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Short communication

The hormonal profile during the estrous cycle and gestation in Damascus goats

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Abstract

Plasma progesterone, estradiol, LH, FSH and prolactin levels were studied before and during an estrous cycle in 11 Damascus does, exposed to different suckling regimens (Group A: does suckled for 60 days; Group B: does suckled for 120 days; Group C: non-lactating does). In addition, plasma progesterone levels were determined during pregnancy in 10 pregnant does. The mean plasma progesterone levels in the lactating does before the onset of the first postpartum estrus, which included the follicular phase, were significantly lower (0.2 ± 0.1 and 0.1 ± 0.02 ng/ml, respectively), compared to the luteal phase (5.4 ± 0.9 and 2.6 ± 0.3, respectively). The mean plasma progesterone levels in non-lactating does prior to and after the onset of the first seasonal estrus were 0.5 ± 0.1 and 3.3 ± 0.4, respectively. A decline in plasma progesterone concentration was observed 24–72 h before the second postpartum (Groups A and B) and seasonal (Group C) estrus, indicating CL regression occurring in all does. The mean plasma progesterone concentrations in pregnant does reached a value of 4.6 ± 2.8 ng/ml at week 2 of gestation, and increased to a level of 24.5 ± 3.1 ng/ml 12 weeks later. During the luteal phase estradiol levels in the does of Groups A–C were lower (45.7 ± 3.1, 30.8 ± 1.4 and 61.04 ± 6.5 pg/ml, respectively) than the first peak, whether at the onset of postpartum (Groups A and B) seasonal estrus (Group C), or during the estrous period (46.1 ± 5.9, 41.6 ± 5.2 and 93.1 ± 39.5 pg/ml, respectively). The difference in the profiles of plasma estradiol levels at the first and the second postpartum (Groups A and B) seasonal (Group C) estrus may be due to the negative effect of progesterone levels. An LH surge was detected in only two lactating does in Group A (59.3 and 33.6 mIU/ml) 24 and 32 h after the onset of the second postpartum estrus following an increase in plasma estradiol concentration. Plasma FSH levels fluctuated in all groups with no distinct trend during the estrous cycle. Prolactin levels at the onset of the postpartum (Groups A and B)/seasonal (Group C) estrus were higher than levels detected before and during estrous period. The Damascus does manifested great variation in hormonal profiles of the individual animals. All does showed normal cycles, not affected by the different suckling regimens or lactation.

Keywords: Damascus goats; Suckling; Estrous cycle; Estrus; Progesterone; Estradiol; LH; FSH; Prolactin

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1. Introduction

Reproduction is a major factor contributing to the efficiency of meat and milk production by influencing the number of surplus animals and contributing to current and future flock production, with restriction of the breeding season, whether due to genetic or environmental factors, being a major limitation to the reproductive efficiency of the female goat (Shelton, 1978). Damascus goats are considered to be the most important goat breed in the Arabian countries, due to its high milk yield and meat production potential. Damascus goats are seasonal breeders, and the occurrence of the first seasonal estrus is somewhat irregular. These does exhibit a short (August–October) and sometimes long breeding season (July–November), rarely demonstrating estrus during winter (December and January) (Al Khouri, 1996).

Several investigators have reported the concentrations of plasma progesterone during the estrous cycle in goats for different breeds (Bauernfeind and Holtz, 1991; El-Hommosy et al., 1991; Pathiraga et al., 1991; Jain, 1992), while Mavrogenis (1988) and Shalaby et al. (2000) studied changes in the plasma progesterone concentration during different stages of the estrous cycle in Damascus goats. However, little information is available regarding changes in plasma estradiol (Bauernfeind and Holtz, 1991), LH (Chemineau et al., 1982), FSH and prolactin (Bono et al., 1983) during the estrous cycle in the goats, compared to that in sheep and other farm animal species.

In order to increase the reproductive efficiency of the Damascus goat and other seasonal goats, estrus could be controlled either by synchronization or by the hormonal induction of estrus. This work was aimed at obtaining better insight regarding the endocrine profiles during natural estrus and the possibility of manipulating the hormonal profiles in Damascus goats, to facilitate the use of breeding programs at different times of the year and protocols for AI and embryo transfer.

2. Materials and methods

Twenty-one Damascus does of different ages (2–8 years) were used in two phases of the experiment. Eleven does were used for recording the hormonal profiles during the estrous cycle and the effect of lactation on these profiles, while 10 does were used for recording the plasma progesterone levels during gestation. Eight does from the former group were divided after kidding into Group A (four does that suckled for 60 days; early weaning) and Group B (four does that suckled for 120 days; traditional weaning). Does of each group were then machine milked twice daily (6:00 and 16:00). When milk yield started to decrease, goats were milked once daily (6:00) then twice a week until dry. Group C (control) consisted of three does that did not kid (non-lactating).

2.1. Management of experimental animals

All animals were housed and maintained according to the NRC (1981) standards in a semi-open shaded yard with kids remaining with the dams for the assigned suckling periods and then separated. Does were fed 800 g/head/day pelleted concentrate, 4.0 kg/head/day clover hay or Egyptian clover (*Trifolium alexandrinum*) and 300 g/head/day maize during late pregnancy and 960 g/head/day pelleted concentrate, 4.80 kg/head/day clover hay or *Trifolium alexandrinum* and 360 g/head/day maize during the lactation period.

Estrous behavior of the lactating and non-lactating does was tested (15 min per session) for estrus with the aid of a teaser buck twice a day (8:00 and 16:00), starting in May (spring) until the incidence of the first estrus, then every 4 h to the end of the second estrous period. Estrous observations were recorded until the end of November (autumn). For the purpose of measuring the hormonal profiles of the Damascus goats during the estrous cycle, does were not mated at the first postpartum (Groups A and B)/seasonal (Group C) estrus.

In the first trial, blood samples were collected from the 11 does as follows: three times a week, 2 weeks prior to and after the occurrence of the first postpartum (Groups A and B)/seasonal (Group C) estrus; twice a day until the onset of the second estrus, and thereafter at 4 h intervals until the end of the estrous period. In the second trial, blood samples were collected at 2 week intervals from the 10 pregnant does through gestation until kidding. Blood samples were collected in heparinized 10 ml vacuum tubes and centrifuged for 20 min at 4000 × g for plasma separation. Plasma samples were stored at −20 °C until hormone determinations.

2.2. Plasma progesterone and estradiol assay

Quantitative determination of plasma progesterone and estradiol was carried out using radioimmunoassay kits (catalog nos. 1188 and 1163, respectively, manufactured by Immunotech, France). The assays are based on a competitive reaction (Bojanic et al., 1991; Garibaldi et al., 1993). Samples and standards (50 μl for progesterone; 100 μl for estradiol) were incubated for 1 h with ^{125}I-labeled progesterone/estradiol (500 μl), as tracer, in antibody-coated tubes. After incubation, the contents of the tubes were aspirated and the bound radioactive complexes measured to determine the plasma progesterone and estradiol concentrations with the aid of a Mini-Gamma counter (LKB 1275, USA). The sensitivity of the assay during progesterone and estradiol determinations was 0.03 ng/ml and 3 pg/ml, respectively. While the intra- and inter-assay coefficient of variation was 4.3 and 8.2% for plasma progesterone and 7.2 and 7.9% for the estradiol determinations.

2.3. Plasma prolactin, LH and FSH assay

Quantitative determination of prolactin in plasma samples was carried out using the double antibody prolactin kit (catalog no. KPRDI, manufactured by Diagnostic Products Corporation (DPC), USA). This kit is for the quantitative determination of prolactin in human plasma, the assay thus was used to determine more a prolactin trend in the does during the estrous cycle. Quantitative measurements of plasma LH and FSH were carried out using the double antibody radioimmunoassay kit (catalog nos. KLHD1 and KFSD1, manufactured by DPC, USA). The assay procedure is based on a competitive radioimmunoassay in which the ^{125}I-labeled LH/ FSH/ prolactin (tracer) competes with LH/FSH/prolactin in the plasma sample for sites on hormone-specific antibody (Zacur, 1983). After incubation for a fixed time, separation of bound from free is achieved by the PEG-accelerated antibody-bound method. The antibody-bound fraction is precipitated and counted by using automatic Mini–Gamma counter (LKB 1275, USA). The sensitivity of the prolactin, LH and FSH assay was 1.4 ng/ml, 2.0 and 1.6 mIU/ml, respectively, while, the coefficient of variation for the intra- and inter-assay was 4.4, 8.6%; 4.9, 6.1%; 3.1, 8.7%, respectively.

Data were analyzed by the general linear model procedures (GLM) of the program SAS (1987). Two models were used to test the effect of treatment groups, days and changes in hormone profiles prior and during the estrous cycle, as well as hours prior to estrus and during the estrus period. Relationships between the sex hormones concentrations were compared by determining the relevant correlation coefficient (Ott, 1988).

3. Results

The mean progesterone, estradiol, LH and FSH levels during the estrous cycle in Damascus does of the different groups are set out in Fig. 1 and Table 1. The overall mean of progesterone, estradiol, LH, FSH and prolactin levels during estrus are illustrated in Fig. 2, Tables 2 and 3.

Does in the different suckling treatments and the control does experienced a normal luteal phase with significant differences between groups in the magnitude of the plasma progesterone plateau. The highest mean plasma progesterone level recorded in Group A (day 5) was 8.6 ± 3.5 ng/ml. In Group B, the maximum level was recorded on day 14 (3.3 ± 0.5 ng/ml) and Group C on day 12 of the estrous cycle (4.2 ± 0.1 ng/ml). Plasma progesterone levels started to decline 24–72 h before the occurrence of estrus and the concentration remained low until the end of estrus. While plasma LH levels did not significantly differ during the estrous cycle, two does in Group A showed two distinct LH peaks 24 and 32 h following the onset of estrus (59.3 and 33.6 mIU/ml, respectively). The mean plasma FSH levels during the estrous cycle were significantly ($P < 0.05$) different between does in the three groups around the onset of estrus, moreover, they fluctuated in all groups with no distinct pattern being recorded before and during the estrous period. During the estrous period, plasma prolactin concentrations at the time of estrus were higher than levels recorded before and after the occurrence of estrus (Table 3).

Plasma estradiol levels increased significantly ($P < 0.01$) during the estrous cycle and between does in the different groups. The weaning of does (Group B) recorded the lowest plasma estradiol concentration

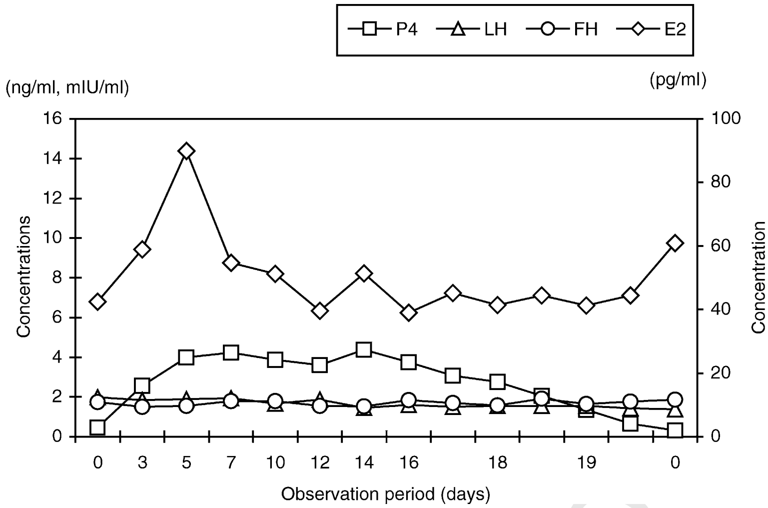

Fig. 1. Changes in hormone concentration of progesterone (P4, ng/ml), estradiol (E2, pg/ml), LH and FSH (mIU/ml) during the estrous cycle of Damascus goats.

before estrus, at estrus and during the estrous period, than early weaning does (A) and the control does (C). The traditional weaning group (B) and non-lactating (Group C) does showed an estradiol peak on the 3rd day after estrus, while early weaning showed an estradiol peak at the onset of the first postpartum estrus.

The plasma progesterone concentrations were negatively correlated with plasma prolactin, estradiol and FSH levels during the estrous cycle ($P < 0.01$; $r = -0.2$, $P < 0.05$; $r = -0.02$ and $P < 0.01$; $r = -0.3$, respectively). Furthermore, the LH levels were positively correlated with the estradiol levels ($P < 0.05$, $r = 0.2$) for the hours prior to estrus and during the estrous period.

Mean progesterone concentration during gestation reached a level of 4.6 ± 2.8 ng/ml during the first 2 weeks of gestation and continued to increase steadily

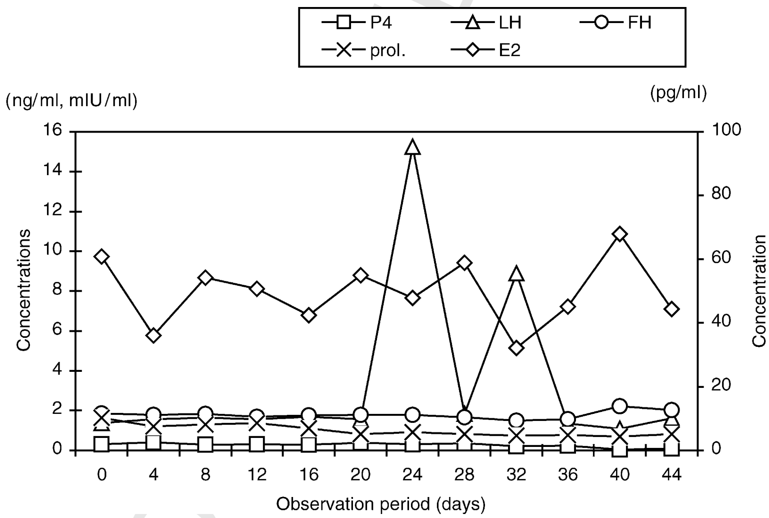

Fig. 2. Changes in hormone concentration of progesterone (P4, ng/ml), estradiol (E2, pg/ml), LH, FSH (mIU/ml) and prolactin (ng/ml) during the estrous period in Damascus goats.

Table 1
Mean (±S.E.) plasma progesterone (P4), estradiol (pg/ml), LH (mIU/ml) and FSH (mIU/ml) 2 weeks prior and post-first estrus in Damascus does in different treatment groups

	Hormones											
	P4 (ng/ml)			E2 (pg/ml)			LH (mIU/ml)			FSH (mIU/ml)		
	A a	B b	C c	A a	B b	C a	A a	B b	C c	A a	B b	C a
No. of samples	4	4	3	4	4	3	4	4	3	4	4	3
Mean 14–3 day before first estrus	0.2 ± 0.1 a	0.1 ± 0.02 a	0.5 ± 0.1 a	34.4 ± 2.8	15.1 ± 4.8	30.03 ± 2.5	1.6 ± 0.1	1.5 ± 0.1	1.6 ± 0.1	2.6 ± 0.2	1.8 ± 0.9	1.4 ± 0.2
Mean at day 0 (estrus)	0.5 ± 0.2	0.4 ± 0.1	0.4 ± 0.3	57.1 ± 18.4	28.7 ± 0.4	41.6 ± 5.2	1. 9 ± 0.2	1.6 ± 0.2	2.4 ± 0.2	1.3 ± 0.6	1.8 ± 0.3	2.2 ± 0.5
Mean at 3rd day after estrus	3.0 ± 1.4 b	2.4 ± 0.8 b	2.3 ± 0.6 b	46.1 ± 5.9	37.5 ± 9.2	93.1 ± 39.5	1.9 ± 0.3	1.7 ± 0.1	1.8 ± 0.2	1.2 ± 0.5	1.7 ± 0.3	1.6 ± 0.4
Mean 5–14 day after first estrus	5.9 ± 0.9 c	2.6 ± 0.3 b	3.5 ± 0.5 b	45.7 ± 3.1	30.8 ± 1.4	61.04 ± 6.5	2.0 ± 0.2	1.7 ± 0.1	1.6 ± 0.2	1.2 ± 0.1	2.2 ± 0.1	1.5 ± 0.1

Groups with different letters (a, b, c) indicate significant differences. Means with different letters (a, b, c) indicate significant differences.

Table 2
Mean (±S.E.) plasma progesterone (P4), estradiol (pg/ml), LH (mIU/ml) and FSH (mIU/ml) prior and during estrus in Damascus does in different treatment groups

	Hormones											
	P4 (ng/ml)			E2 (pg/ml)			LH (mIU/ml)			FSH (mIU/ml)		
	A a	B b	C c	A a	B b	C a	A a	B a	C a	A a	B b	C a
No. of samples	4	4	3	4	4	3	4	4	3	4	4	3
Mean 12–72 h before estrus	1.6 ± 0.6 a	2.4 ± 0.5 a	2.9 ± 0.5 a	45.2 ± 1.3 a	34.0 ± 3.0 a	48.7 ± 3.1 a	1.4 ± 0.8	1.6 ± 0.1	1.5 ± 0.1	1.7 ± 0.9	2.0 ± 0.1	1.6 ± 0.1
Mean at 0 h (estrus)	0.1 ± 0.01 b	0.3 ± 0.1 b	0.6 ± 0.1 b	52.5 ± 4.0	50.6 ± 17.4 b	79.6 ± 16.6 b	1.4 ± 0.3	1.5 ± 0.2	1.2 ± 0.1	2.1 ± 0.4	2.0 ± 0.1	1.6 ± 0.4
Means from 4 h until end of estrus	0.1 ± 0.1 b	0.2 ± 0.04 b	0.6 ± 0.04 b	65.6 ± 4.7 b	38.2 ± 5.9 a	40.9 ± 5.2 a	1.4 ± 0.1	1.8 ± 0.1	1.5 ± 0.1	1.7 ± 0.1	2.0 ± 0.1	1.7 ± 0.1

Groups with different letters (a, b, c) indicate significant differences. Means with different letters (a, b, c) indicate significant differences.

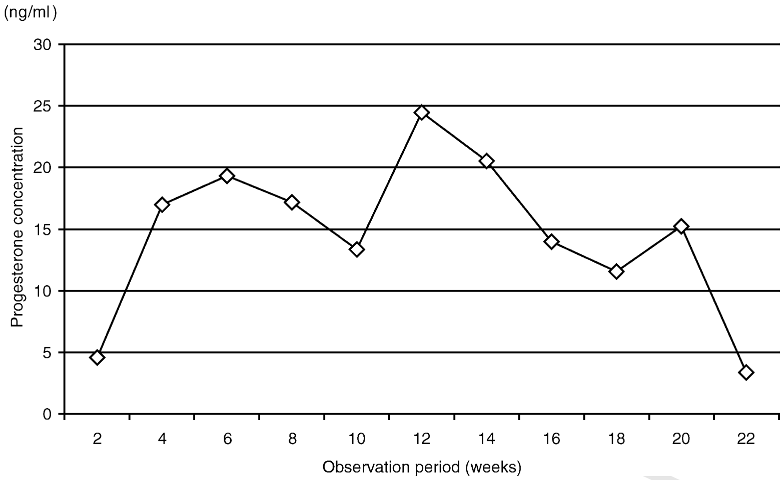

Fig. 3. Mean (±S.E.) plasma progesterone (P4) concentration (ng/ml) during gestation, up to kidding.

Table 3
Mean (± S.E.) plasma prolactin levels prior to the second estrus and during estrous period in Damascus does in different treatments groups

	Hormones, mean (±S.E.) (ng/ml)		
	A	B	C
No. of samples	4	4	3
Mean 12–72 h before estrus	0.9 ± 0.1	0.9 ± 0.1	0.7 ± 0.1
Mean at 0 h (estrus)	1.2 ± 0.5	2.5 ± 0.6	1.3 ± 0.2
Means from 4 h until end of estrus	1.1 ± 0.1	1.0 ± 0.1	0.9 ± 0.1

to week 12 (24.5 ± 3.1 ng/ml) (Fig. 3). A sudden decrease was recorded at this stage and continued until kidding (0.8 ± 0.4 ng/ml). The mean value of plasma progesterone level during the entire 20 weeks of gestation recorded was 14.9 ± 1.9 ng/ml.

4. Discussion

Plasma progesterone concentrations recorded during the estrous cycle of Damascus goats in the present study are in harmony with that recorded for the same breed by Mavrogenis (1988) and Shalaby et al. (2000). Furthermore, plasma progesterone levels recorded at the onset of estrus also agree with levels of other goat breeds (Braun et al., 1988). As corpus luteum (CL) formation results in progesterone secretion (Hafez, 1993), the rise in progesterone level from day 5 to 14 after the onset of first estrus in the Damascus does could be attributed to the growth and development of the CL (Cunnigham et al., 1975). The decline in progesterone concentration 24–72 h before the onset of the second estrus is due to the regression of the CL (Pant et al., 1977).

The present study showed lactation to have an effect on the plasma progesterone concentrations, where the progesterone levels in the lactating does were higher at the onset of the first than the second postpartum estrus confirming that progesterone may play an important role in the endocrine mechanisms governing the transition from the acyclic to cyclic states (Legan et al., 1985). Plasma prolactin levels that peaked at the onset of estrus and increased during estrous period are in agreement with that found in ewes (Rhind et al., 1980). Moreover, the weaning of does (Group B) showed lowest plasma progesterone concentrations to be associated with high prolactin levels before estrus and during estrous period when compared to Groups A and C. These results confirm the hypothesis that high prolactin levels have a luteolytic effect (Rhind et al., 1978). Thus is contrary to the belief that the pre-ovulatory prolactin surge is involved in the establishment and function of the CL (Kann and Denamur, 1974). In addition, Bono et al.

(1983) suggested that differences in prolactin concentrations may depend on the different reproductive status of the animals. In general, it was observed that progesterone levels do not directly affect plasma prolactin levels (Skinner et al., 1998, 2000).

Plasma estradiol levels in the Damascus goats peaked either on the day of estrus, as reported in others breeds (Jain, 1992) or during the 1st days of the cycle as reported in ewes (Gabr, 1986; Mandiki et al., 1990). Since plasma estradiol concentrations were negatively, but (not significantly) correlated with progesterone levels, the rapid decrease in plasma estradiol during the luteal phase may be attributed to the inhibitory influence of the rapidly rising plasma progesterone concentrations (from day 5 to 14 of the cycle) as in the goat (Bauernfeind and Holtz, 1991). Results were also in agreement with the findings of Abeyawardene and Pope (1990), in sheep. However, some plasma estradiol spikes were observed in the second half of the luteal phase, which may be due to the start of the follicular secretions concurrent with the CL secretions (Gabr, 1986). The differences observed in the profiles of plasma estradiol levels between the three treatment groups during the first and the second postpartum (Groups A and B)/seasonal (Group C) estrous cycle could be due to several factors, including the suckling stimulus (Mandiki et al., 1990), high levels of plasma progesterone which could block the stimulatory effects of GnRH/LH on estradiol secretion (Harris et al., 1999), follicular growth which may occur during the cycle and/or individual differences (Gabr, 1986).

Although no specific trend was observed in the plasma LH levels during the estrous cycle, LH levels were higher during the first half of the luteal phase, compared to the late luteal phase, increasing at the onset of estrus. Few studies have reported LH levels in goats, and results were thus compared to that in ewes, where Hauger et al. (1977) recorded the highest LH concentrations during the early and late luteal phases of the estrous cycle in ewes. The lowest level recorded was during the mid-luteal phase. Likewise, Wheaton et al. (1988) reported high LH level pre- and post-luteal than during the luteal phase, while Gabr (1986) reported plasma LH levels to remain basal throughout the estrous cycle in Rahmani and Ossimi ewes. A slight increase was recorded on the day of estrus in Rahmani ewes and two peaks on day 1 and 10 of the estrous cycle in Ossimi ewes, suggesting that such peaks in the pulsatile plasma LH levels may coincide with LH pulses at the time of blood sampling.

The LH surge detected in two does at 24 and 32 h (Group A) at the onset of the second postpartum estrus was in the range reported for goats by Bono et al. (1983) (8–24 h) and in ewes (Hoefler and Hallford, 1987). LH levels were positively correlated to the estradiol levels before the onset of estrus and during estrous period, being more pronounced in does that suckled for 120 days and dry does (Groups B and C), compared to early weaned does (Group A). This correlation agrees with that observed in goats (Bono et al., 1983). Estradiol did not only induce LH surge during the estrous period, but also induced an increase in the LH levels during the estrous cycle as observed in one doe (Group A), where a rise in plasma estradiol on day 5 was followed by a LH increase on day 7. This suggests that estradiol not only has the ability to induce a pre-ovulatory LH surge (Karsch et al., 1983), but also the ability of progesterone priming to regulate the timing of the LH surge through the estradiol-dependent mechanisms. In addition, the LH surge could be also due to the variation between individuals regarding the neural sensitivity to progesterone or estradiol (Harris et al., 1999; Skinner et al., 2000).

Few studies have been reported on the FSH profiles in goats. In the present study, although plasma FSH levels did not follow a specific trend it was significantly different between lactating does with the different suckling periods. Souza et al. (1997) also reported no relationship in the pattern of FSH secretion and follicular growth during the luteal phase in ewes. From Figs. 1 and 2, the undetectable rise in plasma FSH levels recorded during the entire cycle confirms the finding of Smeaton and Roberston (1971) that follicular growth may be a consequence of increased utilization of the circulating FSH, rather than increased secretion (L'Hermite et al., 1972). In addition, Mandiki et al. (1990) claimed the daily levels of plasma FSH in ewes to fluctuate until the occurrence of estrus. This was not significantly different between dry, restricted and unrestricted suckling ewes. Plasma FSH levels during the estrous cycle were found to be negatively correlated with estradiol levels ($P < 0.01$, $r = -0.2$), as well as, with progesterone levels ($P < 0.01$, $r = -0.3$). This suggests that plasma FSH concentration is controlled by the negative effect of the high progesterone or estradiol concentrations (Bono et al., 1983). This negative effect of estradiol was more pronounced in early weaning does (Group A), where FSH levels on the day of the estrus, at the 3rd day after estrus and during the luteal phase were almost half the level 14 days before estrus, concurrent with the high plasma estradiol levels.

Plasma progesterone concentrations during the gestation period in the Damascus goats continued to increase, reaching its highest level at week 12, followed by a decrease until just prior to kidding. This suggests that the goat requires a functional CL at all times during gestation as it is the major source of progesterone in maintaining pregnancy (Gordon, 1997). Results confirm the observation of Mavrogenis (1988) and Kaushik et al. (1992).

5. Conclusion

The present study showed that lactation and suckling manipulation does not affect the hormonal mechanisms during the estrous cycle and estrus and that goats have a longer estrous cycle and estrous duration than sheep. In addition, characterizing the hormonal control of the estrous cycle and ovulation could be used to facilitate the use of breed programs during different seasons and for protocols of AI and embryo transfer.

It is advisable to take more frequent samples for the determination of plasma estradiol and LH levels during the estrous cycle to give more accurate profiles as plasma estradiol peaks every 2 h in response to pulsatile LH release (Scaramuzzi and Land, 1978). As the time when ovulation exactly occurs could be determined by LH levels, it is thus important to collect blood samples more frequently (20–30 min apart) during the estrous period, as LH has a half life of only 30 min (Hafez, 1993).

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