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Effect of dietary fat supplementation on reproductive performance of goats

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Abstract

The study was conducted to evaluate the effect of dietary dry fat inclusion on reproductive performance of Shami goats. Forty-five dry Shami goats (2 - 4 years of age, 64 kg body weight) were selected and divided randomly into 3 groups of 15 goats each in a completely randomized design. Treatments started 45 days before mating using one of three total mixed rations (TMR): 0, 3, or 5% of dry fat. Estrus was synchronized before mating and blood samples were taken to determine plasma progesterone concentrations. Concentrations of plasma progesterone were not affected by adding supplemental fat. The addition of dry fat did not affect the overall conception rate. However, 3% supplemental fat increased ($P < 0.05$) the second-cycle conception rate. A 3% level of dry fat had no effect on litter size, twining rate, or kid birth weight. Feeding 5% supplemental fat adversely ($P < 0.05$) affected these parameters, but improved ($P < 0.05$) kid birth weight. The gestation length was increased ($P < 0.05$) by feeding supplemental fat. It was concluded that adding dry fat at different levels to Shami goat diets could not improve reproductive performance. However, using 5% supplemental fat adversely affected litter size and twining rate, but improved the kid birth weight.

Keywords: Shami goat, fat supplementation, reproductive performance.

Introduction

The Shami or Damascus goat is a seasonal polyestrous breed that is considered to be the most important goat breed in Middle East due to their milk production and prolificacy. Onset of estrous cycles occurs from May to November and become more consistent during September to November (Hassan and Shaker, 1990; Papachristoforou *et al*., 2000). In a study by Teleb *et al*. (2003), plasma progesterone profiles indicated the start of ovarian activity (silent ovulation) many months before the onset of the breeding season in September, and most does showed persistent elevation of plasma progesterone concentrations for 3 months, starting in mid-June (Teleb *et al*., 2003). Sklan *et al*. (1991) reported that greater energy deficiency might explain the delay in resumption of ovarian cyclicity and appearance of behavioral estrus.

Fertility of Shami goats is impaired by increased production (twining and milk), long lactation period with drought seasons, poor pastures, and changes to lower-quality feedstuffs that results in energy deficiency in goats and delays the onset of estrus activity and ovulation (Van Horn *et al*., 1992). Staples and Thatcher (2001) indicated that prolonged and intense negative energy status delayed resumption of estrous cycles and increased the number of days open in dairy cows. Flushing in highly prolific breeds and knowledge of nutritional and reproductive strategies could help maximize overall production efficiency (Sormunen-Cristian and Jauhiainen, 2002).

Although dietary fat is often added to the diets of ruminants to increase energy intake, an additional response to fat supplementation has improved fertility (Staples *et al*., 1998). Many studies showed that adding dietary fat to rations improved reproductive performance parameters of beef and dairy cows by altering both ovarian follicle and corpus luteum function (Staples *et al.*, 1998; William and Stanko, 1999). Improved parameters included conception rate (Son *et al*., 1996), the onset of parturition, and the time of fetal expulsion (Baguma-Nibasheka *et al*., 1999). De Fries *et al.* (1998) reported that fat supplementation may enhance follicular development by stimulating a greater number of smaller follicles to grow to larger sizes. Improved conception rate at first AI was reported for dairy cows fed tallow (Son *et al*., 1996) and prilled and unprilled fatty acids (Ferguson *et al.,* 1990).

Results of different studies showed positive increases in dam pregnancy rates following feeding different types (saturated, unsaturated and protected) with different amounts of fat supplementation for primiparous heifers (Bellows *et al*., 1999), beef cows (Landblom *et al*., 2003; Small *et al*., 2003), lactating ewes (Hegazy *et al*., 1999), and dairy cows (Ferguson *et al*., 1990; Son *et al*., 1996; De Fries *et al*., 1998; Garcia-Bojalil *et al*., 1998).

The mechanism by which fat supplements alter reproductive performance is not well understood. Several hypotheses have been proposed to explain the effect of dietary fat supplementation on the fertility in dairy and beef cows and were based on its effect on energy balance and metabolism or hormonal biosynthesis. However, many of these studies were conducted to investigate the influence of dietary fat supplementation on reproductive performance of cattle with few directed towards these effects on goat reproductive performance. Therefore, the main objective of this study was to investigate the effect of supplemental fat on reproductive performance of Shami goats.

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Materials and Methods

This experiment was carried out at the Agricultural Research Station in the Jordan Valley. Forty-five dry Shami goats of the station herd were selected with a body-weight range from 43 - 85 kg and were 2 - 4 years of age at the beginning of the study. Selected females were at least primiparous. Goats were randomly assigned into 1 of 3 dietary treatments with 15 does per group in a completely randomized design. Females were flushed using 1 of 3 total mixed rations (TMR): 0, 3, or 5% of dry fat (Feedaren, The Modern Establishment for Fats and Glycerin Manufacture, Amman, Jordan). The experimental diets were formulated according the National Research Council (NRC, 1989) recommendation to be approximately isonitrogenous but not isocaloric. The composition and chemical analysis of the diet are mentioned in Table 1. Fatty acid profile of the Ca-soap dry fat used is presented in Table 2. Goats were fed initially at a level of 1.0 kg (DM) per head per day and then raised gradually to the level of 1.5 kg per head per day with *ad libitum* access to alfalfa hay. The feeding regime started by flushing 45 days before the beginning of the breeding season (mating) and lasted to the end of the gestation period. Animals were maintained at ambient temperature and natural day length in covered, loose pens with adjacent pen yards. Clean water was provided all the times. Rations were mixed twice weekly and daily, and allowances were offered to all animals once at 07:00 h. Diets were sampled upon mixing for chemical analysis and kept frozen at 4°C until time of analysis.

Table 1. Ingredient composition and chemical analysis of the experimental diets.[†]

	Diet (% fat)		
Ingredients	0%	3%	5%
Barley	52.00	52.00	52.00
Soybean meal	18.00	18.00	18.00
Alfalfa hay	10.00	10.00	10.00
Straw	13.00	10.00	8.00
Wheat Bran	5.00	5.00	5.00
Dry fat	0.00	3.00	5.00
Di-calcium phosphate	1.00	1.00	1.00
Salt	0.40	0.40	0.40
Limestone	0.50	0.50	0.50
Minerals and Vitamins[††]	0.10	0.10	0.10
Chemical composition			
Dry matter (%)	94.29	94.39	94.30
Crude protein (%)	16.07	16.20	16.32
Ether Extract (%)	1.25	3.35	4.45
Crude Fiber (%)	14.38	14.81	14.22
NDF (%)	29.67	30.42	23.89
ADF (%)	12.22	13.09	12.25
Ash (%)	7.50	7.91	12.40
ME (MJ/kg)	10.21	10.95	11.40

[†]All results are expressed based on dry matter basis.

[††]Each 1 gram contains: 1500 I.U. Vitamin A; 150 I.U. Vitamin D3; 2 mg Vitamin E 50%; 300 µg Vitamin B1; 300 µg Vitamin B2; 300 µg Vitamin B6; 300 µg Vitamin K3 50%; 218 µg Manganese Oxide; 435 µg Ferrous Sulfate; 15.5 µg Copper Oxide; 138.5 µg Zinc Oxide; 2.2 µg Potassium Iodide; 0.9 µg Sodium Selinate; 0.43 µg Cobalt Carbonate, $CaCO_3$ reach 1 g.

Table 2. Fatty acid composition (%) of Ca – salts used in the experimental diets.

Fatty acid	%
C12:0	9.07
C14:0	5.32
C16:0	22.17
C18:0	3.32
C18:1	12.24
C18:2	21.90
C18:3	7.18
C20:1	8.04
C22:1	6.77
C24:0	4.00

Feed samples were ground using a 1-mm screen and analyzed for dry matter (DM), ash, crude protein (CP), crude fiber (CF), and ether extract (Association of Official Analytical Chemists, 1984). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed according to Georing and Van Soest (1970).

Before mating females, estrus was synchronized according to the following protocol. All animals were injected with 100 µg of GnRH (i.m.; Receptal®; Intervet International B. W., Boxmeer, Holland). On the same day, goats were administered an intravaginal progesterone sponge containing 40 mg of

FGA (Ceva, Santa Animals, France) and was left in place for 5 days. On the day of sponge removal, animals received an injection of prostaglandin-$F_{2\alpha}$ (PG; 12.5 mg, i.m.; Lutalyse™; Pharmacia and Upjohn S.A., Puurs, Belgium).

Blood samples were taken to determine plasma progesterone concentrations as an indictor of the onset of corpus luteum function. Blood sampling started on the day of GnRH injection with a second sample taken on the day of PG injection. Another blood sample was collected 3 days after PG injection when animals were expected to be in estrus. The first day of estrus was designated as Day 0. Thereafter, blood samples were collected every 3 days and continued until Day 27.

All blood samples were collected from the jugular vein into lithium heparinized vacutainer tubes (BD Vacutainer™; LH 119 I.U., Belliver Industrial Estate, UK) and placed immediately into ice. Tubes were then centrifuged for 15 min at 3000 rpm. Plasma was separated and stored at -20°C for later analysis. Concentrations of progesterone were determined by commercial radioimmunoassay kits (RIA Progesterone; IM1188, IMMUNOTECH SA, Marseille, France).

Females were mated naturally 24 hours after the PG injection using 6 Shami bucks, 3 - 4 years of age and assigned randomly to one of the three groups with 2 bucks per groups. The bucks were rotated daily between groups. Bucks were with females for a period of 7 days starting at the beginning of the first cycle and left out to the beginning of the next cycle. By the beginning of the third cycle, males were left with females until the end of the breeding season.

From the progesterone profile of each animal, ovulation and conception were presumed to have occurred when concentrations of progesterone were less than 1.0 ng/ml followed by a sustained progesterone concentration more than 1.0 ng/ml until the end of blood sampling. Immediately after kidding, gestation length, conception rate, pregnancy rate, and litter size, weight, and type of birth (single or twin) were recorded. Gestation length was measured as the period (in days) between the day when progesterone concentrations started to increase until the day of kidding.

Female goats were weighed at the beginning of the experiment (initial weight), and weekly during the last month of gestation until the time of kidding (final weight). Initial weight was used as a covariate for correction during analysis. Least-squares analysis of variance was utilized to analyze the data using the General Linear Model of SAS (2000). Least square means were compared using Fisher protected LSD (Steel and Torrei, 1986).

Results

Progesterone

Mean plasma progesterone concentrations of the female goats in the 3 experimental groups are presented in Fig. 1, which shows the treatment by time interaction throughout the experiment. No differences were observed in mean plasma progesterone concentrations on the day of GnRH injection (Day -7), the day of $PGF_{2\alpha}$ injection (Day -3), or the day of presumed onset of estrus (Day 0). This was true for the results among groups or between the 3 and 5% fat supplemented groups.

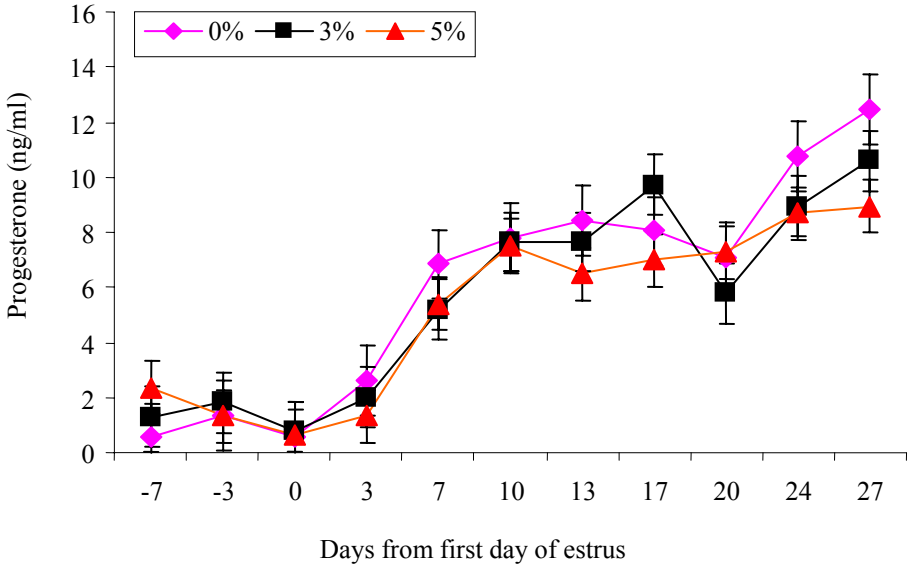

Figure 1. Mean (± SEM) plasma progesterone concentrations of Shami goats supplemented with different levels of dry fat in their rations.

Progesterone concentrations increased gradually from Day 0 and thereafter. Except for values on Day 3 and 17 postestrus, no differences were observed among groups thereafter until the end of the collection period. On Day 3, the mean progesterone concentration for the goats fed the control diet was greater ($P < 0.05$) than that of the goats on the 5% dry fat diet but not different from that of those on the 3% diet. Goats that received the 3% ration had numerically but not significantly greater mean progesterone concentrations than those of the 5% group.

Body weight

Initial and final body weights of dams are presented in Table 3. No differences were reported in initial body weights among groups or between pooled and control groups. Average weekly body weights during the last 4 weeks before kidding were not affected by fat supplementation and no week by treatment interaction was observed. However, final body weight of dams was numerically greater as fat percentage in the diet increased.

Conception and pregnancy rates

Conception rate (%) to first, second, and third cycle and the overall conception rate and pregnancy rate are presented in Table 3. Conception rate to the first cycle was not different among groups but was numerically less for goats that received 3% supplemental fat compared to those received either the high level of supplemental fat (5%) or no supplemental fat (control) in their diets. The conception rate at the second cycle was significantly greater ($P < 0.05$) for goats received 3% supplemental fat in their diets than those fed control diets but not different from those of the 5% supplemental fat group. No differences were observed between goats of the 5% fat group and those of the control group. In the third cycle, no differences were observed among groups or between both treatment groups. The pregnancy rate or overall conception rate (percentage of total goats diagnosed pregnant) was significantly ($P < 0.05$) greater for goats in the two treatment groups (3% or 5%) than those of the control group (Table 3).

Table 3. Mean (± SEM) conception rates at different estrous cycles and pregnancy rate percentages of Shami goats supplemented with different levels of dry fat in their rations.

	0%	3%	5%	P - value
No. of goats	15	15	15	
Initial weight (Kg)	61.61 ± 2.21	54.20 ± 2.21	61.60 ± 2.21	0.62
Final weight (Kg)	57.30 ± 2.16	60.15 ± 2.16	64.93 ± 2.02	0.37
Conception rate (%)				
1st cycle	87.00 ± 0.10	73.00 ± 0.10	87.00 ± 0.10	0.51
2nd cycle	0.00 ± 0.09[a]	27.00 ± 0.09[b]	13.00 ± 0.09[ab]	0.03
3rd cycle	6.70 ± 0.04	0.00 ± 0.04	0.00 ± 0.04	0.19
Pregnancy rate (%)	93.00 ± 0.04[a]	100.00 ± 0.04[b]	100.00 ± 0.04[b]	0.04

[a,b] Means with different superscripts within the same raw are different ($P < 0.05$).

Gestation length and litter size

The gestation length was longer ($P < 0.05$) for the groups fed supplemental fat than the control and goats of the 5% group had a longer gestation period than the group fed 3% supplement (Table 4).

Litter size per dam that gave birth was greater ($P < 0.05$) for dams that received 3% supplemental fat and control diet than those fed 5% supplemental fat (table 4). Likewise, the total number of kids per experimental group was similar between control goats and those of the 3% supplemental fat. However, the litter size of the 5% goats was less ($P < 0.05$) than the 3% goats but not different from the control goats. Twining rate (number of dams that gave twins to total dams in the group) was higher ($P < 0.05$) for goats fed the 3% and 0% diets compared to those fed the 5% diet.

Table 4. Mean (± SEM) gestation length, litter size, and twining rate of Shami goats supplemented with different levels of dry fat in their rations.

	0%	3%	5%	P - value
Gestation length (days)	146.00 ± 0.52[a]	147.60 ± 0.51[a]	148.07 ± 0.51[b]	0.02
Litter size/dam that gave birth	2.00 ± 0.15[a]	2.07 ± 0.14[a]	1.50 ± 0.14[b]	0.04
Litter size/total dams	1.87 ± 0.16[ab]	2.07 ± 0.16[a]	1.50 ± 0.16[b]	0.03
Twining rate (%)	86.67 ± 0.10[a]	93.33 ± 0.10[a]	40.00 ± 0.10[b]	0.03

[a,b] Means with different superscripts within the same raw are different ($P < 0.05$).

Birth weight

Goats fed 5% supplemental fat had a heavier ($P < 0.05$) overall birth weight than the 3% supplemental fat and control groups (Table 5). However, no differences were observed between the 3% and the control groups. No differences were observed among treatments when birth weight was compared based on sex or type of birth.

Table 5. Mean (± SEM) birth weight of Shami goats supplemented with different levels of dry fat in their rations.

	0%	3%	5%	P - value
Birth weight (Kg)	3.76 ± 0.11^{a}	3.71 ± 0.11^{a}	4.05 ± 0.11^{b}	0.03
Male	3.92 ± 0.14	3.91 ± 0.18	4.16 ± 0.16	0.11
Female	3.50 ± 0.17	3.63 ± 0.12	3.90 ± 0.17	0.26
Single	3.90 ± 0.52	4.50 ± 0.52	4.47 ± 0.17^{c}	0.08
Twins	3.75 ± 0.10	3.60 ± 0.10	3.74 ± 0.10^{d}	0.23

[a,b] Means with different superscripts within the same raw are different ($P < 0.05$).
[c,d] Means with different superscripts within the same column are different ($P < 0.05$).

Discussion

The numerically greater mean plasma progesterone concentrations on day of the GnRH injection for the treated groups compared to those of the control and those received the 5% level of supplemental fat compared to those received the low level of supplemental fat (3%) is consistent with Staples *et al.* (1998), who reported that cows fed supplemented fat had more active ovaries with higher progesterone concentrations. However, similar progesterone concentrations among treatment groups agreed with the results reported by De Fries *et al*. (1998) and Moallem *et al*. (1999), who found no effect of feeding supplemental fat on progesterone concentration. However, Hightshoe *et al*. (1991) found that feeding supplemental fat to beef cows improved progesterone concentrations during the luteal phase of the first postpartum estrous cycle.

Because ultrasonographic description of the ovaries was not carried out in the present study, the following discussion is only speculative. The greater mean progesterone concentrations of the control group might indicate some differences in response to the $PGF_{2\alpha}$ injection as the number of goats that were in heat at Day 0 was greater in the control group compared to those of the group that received 3% or 5% supplemental fat. Several reports indicated that supplemental fat could result in delaying or prevention of follicle turnover. Oldick *et al*. (1997) and Moallem *et al*. (1999) reported that feeding fat supplemented diets to dairy cows promoted follicular turnover and suppressed continued increase in plasma estradiol concentrations due to elevated progesterone levels. Feeding high fat diets was found to increase progesterone concentrations in dairy and beef cows and delayed CL regression (Oldick *et al.*, 1997; Garcia-Bojalil *et al.*, 1998; Moallem *et al*., 1999). Furthermore, Hightshoe *et al*. (1991) indicated that the ability of the CL of dairy cows to withstand exposure to the uterine PGF2α could partially be explained due to feeding hyperlipidemic diets.

Similar results regarding body weight were reported by others who found no effect of different fat sources supplemented to dairy cows on body weight at calving or on BCS during the postpartum period (Espinoza *et al*., 1995; Moallem *et al*., 1999; Bottger *et al*., 2002). Moallem *et al*. (1999) stated that high yielding dairy cows fed calcium soaps of fatty acids had, in most cases, similar BW and BCS compared with control cows. Working with beef cows, Lake *et al.* (2005) observed no effect of dietary fat treatment on BW change. Such results were justified by similar energy content (isocaloric) of the fed diets that prevented any differences in body weights. In the present study, the assumption was that fat supplementation results in more active ovaries and more twining (Staples *et al.*, 1998) which means that the 5% fat supplemented group would have more embryos and more energy demand. Higher final body weight of the 5%-fat-supplemented dam would most probably be due to a higher net energy intake of this group.

The reason behind the lower conception rate at the first cycle for the 3% group compared to other groups is not clear. It might be that the limited number of animals used in the study, 15/group, had resulted in this contradiction. Most probably, lower conception rate at the first cycle of goats in the 3% group was due to their lower initial body weight as they had a numerically lower initial body weight compared to those of the control or 5% group.

Hess *et al.* (2005) reported that precalving lipid supplementation of beef cows in adequate body condition did not improve AI first-service conception rate. They also suggested that prepartum fat supplementation of beef cows may or may not increase postpartum first-service conception rate. However, several earlier studies indicated that supplementary fat resulted in increased follicle size (Hightshoe *et al*., 1991; De Fries *et al.,* 1998; Moallem *et al*., 1999; Hess *et al*., 2005). Furthermore, Lucy *et al.* (1991), De Fries *et al.* (1998), and Hightshoe *et al*. (1991) reported that supplemental fat provides metabolites that are critical

components for steroidogenesis associated with follicle maturation, and this growth may result in enhanced follicle growth. Also, feeding supplemental fat resulted in increased synthesis and circulatory concentrations of $PGF_{2\alpha}$ (Lammoglia *et al*., 1997; Oldick *et al.*, 1997). It could be that a high fat level (5% diet) resulted in more follicle growth and $PGF_{2\alpha}$ production and therefore a better first-cycle conception rate. The better conception rate at the second cycle might be a result of more circulatory $PGF_{2\alpha}$, progesterone and LH in the treated groups (Hightshoe *et al*., 1991). Likewise, Carroll *et al.* (1990) reported that improved pregnancy rates in repeatedly-bred cows were due to high progesterone levels. Meanwhile, Espinoza *et al.* (1995) reported that conception rate at the second cycle was higher due to more normal cyclicity and stimulated ovarian function in fat-treated cows at the second cycle. However, the lack of a difference between the 5% group and the control group at this cycle is a result of a greater conception rate at the first cycle. The conception rate at the third cycle was not surprising considering all dams were bred during the first 2 cycles.

Small *et al.* (2003), Landblom *et al*. (2003), Bottger *et al*. (2002), and Carroll *et al*. (1990) found no effect of adding fat on conception rate. Most of the published literature on the effect of supplemental fat on reproductive performance is for dairy cattle in which reproductive performance is closely related to body weight changes and body condition. Moallem *et al*. (1999) reported that high yielding dairy cows had similar or slightly improved conception rate compared to the controls regardless of their body weight or body condition. In the present study, no significant changes were observed in body weight; however, conception rate was improved following fat supplementation.

Goats fed supplemental fat had 100% pregnancy rate while goats fed the control diet had 93% pregnancy rate. Improved pregnancy rate was a direct effect of improved conception rate. Such results are similar to those of De Fries *et al*. (1998), Hegazy *et al*. (1999), and Hess *et al*. (2005), who found that adding supplemental fat improved pregnancy rates in ewes and beef cows. Skalan *et al.* (1991) concluded that higher pregnancy rates following fat supplementation were due to elevated progesterone levels after treatment. Meanwhile, Carroll *et al*. (1990) and Son *et al*. (1996) found no effect of adding supplemental fat on pregnancy rate. Furthermore, Carroll *et al.* (1990) reported that pregnancy rates of dairy cattle might possibly have improved due to elevated progesterone but this increased progesterone was not associated with an increased first-service conception rate. Contrary to that, De Fries *et al.* (1998) suggested that improved pregnancy rate in fat-supplemented cows might be due to either a greater body condition or increased systemic concentrations of $PGF_{2\alpha}$. It must be remembered that male fertility was not evaluated during the experimental period. The low number of animals in the present study and other confounding factors like male fertility and breeding protocol might attribute to the results obtained.

The significantly-longer ($P < 0.05$) gestation period for the groups fed supplemental fat than the control group is similar to that reported by Lammoglia *et al*. (1996), who found that beef cows fed high supplemental fat had longer gestation lengths compared to non-fed cows. The same study supported the hypothesis that fat supplementation influences circulating steroid hormone concentrations before parturition. Baguma-Nibasheka *et al*. (1999) reported a positive correlation between prolonged intake of a high-fat diet in late pregnancy and gestation length and birth weight, possibly due to the alteration of the balance between stimulatory and inhibitory prostaglandins in the parturition process. It is possible that decreased estradiol-17β concentrations in one side and the decreased progesterone clearance rate and its conversion to estrogens at the end of gestation in: cows receiving supplemental fat might have altered other endocrine profiles, therefore prolonging gestation (Lammoglia *et al*., 1996; Baguma-Nibasheka *et al*., 1999). Decreased estrogen production would result in a decrease in PGE_2 synthesis and thus in delay or prevention of the switch of the myometrial contractility pattern to labor-type contractions (Baguma-Nibasheka *et al*., 1999). Although results showed significant differences in gestation length, this might not be true. Differences in gestation length were variable; however blood samples were taken every 3 days and not on a daily basis. It could be that some dams might have been in estrus and been fertilized during the 3-day intervals of blood sampling.

Hegazy *et al*. (1999) found that feeding different types of supplemental fat to ewes during late and early lactation improved the prolificacy rate. Lucy *et al*. (1993) and De Fries *et al*. (1998) reported that dairy cows fed supplemented fat had, larger and more mature preovulatory follicles than non-fed cows. Moreover, De Fries *et al*. (1998) stated that this effect might be beneficial due to the presence of substantial increase in the number of potential ovulatory follicles. Dietary fat may enhance follicular development through metabolites and metabolic hormones that act to influence GnRH secretion (De Fries *et al*., 1998) and thereby improve litter size and twining rate.

On the other hand, feeding supplementary fat sources was associated with increasing basal LH concentration and pulse amplitude and increasing diameter of the largest follicle (Hightshoe *et al*., 1991; Lucy *et al.* 1991; De Fries *et al*., 1998). Both mechanisms might have resulted in the increased litter size and twining rate observed in this study.

Hegazy *et al*. (1999) reported similar results regarding birth weight. Opposite to our results, birth weight was not affected by supplemental fat in many studies (Espinoza *et al*., 1995; Lammoglia *et al*., 1996; Bottger *et al*., 2002; Landblom *et al*., 2003; Small *et al*.,

2003; Lake *et al*., 2005). When birth weight was compared within the same treatment, only single kids were greater ($P < 0.05$) than twins in the 5% groups. Lammoglia *et al*. (1996) suggested that maternal variation in circulating concentrations of estrogen in late-pregnant cows could be influenced by placental size and/or function that are reflected in the birth weight of the calf. They reported that dietary fat before calving may influence birth weight through changes in circulating steroid hormone concentrations at the end of pregnancy. In a study by Espinoza *et al*. (1995), no differences were observed in calf birth weight due to insufficient metabolizable energy provided by the fat-treated diet to stimulate greater fetal growth. Meanwhile, Bottger *et al*. (2002) reported that the potential beneficial effect of feeding supplemental fat on calf performance may be more pronounced in dams with a poor body condition.

Lake *et al*. (2005) suggested that energy balance of dams during the last trimester is a greater influence on birth weight than actual BW or BCS of dams at parturition. Differences in weight could be a result of greater utilization efficiency of dietary energy as feeding supplemental fat has been reported not only to increase energy density but also to improve energetic efficiency (Lammoglia *et al*., 2000). The greater birth weight of kids in the 5% group could mostly be a result of both assumptions. In addition, dams of the 5%-treated group had a lower litter size and twining rate compared to dams of other groups, which would explain the higher birth weights of their kids.

In conclusion, these results showed that feeding dry fat to breeding goats at different levels did not affect conception rate or plasma progesterone concentrations. Moreover, feeding 5% supplemental fat adversely affected the litter size and twining rate but improved kid birth weight. The gestation length was increased by feeding supplemental fat. The number of animals utilized per treatment in this study might not be large enough to clarify changes due to adding supplemental fat. Therefore, more research is also needed with greater numbers of animals to make a judgment about the effect of supplemental fat on reproductive performance of Shami goats.

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