, 97.0% and 131.1%, respectively). Pregnancy, lambing and fecundity rates were significantly ($P < 0.01$)

higher in ewes injected with 300IU PMSG 24h prior to (78.0%, 115.3% and 147.8%, respectively) or at sponge withdrawal (75.0%, 94.6% and 126.2%, respectively), compared to ewes injected 24h after sponge withdrawal (70.2%, 73.7% and 105.0%, respectively) or ewes not injected with PMSG (60.0%, 70.0% and 116.7%, respectively). The maximum pregnancy rate (93.3%) was recorded in ewes synchronized with FGA sponges plus 300IU PMSG administered intramuscular 24h after sponge withdrawal and FGA plus 300IU PMSG administered subcutaneous 24h before sponge withdrawal.

In experiment 2, oestrous synchronization trial was conducted on Blackhead Ogaden (BHO) ewes, one of the lowland sheep breed in Ethiopia, maintained under traditional management conditions. MAP (60mg) and FGA (40mg) treatments with different durations of priming (9, 12 or 15-days), 300IU PMSG with different times of administration relative to progestagen withdrawal (24h before, at sponge withdrawal and controls) and the combined effect of all these factors were evaluated. Both MAP and FGA progestagen sponges were equally effective in inducing oestrus (90.2% vs. 93.0%, respectively). These progestagen sponges induced a similar response in the time to onset of oestrus (40.0 ± 2.2 h vs. 39.4 ± 2.1 h, respectively) and the duration of induced oestrus (46.1 ± 2.4 h vs. 43.9 ± 2.3 h, respectively). No significant differences were recorded between MAP and FGA sponges regarding the pregnancy, lambing and fecundity rates. Administration of 300IU PMSG significantly ($P < 0.01$) increased the induction of oestrus and decreased the time to onset of oestrus relative to progestagen withdrawal. Regardless of the time of PMSG administration, oestrous response was higher ($P < 0.01$) in PMSG administered ewes (100.0%), compared to the control (75.0%) ones. The time to oestrus relative to progestagen sponge withdrawal was also significantly ($P < 0.01$) earlier in PMSG treated ewes, compared to the control ewes. Pregnancy and lambing rates were also significantly ($P < 0.05$) higher in PMSG administered ewes, compared to control ewes. The duration of progestagen priming period significantly ($P < 0.01$) affected the oestrous response in these ewes. The percentage of ewes, which exhibited overt oestrus, was significantly ($P < 0.01$) higher in the 12 and 15-day (93.1% and 96.2%, respectively), compared to 9-day progestagen priming (86.2%). The duration of progestagen treatment, however, had no significant effect on time to onset of oestrus, the duration of induced oestrus, pregnancy and lambing rates. Pregnancy rate was higher ($P < 0.01$) in ewes with a BCS of between 3.1

and 3.5 (82.6%), compared to ewes with a BCS of >3.5 (41.7%). The lambing rate was also higher ($P<0.01$) in ewes with a BCS of between 3.1 and 3.5 (87%), compared to ewes with a BCS of >3.5 (41.7%). From 18 synchronization treatment combinations compared in this trial, synchronization with FGA sponges for 9 days with no PMSG or MAP sponges for 12 days with no PMSG induced oestrus in a significantly ($P<0.01$) lower percentage of ewes (25.0% and 60.0%, respectively). Similarly the pregnancy rates were also lower ($P<0.01$) in ewes synchronized with FGA sponges for 9 days with no PMSG (0.0%) or MAP sponges for 12 days with no PMSG (40.0%). The best pregnancy rates (100.0%) were recorded in ewes synchronized with MAP sponges for 9 days and 300IU PMSG 24h before sponge withdrawal, MAP sponges for 15 days plus 300IU PMSG at sponge withdrawal, FGA sponges for 9 days plus 300IU PMSG 24h before sponge withdrawal and FGA treatment for 12 days plus 300IU PMSG at sponge withdrawal.

In experiment 3, oestrous synchronization trial was conducted on 120 Somali does in Eastern Ethiopia. Synchronization efficiency in terms of oestrous response, pregnancy, kidding and fecundity rates of MAP (60mg) and FGA (40mg) progestagen sponges with 4 priming periods (9, 12, 15 or 18 days), with or without administration of PMSG at different times were compared. Both MAP and FGA intravaginal sponges with 9, 12, 15 or 18-day treatment periods were recorded to be equally effective in inducing overt oestrus — with no significant difference in pregnancy, kidding and fecundity rates. The pregnancy rate was significantly ($P<0.05$) higher in control does (no PMSG) (39.5%), compared to does administered 300IU PMSG 24h prior to (25.7%) or at sponge withdrawal (28.6%). Besides oestrous synchronization treatment, age and body weight (BW) of the does at AI significantly ($P<0.05$) affected the pregnancy rates. Pregnancy and kidding rates were significantly higher in 6 year old does (60.9% and 60.9%, respectively), compared to 1 (25.8% and 27.9%, respectively) and 9 year old does (17.7% and 29.4%, respectively). Similarly, significantly ($P<0.05$) higher pregnancy and kidding rates were recorded in does with a body weight of above 20kg at AI, compared to does below 20kg body weight. Significantly higher pregnancy rates were recorded in does with a body condition scores (BCS) between 2.6 and 3.0 at AI (44.8%), compared to those with a BCS between 2.0 and 2.5 or 3.1 and 3.5 (25.4% and 37.5%, respectively). Therefore, the use of PMSG as an oestrous synchronizing agent in Somali does

is not recommended, as it would seem to compromise fertility. An upper and lower reproductive age limit should be set for this breed. Maintaining an optimal pre-mating BW (21 to 30kg in this case) and BCS (2.6 to 3.0) is crucial for the success of a synchronized breeding program.

In general, both MAP (60mg) and FGA (40mg) progestagen sponges were equally effective in inducing synchronized oestrus with no significant difference in subsequent fertility. Thus, either of the progestagen types can be used for controlled breeding. Unlike in Somali does, administration of 300IU PMSG either 24h prior to or at sponge withdrawal improved fertility in the Dorper and BHO ewes. Therefore, the use of 300IU PMSG as synchronization agent is recommended in Dorper and BHO ewes but not in Somali does. The duration of progestagen treatment did not affect subsequent fertility both in Somali does and BHO ewes. Maintaining an optimal BCS (3.1 to 3.5) prior to AI is recommended in BHO ewes. Reproductive maturity age and the maximum age limit for culling should be implemented in Somali female goats. In all cases, the effect of nutritional status, dose of PMSG and season of synchronization warrant further investigation. Early pregnancy diagnosis by use of ultrasonic equipment is important to identify possible embryonic resorption, as large differences exist between the non-return rate and the actual pregnancy rate in both Somali goats and BHO ewes in Ethiopia.

Further studies on the response of African small ruminant breeds to assisted reproductive techniques under different nutritional management and during different seasons are recommended.

OPSOMMING

VERBETERING VAN DIE REPRODUKSIE DOELTREFFENDHEID IN KLEINVEE DEUR MIDDEL VAN BEHEERDE TELING

Zelege Mekuriaw Zelege

Promotor: Prof. J.P.C. Greyling
 Mede-Promotor: Dr. L.M.J. Schwalbach
 Departement: Vee-, Wild- en Weidingkunde
 Universiteit: Universiteit van die Vrystaat, Bloemfontein
 Graad: Ph D (Agric) Veekunde

Drie proewe is uitgevoer op skape en bokke om die doeltreffendheid van sinkronisasie in die induksie van estrus en vrugbaarheid na sinkronisasie en KI te vergelyk. In die eerste proef is estrus sinkronisasie uitgevoer op 224 Dorperooie onder ekstensiewe toestande tydens die oorgangperiode van die natuurlike teelseisoen na die anoestrusperiode. Twee tipes intravaginale progestageen sponse (MAP; 60mg en FGA; 40mg), verskillende metodes van DMSG toediening (binnespiers en onderhuids) en 'n kombinasie van hierdie faktore is vergelyk om estrus sinkronisasie doeltreffendheid (estrus respons, tyd tot aanvang van estrus en die lengte van die geïnduseerde estrus) en vrugbaarheid (dragtigheid, lampersentasie en fekunditeit) na KI met 0.1ml vars verdunde semen, te vergelyk. Geen betekenisvolle verskille is waargeneem t.o.v. verskille in die tipe progestageen sponse, tyd en roete van DMSG toediening of 'n kombinasie van hierdie faktore nie. Die algehele dragtigheid, lampersentasie en fekunditeit was 72.3%, 91.1% en 126.0% respektiewelik met geen betekenisvolle verskil in dragtigheid, lampersentasie en fekunditeit tussen MAP en FGA behandelde ooie nie (70.6%; 85.3%; 120,8% vs 74.0%; 97,0%; 131,1% respektiewelik). Dragtigheid, lampersentasie en fekunditeit was betekenisvol ($P < 0.01$) hoër in ooie behandel met 300 IE DMSG 24 uur voor (78.0%; 115.3%; 147.8%, respektiewelik) of met sponsontrekking (75.0%; 94.6%; 126.2% respektiewelik), vergeleke met ooie behandel met DMSG 24 h na spons ontrekking (70.2%; 73.7%; 105.0% respektiewelik) of ooie nie behandel met DMSG (60.0%; 70.0%; 116.7% respektiewelik). Die hoogste dragtigheidssyfer (93.3%) is aangeteken in ooie gesinkroniseer

met FGA sponse en 300 IE DMSG binnespiers, 24h na spons onttrekking en FGA plus 300IU DMSG toegedien onderhuids 24h voor sponsonttrekking.

In die 2de eksperiment is estrus sinkronisasie geëvalueer op BHO ooie, een van die skaaprasse in die laagliggende dele van Ethiopië. MAP (60mg) en FGA (40mg) behandelings met verskillende toedieningsperiodes (9,12 of 15 dae), verskillende tye (24h voor, met sponsonttrekking en kontroles) van 300IE DMSG toediening relatief tot sponsonttrekking en faktore wat die respons kan beïnvloed, is getoets. Beide MAP en FGA progestageen sponse was effektief in die indusering van estrus (90.2% vs 93.0% respektiewelik). Albei progestageen sponse het 'n soortgelyke effek op die tyd tot estrus (40.0 ± 2.2 h vs 39.4 ± 2.1 h respektiewelik) en die tydsduur van die geïnduseerde estrus (46.1 ± 2.4 h vs 43.9 ± 2.3 h) gehad. Geen betekenisvolle verskille is gevind tussen MAP en FGA spons behandeling wat die konsepsie, lampersentasie en fekunditeit betref. Die toediening van 300IE DMSG het die indusering van estrus betekenisvol ($P < 0.01$) verhoog tesame met die vermindering in die tyd tot aanvang van estrus. Onafhanklik van die tyd van DMSG toediening was die estrus respons hoër ($P < 0.01$) in DMSG-behandelde ooie (100.0%) vergeleke met die kontrole diere. Die tyd van estrus relatief tot progestageen onttrekking was ook betekenisvol ($P < 0.01$) vroeër in DMSG-behandelde ooie, vergeleke met die kontrole ooie. Dragtigheid en lampersentasie was ook betekenisvol ($P < 0.05$) hoër in die DMSG behandelde ooie, vergeleke met die kontrole diere. Die interval van progestageen behandeling het die estrus respons in hierdie ooie ook betekenisvol ($P < 0.01$) beïnvloed. Die persentasie ooie wat uitwendige tekens van estrus getoon het, was betekenisvol ($P < 0.01$) hoër in die 12 en 15 dag behandelingsgroepe (93.1% vs 96.2% respektiewelik), vergeleke met die 9 dae progestageen behandeling (86.2%). Die duur van progestageen behandeling het geen betekenisvolle effek op die tyd tot aanvang van estrus, die tydsduur van die geïnduseerde estrus, dragtigheid en die lampersentasie gehad nie. Die dragtigheidssyfer was hoër ($P < 0.01$) in ooie met 'n BCS van tussen 3.1 en 3.5 (82.6%) vergeleke met ooie met 'n BCS van > 3.5 (41.7%). Die lampersentasie was ook hoër ($P < 0.01$) in ooie met 'n BCS tussen 3.1 en 3.5 (87%), as ooie met 'n BCS van > 3.5 (41.7%). Uit die 18 sinkronisasie kombinasies vergelyk in hierdie studie, het FGA behandeling vir 9 dae met geen DMSG of MAP behandeling vir 12 dae met geen DMSG betekenisvol ($P < 0.01$) minder ooie

in estrus geïnduseer (25% en 60.0% respektiewelik). Soortgelyk was die vrugbaarheidsresultate ook laer ($P < 0.01$) in ooie gesinkroniseer met MAP sponse vir 12 dae met geen DMSG (40.0%). Die hoogste konsepsiesyfer (100.0%) is waargeneem in ooie gesinkroniseer met MAP sponse vir 9 dae en 300IE DMSG 24h voor sponsonttrekking, MAP sponse vir 15 dae en 300IE DMSG met sponsonttrekking, FGA sponse vir 9 dae en 300IE DMSG 24h voor sponsonttrekking en FGA behandeling vir 12 dae met 300IE DMSG met sponsonttrekking.

In eksperiment 3 is sinkronisasie van estrus geëvalueer op 120 Somali bokooie in Oos-Ethiopië. Sinkronisasie doeltreffendheid in terme van estrus respons, dragtigheid, lampersentasie en fekunditeit na gebruik van MAP (60mg) en FGA (40mg) vir 4 behandelingsperiodes (9,12,15 of 18 dae), met of sonder DMSG behandeling is vergelyk. Beide MAP en FGA intravaginale sponse met 9,12,15 of 18 dae behandeling was ewe effektief in die indusering van estrus – geen betekenisvolle verskille in dragtigheid, lampersentasie en fekunditeit is waargeneem. Die dragtigheidssyfer was betekenisvol ($P < 0.05$) hoër in die kontrole bokooie (geen DMSG) (39.5%) vergeleke met ooie behandel met 300 IE DMSG 24h voor (25.7%) of met (28.6%) spons onttrekking. Behalwe sinkronisasie behandeling het ouderdom en liggaamsgewig met KI die konsepsiesyfer betekenisvol ($P < 0.05$) beïnvloed. Dragtigheid en lampersentasie was betekenisvol hoër in 6 jaar oue ooie (60.9% en 60.9% respektiewelik) vergeleke met 1 (25.8% en 27.9% respektiewelik) en 9 jaar oue ooie (17.7% en 29.4% respektiewelik). Soortgelyk, is betekenisvolle hoër konsepsiesyfer en lampersentasies aangeteken in ooie met 'n liggaamsgewig van meer as 20kg by KI, vergeleke met ooie ligter as 20kg. Betekenisvol hoër konsepsiesyfers is aangeteken in ooie met 'n BCS tussen 2.6 en 3.0 by KI (44.8%), vergeleke met ooie met 'n BCS van tussen 2.0 en 2.5 of tussen 3.1 en 3.5 (25.4% en 37.5% respektiewelik). Die gebruik van DMSG by estrus sinkronisasie in Somali bokooie word nie aanbeveel aangesien dit blyk om bevrugting nadelig te beïnvloed. 'n Ouderdom perk t.o.v. vrugbaarheid moet ook vir die ras vasgestel word. Die handhawing van 'n optimale (21 tot 30kg) liggaamsgewig en BCS (2.6 tot 3.0) is noodsaaklik vir 'n suksesvolle sinkronisasie program.

Oor die algemeen was beide MAP (60mg) en FGA (40mg) progestagen sponse ewe doeltreffend in die indusering van estrus, met geen betekenisvolle verskil in vrugbaarheid. Dus kan enigeen van die progestagen behandelings gebruik word vir beheerde teling. Anders as in Somali bokooie, het die toediening van 300 IE DMSG of 24 voor of met sponsonttrekking vrugbaarheid verhoog in Dorper en BHO ooie. Dus word die gebruik van 300 IE DMSG as sinkronisasiemiddel in Dorper en BHO ooie aanbeveel – anders as by die bokooie. Die tydsduur van progestageen het geen effek op die gevolglike vrugbaarheid in beide BHO en Somali ooie gehad nie. Die handhawing van 'n optimale BCS (3.1 tot 3.5) voor KI word aanbeveel in BHO ooie. Geslagsrypheid en die maksimum ouderdom by die prul van Somali bokooie moet in aanmerking geneem word. In alle gevalle regverdig die effek van voedingstatus, dosis DMSG en seisoen van sinkronisasie verdere ondersoek. Vroeë dragtigheidsondersoeke d.m.v. ultrasoniese apparaat is belangrik in die identifisering van moontlik embrionale resorpsie aangesien groot verskille bestaan tussen die diere wat nie weer estrus toon nie en die werklike dragtigheidssyfer vir beide Somali en BHO ooie in Ethiopië.

Verdere studies aangaande die respons van kleinvee in Afrika na beheerde teling word aanbeveel om die effek van ander veranderlikes te evalueer (ras, seisoen, voedingstatus, ens).

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