韓國受精卵移植研究會誌(1986) 第 1 卷 第 1 號
Korean J. Emb. Trans. (1986) Vol. 1, No. 1 pp. 59~68

Some Aspects of Physiology of Estrous Cycle in Goats

Choong Saeng Park

College of Agriculture, Gyeongsang National University

산양의 발정주기의 생리에 관한 고찰

박 충 생

경상대학교 농과대학

초록 : 산양의 발정주기의 생리와 조절에 관한 최근의 연구 보고들과 한국재래산양에 대한 이들 연구 결과를 모아 고찰하였다. 온대지역에서 산양의 번식계절은 분명하나 한국재래산양의 경우는 비번식계절이 비교적 짧거나 계절적 무발정율이 낮은 편이며, 비번식계절에는 기능적 황체가 유지되지 않는다. 한국재래산양의 발정주기와 발정지속기간은 타품종과 비슷하며, 발정지속기간의 반복력은 매우 낮으며, 발정주기중의 progesterone과 estradiol-17β의 소장을 규명하였다. 한국재래산양의 경우 황체기에 PGF 2α 1-3mg을 투여하면 황체퇴행을 유기할 수 있으나 주기중의 투여시기에 따라 투여후 발정개시 시간에 차이가 있었다. 그리고 progesterone priming후 PGF 2α를 투여함으로써 효과적인 발정동기화를 이룰 수 있었다. 분만후 1개월경과 유산후 12일경에 발정이 재귀되었으며, 첫 발정 후 80%의 산양에서 5~7일의 단발정주기를 나타냈으며, 대부분의 과배란유기 산양에서도 단발정주기를 나타냈는데 이는 황체의 조기퇴행 때문이었다. 초발정 후 3~5일에 GnRH를 연속 주사하면 단발정주기의 발생율이 유의적으로 감소되었다.

Introduction

Reproductive efficiency in goats is determined by many different process which result from interactions among genetic and environmental factor. The processes involved, singly or in concert, include length of breeding season, ovulation rate, fertilization rate, placentation, embryo and fetal development and survival, and viability and growth of the newborn. These processes are controlled and regulated and levels determined by climatic factors such as nutrition, disease, care and handling, housing, age of the animals, and inter- and intra-genotypic factors. The net effect of all of these nfluences determine the level and efficiency of reproduction. Reproduction can be expressed as kidding rate, kidding interval, weight of kids born or weaned, survivability of kids, and/or length of reproductive life.

Generally, goats are polyestrous during the normal breeding season, but near the equator they cycle year round. The normal estrous cycle in goats is 19 to 24 days (Phillips et al., 1943; Carrera and Butterworth, 1969; Jarosz et al., 1971), but a certain proportion of estrous cycle lengths are short (Ott et al., 1981; Corteel et al., 1982; Simplicio et al., 1982; Gonzalez and Madrid, 1982; Chemineau, 1982; Thangevelu and Mukherjee, 1982; Camp et al., 1982, 1983).

Recent findings on breeding season, estrous cycle, puberty, postpartum interval to estrus, and control of reproduction in goats are well reviewed by Riera (1982) and Corteel et al. (1982).

This review will focus on the recent works on the breeding season, estrous cycle, estrus synchronization, postpartum interval to estrus and short estrous cycle in Korean native goats.

Breeding Season

The length of the breeding season is dependent primarily on the genotype of goats and interaction of genotype and environment playing a major role. Different climatic factors, such as temperature and photo-

period and perhaps other climatic factors in the tropics and subtropics result in extended periods of breeding including continuous, year round sexual activity in goats (Devendra, 1962; Amble et al., 1964; Hofmeyer et al., 1965; Mishra and Biswas, 1966; Sahni and Roy, 1967; Singh and Singh, 1974; Khatter and Mishra, 1977; Simplicio et al., 1982).

In temperate zones including our country, the goats behaves as a seasonal breeder showing a clear anestrous period due to the influence of changes in photoperiod (Phillips et al., 1943; Gill and Dev., 1972; Corteel, 1977; Shelton, 1978). The photoperiod in seasonlity of breeding in tropical goats is less important (Sands and McDowell, 1978) than ecological factors like temperature, rainfall, vegetation and herbal growth (Rajkonwar and Borgohain, 1978).

Song et al. (1984c) reported that the monthly percentage of goats showing more than one estrous behaviour to all the experimental goats available for breeding was highest (94-100%) in October to Februray, lowest (17-22%) in July to August, and not varied greatly (58-76%) between the other months (Table 1).

Table 1. Monthly Patterns in the Percentage of Goats Showing more than One Estrous Behaviour per Month in Korean Native Goats

Items	1982	1983										
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
No. of goats observed	16	15	17	14	14	19	18	18	18	17	15	19
No. of goats showing estrus	16	15	16	10	9	11	12	4	3	13	15	19
Percentage of goats showing estrus	100	100	94	71	64	58	67	22	17	76	100	100

(Song et al., 1984 c)

Lee et al. (1985) measured progesterone concentration in blood samples collected from the jugular vein during seasonal anestrus in Korean native goats. Serum progesterone concentration was ranged from 0.05 to 0.44ng/ml except for a short period in most of the seasonal anestrous goats. These results indicate that Korean native goats have a nonbreeding season of which duration may be varied, but relatively short, compared with other breeds of goat in the temperate areas.

Estrous Cycle

The length of estrous cycle: The length of the estrous cycle is well documented and indicates an extreme variation from cycles as short as 3 days to cycles as long as 62 days (Shelton, 1961; Carrera and Butterworth, 1969; Devendra and Burns, 1970; Jarosz et al., 1971; Sands and MocDowell, 1979; Bhattacharyya et al., 1981). The majority of the estrous cycles, however, are 19 to 21 days in length (Riera, 1982; Song et al., 1984 a; Smith, 1986).

Song et al. (1984 a) using records of 143 estrous cycles from Korean native goats categorized them into short ($<$ 11 days), normal (18-24 days) and long ($>$ 25 days) cycles.The frequency of each category was 31, 50 and 19% and 5.9 $\pm$ 0.2, 21.0 $\pm$ 0.1 and 43.7 $\pm$ 3.3 days of duration, respectively, with an overall mean of 20.5 $\pm$ 1.3 days (Table 2).

The duration of estrous period: The estrous period also appears to be variable in length. However, the most common length of estrous period reported was 36 hours with a variation from 22 hours (Van Rensburg, 1964) to 60 hours (Ajelo, 1950) and many other with intermediate lengths (Phillips et al., 1943; Mishra and Biswas, 1966; Sahni and Roy, 1967; Prasad and Bhattacharyya, 1979; Bliss, 1980). The occurrence of estrus for as long as 10 days has been reported by Jarosz et al. (1971). In Korean native goats, Song et al. (1984a)

Table 2. The Length of Estrous Cycle following Natural and Induced Estrus in Korean Native Goats

Estrous cycle followed by	No. and length of estrous cycle	Estrous cycle			
		Short (<11days)	Normal (18-24days)	Long (>25days)	Total Total
Natural estrus	No. of cycle	33	51	24	108
	Length (days)	6.1 ± 0.2	21.0 ± 0.2	42.2 ± 3.2	21.2 ± 1.4
Induced estrus	No. of cycle	12	20	3	35
	Length (days)	6.2 ± 0.1	21.0 ± 0.3	55.3 ± 14.7	18.5 ± 2.5
Total	No. of cycle	45	71	27	143
	Length (days)	5.9 ± 0.2	21.0 ± 0.1	43.7 ± 3.3	21.5 ± 1.3

(Song et al., 1984 a)

reported that the duration of estrus in natural or induced estrus was 32.9 ± 1.2 hours and 33.3 ± 1.7 hours, with an overall mean of 33.0 ± 1.0 hours. The repeatability for the duration of estrous period was very law as r = 0.049.

Progesterone and estradiol-17β concentration during the estrous cycle: The control of reproductive cycle in sexually mature and adult female is an interplay of estrogen and progesterone hormones liberated from the ovary under the influence of pituitary gonadotropins. The major release of LH and FSH occurs at estrus. This surge release of gonadotropins is triggered by a positive feedback effect of estradiol from the preovulatory follicle during the immediate postestrous period, when ovarian steroid ocncentrations in blood are relatively low, FSH increases in the absence of any increase in LH. This rise in FSH may be due to removal of the negative feedback effect of inhibin when its source is destroyed by ovulation. The increase in FSH may play a role in recruitment of pre-antral follicles. At approximately 3 to 4 day postestrus, a large follicle appears on the ovary. Estrogen from this follicle, plus progesterone from the newly formed corpus luteum feedback negatively on LH. During the luteal phase of the estrous cycle, gonadotropin secretion is under the negative feedback influence of estradiol and progesterone. Following luteal regression, a slight but significant increase in LH occurs, which may be important in inducing follicular maturation and the proestrous rise in estradiol. Studies on hormonal control of the estrous cycle in the goat essentially concern plasma progesterone variations (Heap and Linzell, 1966; Thorburn and Schneider, 1972; Jones and Knifton, 1972; Wentzel et al., 1979; Kakusya, 1980; Thibier et al., 1981). Weight of the corpus luteum in goat increases during the first postestrous week and reaches mature size by day 13 of estrous cycle, after which the luteal cells slowly degenerated (Harrison, 1948). The mean plasma concentration of progesterone was extremely low on the day of estrus with below 1.0 ng/ml (Jones and Knifton, 1972; Thorburn and Scneider, 1972; Chemineau et al., 1982; Bono et al., 1983), gradually increased from day 3 to 9 (Jones and Knifton, 1972; Camp et al., 1982), and reached to a maximal level of 4 to 8.9ng/ml by day 10 to 12 of the estrous cycle (Jones and Knifton, 1972; Thorburn and Scneider, 1972; Chemineau et al., 1982; Bono et al., 1983). Before the estrus, mean concentration of estradiol-17β did not fluctuated much during the estrous cycle from day 2 to 17 with 9.4pg/ml (Chmineau et al., 1982) and 16.96 to 22.98pg/ml (Jain et al., 1982) in plasma or 20.2 to 25.7pg/ml in serum (Camp et al., 1982). However, the maximal concentrations of estradiol-17β with 32.3 pg/ml (Chemineau et al., 1982) and 34.98 pg/ml (Jain et al., 1982) in plasma or 25.7 pg/ml in serum serum (Camp et al., 1982) were observed at preovulatory period.

Song et al. (1984 b) studied the serum levels of progesterone and estradiol-17β of 3 Korean native goats which showed an 20 days of estrous cycle. The mean progesterone levels were lower than 0.02 ng/ml on the first day of estrus (Day 0) and gradually increased to 0.14 to 4.46 ng/ml on Day 2 to 6 of the cycle. The pro-

gesterone reached to highest level of 8.98 ng/ml on Day 14 and then decreased to 0.26 ng/ml on Day 18 and lower than 0.02 ng/ml on the following estrus. The mean levels of estradiol-17β were ranged from 23.79 pg/ml to 28.40 pg/ml between 6 hours before and 12 hours after the onset of estrus, and were lower than 10 pg/ml in the other stages of estrous cycle with exceptions of higher level in some goats at the various stages of the cycle (Fig. 1).

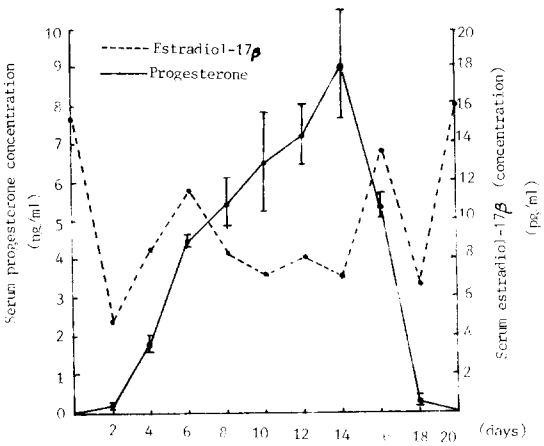

Fig. 1. Serum Progesterone and Estradiol-17β Concentrations during the Normal Estrous Cycle of 20 days in Korean Native goats (n=3).

Estrus Synchronization

Programs for synchronization of estrus and ovulation in the goats have been based on the use of progestogens (Corteel, 1975). However, transport and survival of spermatozoa have been found to be deleteriously affected in the reproductive tract of the progestogen-treated ewe (Hawk et al., 1972). For this reason, a second method for synchronization of estrus and ovulation was used. This method involved induction of luteolysis by administration of prostaglandin F2α (PGF2α) which was recognized potential for control of ovulation in domestic livestock (Inskeep, 1973). In the goats, PGF2α was luteolytic after intraluteal (Shutt et al., 1976) and intramuscular administration (Bretzlaff et al., 1983; Bretzlaff and Ott, 1983). A major disadvantage in the use of PGF2α is that it is successful only when given between Days 4 to 16 of the estrous cycle (Bosu et al., 1978) in goats. This problem has been circumvented by 2 injections of PGF2α 11 days apart (Ogunbiyi et al., 1980; Ott et al., 1980 a,b).

Dosages of PGF2α: Dosages of PGF2α 15mg (Bosu et al., 1978), 8mg (Ott et al., 1980 b), or 8mg divided into 2 injections given 4 hours apart (Ott et al., 1980 a) have been used effectively for induction of estrus in the goats when administered between Days 4 and 16 of the estrous cycle. In a recent studies, varying dosages of PGF2α have been injected in cycling goats during the luteal phase to determine the minimum dose effective for induction of estrus. Bretzlaff et al. (1981, 1983) reported as little as 1.25 mg or 1.75 mg was effective for the induction of estrus in the dairy goats. In Korean native goats, 1mg (Song an Park, 1984) or 3mg (Park et al., 1986) or PGF2α was successful for estrus synchronization. Prostaglandin analogues have also been used in the goats, with 125μg cloprostenol (Perera et al., 1978) and 16μg ICI 79939 (Hearnshaw et al., 1974) reported as luteolytic in this species.

Stages of estrous cycle for PGF2α treatment: Bretzlaff et al. (1981, 1983) was successfully induced estrus with intra-muscular injection of PGF2α between Day 7 and 10 of estrous cycle with 43 ± 5.5 to 47 ± 3.1 hours after PGF2α injection. Park et al. (1986) showed that a single intramuscular injection of PGF2α on Day 5 to 12 of estrous cycle induced estrus, but this treatment on Day 3 to 4 was not effective. More effective synchronization of estrus was resulted from progesterone priming for 6 to 7 days followed by PGF2α injection 24 hours prior to the last progesterone treatment, compared with a single intramuscular injection of PGF2α alone. Time from PGF2α to estrus induction was significantly earlier in PGF2α treatment during Day 5 to 6 than during Day 7 to 12 of cycle (38.2 ± 1.5 *vs* 54.7 ± 2.0 hours). PGF2α treatment with progesterone priming delayed (96.5 ± 1.7 hours) significantly the estrus induction compared with the PGF2α injection only during mid-luteal phase of the estrous cycle. The percentages of estrus synchronization after PGF2α injection, Ogunbiyi et al. (1980) and Ott et al. (1980b) observed estrus synchronization in the goats employing the double injection regimen of 7.5mg and 8mg of PGF2α at each injection, resulted in 84% and 94% after the second injection of PGF2α. Song and Park (1984) reported single intramuscular injection of 1mg or 3mg PGF2α was induced estrus in 83 to 100% within 5 days after PGF2α injection, and Park et al. (1986) resulted in 96% of 31 goats after PGF2α without progesterone and 100% of 23 goats after PGF2α with

progesterone pretreatment.

Progesterone profile after estrus synchronization with PGF2α: Ott et al. (1980) observed progesterone concentration after PGF2α declined from pretreatment of 5.2 ± 0.31ng/ml to 36 hours post-treatment concentrations below the lower limits of the sensitivity of the assay (0.125ng/ml). Park et al. (1986) reported serum progesterone concentration was decreased to a nadir at 24 to 48 hours after PGF2α treatment on Day 5 to 8, but increased to 2.69 ±0.56 at 48 hours after PGF2α injection on Day 3 to 4 of estrous cycle (Fig. 2).

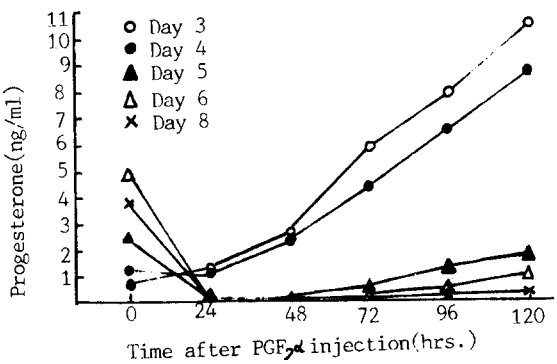

Fig. 2. Serum Progresterone Concentration after a Single 1.m. Injection of 3mg PGF2α on Day 3 6 and Day 8 of Estrous Cycle in Goats (n=3).

Postpartum Interval to Estrus and Postpartum Estrous Cycle

The interval between parturition and the first postpartum estrus and service period are also important traits which contribute to reproductive efficiency in goats. The earlier postpartum that does return to estrus the earlier conception can occur, the shorter the kidding interval and the more efficient the reproductive efficiency. This interval varies among breeds, lactation, nutritional regime, etc. (Riera, 1982). The mean values postpartum interval to estrus varied from 4 to 6 days after kidding (Prasad, 1979) and from 41 to 210 days or more (Sahni and Roy, 1967). Prasad (1979) reported that the duration of postpartum estrus in Barbari does varied from 1 day (70%) to 4 days (1.43%).

Song et al. (1984c) observed that the mean return interval to estrus after kidding of PGF2α-induced abortion in Korean native goats was 12.2 ± 1.2 days, 27.2 ± 7.2 days and 33.0 ± 3.2 days in the group of induced abortion, parturition without and with suckling, respectively. There were significant differences in return period to estrus between induced abortion and parturition with or without suckling (Table 3). This delayed postpartum interval to estrus by suckling stimulus was reported in cattle (Carruthers et al., 1980; Hinshelwood et al., 1982; Montgomery, 1982; Cunn etal., 1985),

Table 3. Return to Estrus following Normal Partirition and Induced Abortion in Korean Native Goats

Items	Normal parturition			Induced abortion
	Suckled	Non-suckled	Total or mean	
No. of goats examined	5	5	10	5
Return to 1st estrust (days)	33.0 ± 3.2^{aA}	27.2 ± 7.2^{aAB}	30.1 ± 3.8	12.2 ± 1.2^{bB}
Duration of 1st estrus (hours)	14.4 ± 5.6	28.8 ± 4.8	21.6 ± 4.2	24.0 ± 10.6
Length of 1st estrous cycle (days)	6.4 ± 0.1	14.7 ± 3.7	11.2 ± 2.4	4.9 ± 0.4

* Means ± S.E.M. with different small ($P < 0.05$) and capital ($P < 0.01$) letters are significantly different.

(Song et al., 1984 c)

pig (Grinwich and McKay, 1985), sheep (Kann and Martinet, 1975) and goats (Song et al., 1984 c; Park et al., 1986).

Carruthers et al. (1980) and Peters et al. (1981) hypothesized that suckling prolongs the interval of postpartum anestrous and anovulation by reducing frequency and perhaps amplitude of LHRH secretion. As a consequence of reduced LH-RH secretion, LURH "self-primiming" is reduced, which decreases the releasable pool of LH in the pituitary and frequency and magnitude of episodic LH release. The end result of the suckling-induced reduction in episodic LH secretion is a delay in ovarian follicular maturation and prolongation of the interval of postpartum anovulation.

Short Estrous Cycle

In goats, short estrous cycles of less than 12 days, and often of only 5 to 7 days, are quite common (Smith, 1986). These abnormal short estrous cycles have been observed in seasonally breeding goats during the initiationof the breeding season (Gonzalez and Madrid, 1982; Camp et al., 1982 1983), after introduction of a buck to a group of late seasonally anestrous goats (Shelton, 1960; Ott, 1981; Chemineau, 1982), following the post-partum interval (Riera, 1982; Song et al., 1984 c; Park et al., 1986), after PGF2α-induced abortion (Bretzlaff et al., 1982; Song et al., 1984 c; Park et al., 1986), or estrus (Song and Park, 1984; Park et al., 1986) and following superovulation with PMSG (Armstrong et al., 1983 a,b; Park et al., 1986) or FSH (Park et al., 1986).

Park et al. (1986) measured the serum progesterone concentration during the short estrous cycle of 6 or 7 days in Korean native goats. The mean concentration of serum progesterone was found to be basal level at estrous phase, but considerably high level up to 1.15 ng/ml at Day 4 to 5 of the cycle. Studies with laparoscopy (Chemineau, 1982; Camp et al., 1983) or progesterone assay (Park et al., 1986) indicate that these short estrous cycles were related to premature regression of luteal function.

Park et al. (1986) administered 4 times daily intramuscular injectionof 25μg GnRH between Day 3 to 5 of the first postpartum estrous cycle in Korean native goats. The incidence of short estrous cycles were significantly reduced to 38.5%, compared with 80.0% in GnRH-untreated control groups of goats (Table 4). The magnitude and duration of the GnRH-induced LH surge also appeared to be associated with enhanced corpus luteum function and lifespan (Troxel and Kesler, 1984).

Table 4. Effect of GnRH Treatment for Day 3 to 5 of the First Estrous Cycle following Parturition or Abortion on the Length of the Subsequent Estrous Cycle

Treatment	No. of goats examined	First estrous cycle		Duration of second estrus (hrs.)	Second estrous cycle	
		Length (days)	% short cycle		Length (days)	% short cycle
Control						
Parturition	9	11.1 ± 2.4^{A}	66.7^{A}	46.7 ± 2.4^{a}	23.3 ± 6.9^{a}	42.9^{a}
Abortion	6	5.3 ± 0.5^{B}	100.0^{B}	38.0 ± 6.5^{b}	12.1 ± 3.7^{a}	60.0^{a}
Total or mean	15	$8.8 \pm 2.8^{A*}$	80.0^{A*}	$43.2 \pm 3.1^{a*}$	$18.6 \pm 4.5^{a*}$	50.0^{a*}
GnRH						
Parturition	8	17.8 ± 3.5^{a}	50.0^{A}	41.3 ± 8.7^{a}	17.4 ± 3.1^{a}	25.0^{a}
Abortion	5	20.0 ± 4.0^{a}	20.0^{B}	36.0 ± 5.4^{a}	18.4 ± 6.1^{a}	40.0^{a}
Total or mean	13	$18.6 \pm 2.8^{B*}$	38.5^{B*}	$39.2 \pm 5.6^{a*}$	$17.8 \pm 2.9^{a*}$	30.8^{b*}

1) Means ± S.E.M. and percentages with different small ($P < 0.05$) or capital ($P < 0.01$) letters wit in group, and different star-marked small ($P < 0.05$) or capital ($P < 0.01$) letters between groups in column are significantly different.

(Park et al., 1986)

Summary

Recent findings on some aspects of physiology of estrous cycle and control of reproduction in goats are reviewed with a focus on the research works on estrous cycle in Korean native goats. Goats in the temperate zones show a clear breeding season but a relatively short or weak anestrous period in late spring and summer was found in Korean native breed. During seasonal anestrus it was found that the goats had no functional corpus lutea by assessing the progesterone profile of their peripheral sera.

Korean native goats also exhibited a similar length of estrous cycle and duration of stadning estrus, and the change in serum level of progesterone and estradiol-17β during the cycle to other breeds of goat. The duration of estrus in goats was fould very low in repeatability. A single dose of 1 to 3mg prostaglanin $F_2\alpha$ induced luteolysis successfully but the time of estrus exhibition after $PGF_2\alpha$ was significantly different by the stage of cycle for $PGF_2\alpha$ treatment, and $PGF_2\alpha$ at 3-4 days of the cycle was not effective for luteolysis in goats. Progesterone priming for 6 to 7 days followed by $PGF_2\alpha$ at 1 day before progesterone withrwal was found a satifactory method for estrus synchronization in goats. The postpartum period to estrus was shorter in the goats of induced abrotion than normal parturition. Most of the goats of induced abortion than normal parturition. Most of the goats after first postpartum estrus or superovulation treatment had a short estrous cycle of 5 to 7 days because of the premature luteal regression and the short cycle was in part prevented by GnRH treatment for Days 3 to 5 of the cycle following the estrus.

References

1. Ajelo, P. (1950). Observationi sulla citologia du secreto vaginale durnate el ciclo sessuale dell capra Siciliana. Nuova Vet., 26: 226-231.
2. Amble, V.N., Khander, N.C. and Barg,. N. (1964). Statistical studies on breeding data of Beetal goats. Indian Counc. Agr. Res., pp. 70.
3. Armstrong, D.T., Pfitzner, A.P., Warnes, G.M., Ralph, M.M. and Seamark, R.F. (1983a). Endocrine responses of goats after induction of superovulation with PMSG and FSH. J. Reprod. Fert., 67: 395-401.
4. Armstrong, D.T., Pfitzner, A.P., warnes, G.M. and Seamark, R.F. (1983b). Superovulation treatments and embryo transfer in Angora goats. J. Reprod. Fert., 67: 403-410.
5. Bhattacharyya, B.K., Mazumdar, N.K., Mazumdar, A. and Luktuku., S.N. (1981). Studies on certain aspects of estrous behaviour in Pashimina goats. Indian J. Anim. Sci., 61: 67-69.
6. Bliss, E.L. (1980). Dairy goat reproductive management. Dairy Goat J., 58: 3, 12, 13.
7. Bono, G., Cairoli, F., Tamanini, C. and Abrate, L. (1983). Progesterone, estrogen, LH, FSH and PRL concentrations in plasma during the estrous cycle in goat. Reprod. Nutr. Develop., 23: 217-222.
8. Bosu, W.T.K., Serna, J. and Barker, C.A.V. (1978). Peripheral plasma levels of progesterone in goats treated with fluorogestone acetate and prostaglandin $F_2\alpha$ during the estrous cycle. Theriogenol., 9: 371-390.
9. Bretzlaff, K., Ott, R.S., Weston, P.G. and Hixon, J.E. (1981). Doses of prostaglandin $F_2\alpha$ effective for ir luction of estrus in goats. Theriogenol., 16: 587-591.
10. Bretzlaff, K.N., McEntee, M., Hixon, J. and Ott., R.S. (1982). Short estrous cycles after $PGF_2\alpha$-induced abortion in goats. Proc. 3rd Int. Conf. Goat prod. Dis., Tucson, Arzona, U.S.A., pp. 498.
11. Bretzlaff, K.N., Hill, A. and Ott, R.S. (1983). Induction of luteolysis in goats with prostaglandin $F_2\alpha$. Am. J. Vet. Res., 44: 1162-1164.
12. Camp, J.C., Wildt, D.E., Howard, P.K., Stuart, L. and Charkaborty, P.K. (1982).Behavioral, endocrine, and ovarian relationship during the estrous cycle of the Nubian goat. Proc. 3rd Int. Goat Prod. Dis., Tucson, Arizona, U.S.A., pp. 310.
13. Camp, J.C., Wildt, D.E., Howard, P.K., Stuart, L.D. and Chakraborty, P.K. (1983). Ovarian activity during normal and abnormal length estrous cycle in the goat. Biol. Reprod., 28: 673-681.
14. Carrera, C. and Butterworth, M.H. (1969). Preliminary study of the oestrous cycle in goats. In: World Conf. Anim. Prod. 2. Proceedings. pp. 368.
15. Carruthers, T.D., Convey, E.M., Kesner, J.S., Hafs, H.D. and Cheng, K.W. (1980). The hypothalamo-pituitary gonadotrophic axis of suckled and non-

suckled dairy cows postpartum. J. Anim. Sci., 51: 949-959.

16. Chemineau, Ph. (1982). Reproductive performance in a "Creole" meat goat flock at three mating periods. Proc. 3rd Int. Goat Prod. Dis., Tucson, Arizona, U.S.A., pp. 495.
17. Chemineau, P., Gauthier, D., Poirier, J.C and Saumande, J. (1982). Plasma levels of LH, FSH, prolactin, oestradiol-17β and progesterone during natural and induced oestrus in the dairy goat. Theriogenol., 17: 313-323.
18. Corteel J.M. (1975). The use of protesterone to control the estrous cycle of the dairy goat. Ann. Biol. Anim. Biochim. Biophys., 15: 353-363.
19. Corteel, J.M. (1977). Production, storage and insemination of goat semen. In: Proc. Symp. Man. Reprod. Sheep & Goats, July 24-25, Madison, Wisconsin. pp. 41-57.
20. Corteel, J., Gonzalez, C. and Nunes, J.F. (1982). Research and development in the control of reproduction. Proc. 3rd Int. Conf. Goat Prod. Dis., Tucson, Arizona, U.S.A., pp. 584-601.
21. Eevendra, C. (1962). Upgrading of local goats by the Anglo-Nubian at the Federal Experiment Station, Serdang. Malaya Agr. J., 43: 265-280.
22. Devendr, C. and Burns, M. (1970). Goat production in the tropics. Farhan Royal, Bucks, Commonwealth Agricultural Bureaux, pp. 184.
23. Dunn, RJ., Jr., Smith, M.F., Garverick, H.A. and Faley, C.W. (1985). Effects of 27 hr calf removal and/or gonadotropin releasing hormone on luteinizing hormone release and ovarian activity in postpartum beef cows. Theriogenol., 23: 767-776.
24. Gill, G.S. and Dev, D.S. (1972). Performance of two exotic breeds of goats under Indian conditions. Indian J. Anim. Prod., 3: 173-178.
25. Gonzalez, S.C. and Madrid, B.N. (1982). Sexual season and estrous cycle of native goats in a tropical zone of Venezuela. Proc. 3rd Int. Conf. Goat Prod. Dis., Tucson, Arizona, U.S.A., pp. 311.
26. Grinwich, D.L. and McKay, R.M. (1985). Effects of reduced suckling on days to estrus, conception during lactation and embryo survival in sows. Theriogenol., 23: 449-459.
27. Harrison, RJ. (1948). The changes occurring in the ovary of the goat during the estrous cycle and in early pregnancy. J. Anat., 82: 21-48.
28. Hawk, H.W. and Conley, H.H. (1972). Investigation of sperm failure in ewes administered synthetic progestogen. J. Anim. Sci., 34: 609-613.
29. Heap, R.B. nd Linzell, J.L. (1966). Arterial concentration, ovarian secretion and mammary uptake of progesterone in during the reproductive cycle. J. Endocr., 36: 389-399.
30. Hearnshaw, H., Restall, B.J., Nancarrow, C.D. and Mattner, P.E. (1974). Synchronization of estrus in cattle, sheep, and goats using a prostaglandin analogue. Proc. Aust. Anim. Prod., 10: 242-245.
31. Hinshelwood, M.M., Hanseen, P.J. and Hauser, E.R. (1982). Short estrous cycle in postpartum cows as influenced by level of milk production, suckling, diet, season of calving and interval to first estrus. Theriogenol., 18: 383-392.
32. Hofmeyer, M., Joubert, D.M., Badenhorst, F.J.G. and Steyn, D. (1965). Adaptability of sheep and goats to a South African tropical environment. Proc. So. Afr. Soc. Anim. Prod., 4: 191-195.
33. Inskeep, E.K. (1973). Potential uses of prostaglandins in control of reproductive cycles of domestic animals. J. Anim. Sci., 36: 1149-1156.
34. Jain, G.C., Pandey, R.S. and Madan, M.L. (1982). Plasma estradiol-17B levels during oestrous cycle, pregnancy and peripartum in goats. Proc. 3rd Int. Goat Prod. Dis., Tucson, Arizona, U.S.A., pp. 313.
35. Jarosz, S.J., Deans, R.J. and Dukelow, W.R. (1971). Thereproductive cycle of the African Pygmy and Toggenburg goat. J. Reprod. Fert., 24: 119-123.
36. Jones, D.E. and Knifton, .A. (1972). Progesterone concentration in the peripheral plasma of goats during the oestrus cycle. Res. Vet. Sci., 13: 193-195.
37. Kann, G. and Martinet, J. (1975). Prolactin levels and duration of postpartum anoestrus in lactation ewes. Nature, 257: 63-64.
38. Kakusya, G.R.E. (1980). Reproductive hormone patterns in female pygmy goats. Anim. Breed. Abstr., 48: 806.
39. Khatter, S.S. and Mishra, R.R. (1977). A note on age at first kidding of Alpine, Beetal andAlpine x Beetal crossbred goats. Indian J. Anim. Sci., 47: 846-847.
40. Lee, J.S., Kwack, D.O. and Park, C.S. (1985). Fluctuations of serum progesterone concentration during seasonal anestrus in Korean native

goats. Korean J. Anim. Sci., 27: 741-747.
41. Misha, H.R. and Biswas, S.C. (1966). A study on distribution of oestrus in deshi goats. Indian J. Dairy Sci., 19: 132-144.
42. Montgomery, G.W. (1982). In fluence of suckling requency and bromocryptine treatment on the resumption of ovarian cycles in postpartum beef cattle. Theriogenol., 17: 551-563.
43. Ogunbiyi, P.O., Molokwu, E.C.I. and Scooriyamoorthy, Y. (1980). Estrus synchronization and controlled breeding in goats using prostaglandin $F_2\alpha$. Theriogenol., 13: 257-260.
44. Ott, R.S., Nelson, D.R. and Hixon, J.E. (1980a). Peripheral serum progesterone and luteinizing hormone concentration of goats during synchronization of estrus and ovulation with prostaglandin $F_2\alpha$. Am. J. Vet. Res., 41: 1432-1434.
45. Ott, R.S., Nelson, D.R. and Hixon, J.E. (1980b). Fertility of goat following synchronization of estrus with prostagladin $F_2\alpha$. Theriogenol., 13: 341-345.
46. Ott, R.S. (1981) Some aspects of caprine theriogenology. Proc. Ann. Meet. Soc. Theriogenol., pp. 152-159.
47. Park, C.S., Choe, S.Y., Lee, H.J. and Lee, J.S. (1986). Studies on the technological development of embryo transfer and manipulation in goats. I. Estrus induction, short estrous cycle and superovulation in goats. Proc. 1st Conf. Mol. Biol. & Gen. Eng., Seoul, Oct. 16-17, pp. 215-222.
48. Perera, B.M.A.O., Bongso, T.A. and Abeynaike, P. (1978). Oestrus synchronization in goats using cloprostenol. Vet. Rec. 102: 314.
49. Peters, A.R., Lamming, G.E. and Fisher, M.W. (1981). A comparison of plasma LH concentrations in milked and suckling post-partum cows. J. Reprod. Fert. 62: 567-573.
50. Phillips, R.W., Simmons, V.L. and Schott, R.G. (1943). Observation on the normal oestrus and breeding season in goats and possibilities of the breeding season with gonadotropic hormones. Am. J. Vet. Res., 4: 360-367.
51. Prasad, S.P. and Bhattacharyya, N.K. (1979). Oestrous cycle behaviour in different season in Barbari nannies. Indian J. Anim. Sci. 42: 1058-1062.
52. Rajkonwar, C.R. and Borgohain, B.N. (1978). A note on the incidence and signs of oestrus in local does (Capra hircus) of Assam. Indian J. Anim. Sci., 48: 7580759.
53. Riera, S. (1982). Reproductive efficiency and management in goats. Proc. 3rd Int. Goat Prod. Dis., Tucson, Arizona, U.S.A., pp. 162-174.
54. Sahni, K.L. and Roy, A. (1967). A study on the sexual activity of the Barbari goat (Capra hircus L.) and conception rate through artificial insemination. Indian J. Vet. Sci., 37: 269-276.
55. Sands, M. and McDowell, R.E. (1978). The potential of the goat for milk production in the tropics. Cornell Int. Agr. mimeograph 60, Dept. of Sci., Ithaca, New York, pp. 53.
56. Shelton, M. (1961). Factors affecting kid production of Angora does. Miscellaneous publication, Texas Agricultural Experiment Station Nol MP-496, pp. 8.
57. Shelton, M. (1978). Reproduction and breeding of goats. J. Dairy Sci., 61: 994-1010.
58. Shutt, D.A., Smith, L.D. and Sherman, R.P. (1976). Prostaglandins and luteolysis in the goat and human. Theriogenol., 6: 610.
59. Simplicio, A.A., Riera, G.s. and Nunes, J.R. (1982). Estrous cycle and period evaluation in an underfined breed type (SRD) for goats in northeast Brazil. Proc. 3rd Int. Conf. Goat Prod. Dis., Tucson, Arizona, U.S.A., pp. 310.
60. Singh, B.B. and Singh, B.P. (1974). Performance of Jamnapari goats. Indian Vet.. J., 51: 326-336.
61. Smith, M.C. (1986). The reproductive anatomy and physiology of the female goat. In: Current therapy in theriogenology 2 (D.A. Morrow, ed.). pp. 577-579.
62. Song, D.J. and Park, C.S. (1981). A study on induction and synchronization of estrus in Korean native goats. Korean J. Anim. Sci., 26: 13-22.
63. Song, D.J., Park, C.S. and Choe, S.Y. (1984a). Estrus cycle length and estrus period in Korean native goats. Korean J. Anim. Sci., 26: 527-533.
64. Song, D.J., Park, C.S. and Choe, S.Y. (1984b). Serum levels of progesterone and estradiol-17β during the estrus cycle in Korean native goats. Korean J. Anim. Sci., 26: 534-540.
65. Song, D.J., Park, C.S., Choe, S.Y. and Choe, K.M. (1984c). Seasonal variation in breeding activity and return to estrus after parturition or induced

abortion in Korean native goats. Korean J. Anim. Sci., 26: 350-356.

66. Thangevelu, B. and Mukherjee, T.K. (1982). Oestrus cycle lengths and oestrus behaviour studies in the Kambing Katjang (Goat). Proc. 3rd Int. Goat Prod. Dis., Tucson, Arizona, U.S.A., pp. 312.
67. Thibier, M., Pothelet, D. and Jeenguyot, N. (1981). Estrous behaviour, progesterone in peripheral plasma and milk in dairy goats at onset of breeding season. J. Dairy Sci., 64: 513-519.
68. Thorburn, G.D. and Schneider, W. (1972). The progesteron concentration in the plasma of the goat during the oestrous cycle and pregnancy. J. Endocr., 52: 23-36.
69. Troxel, T.R. and Kesler, D.J. (1984). The effect of progestin and GnRH treatments on ovarian function and reproductive hormone secretions of anestrous postpartum suckled beef cows. Theriogenol., 21: 699-711.
70. Van Rensburg, S.J. (1964). Possible endocrine mechanisms for gestation failure. 5th Int. Cong. Anim. Reprod. Artif. Insem., Trento.
71. Wentzel, D., Botha, L.J. J. and Viljoen, K.S. (1979). Progesterone levels in the peripheral plasma of the cycling angora goat doe. Agroanimalia 11: 27-28.