SEASONAL AND ALTITUDINAL VARIATIONS ON ADAPTATION, GROWTH AND TESTICULAR ACTIVITY OF BALADI GOATS WITH VERTICAL TRANSHUMANCE IN EASTERN MEDITERRANEAN

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ABSTRACT

The effects of transhumance on body growth and adaptation parameters in the Baladi goat, and testicular activity in bucks were studied over a period of one year. Thirty two animals were allocated to 4 similar groups according to age (100 days for 8 male and 8 female kids, and 3-4 years for 8 bucks and 8 does) and sex. Goats were raised in a coastal pasture area for the winter period (WP), then transhumed towards a mountainous area in May for the summer period (SP). Every 21 days, animals were weighed and monitored for a whole day to estimate the distance travelled; four does and four bucks were followed for two successive days to evaluate the nature of the plants grazed by direct observation. Four summer and two winter collections of these plants were subjected to proximate analysis; Respiration and heart rates were recorded every two hours between 6:00 a.m. and 6:00 p.m.; Testicular volume and semen quality were also measured. Animals traveled 1 km/h in summer period and 0.8 km/h in winter. Herbaceous plants formed 95% of the plants grazed in SP and ligneous plants formed the majority of the plants ingested (80 to 95%) in WP. Protein percentages decreased from 15.2 to 8.6% between the beginning and the middle of the SP whereas it was around 11% in WP. Weight gain was greater during SP in comparison to WP except for bucks (12, 7.6, 4.2 and -3.3 kg vs. 3.4, 1.8, -7.5 and 3.3 kg for male and female goat kids, does and bucks, respectively). Respiration and heart rates showed adaptation of animals to walking long distances in both zones, stabilizing respectively at 47-50 breaths/min and 83-90 beats/min after a 6 km walk. Decrease in semen concentration was observed at the end of the animal's stay in each zone, with values between 3.1 and 3.7 spermatozoa x 10^9/ml vs. 1.7 and 2.7 spermatozoa x 10^9/ml in SP and WP, respectively. The volume varied between 1.0 ± 0.2 and 1.6 ± 0.4 ml in SP, and decreased to 0.6 ± 0.3 ml in WP. Transhumance is thus beneficial for only two months, i.e. between the end of spring and beginning of summer; this advantage is then reduced when dietary protein levels fall to 8%. Semen quality showed acceptable seasonal fluctuations, with maximum spermatogenetic activity in the summer period.

Keywords: Baladi goat, transhumance, adaptation, growth, testicular activity

INTRODUCTION

Goat herds are the largest of the small ruminant herds in Lebanon, with an estimated total of 438.000 heads (FAO, 2003). The rearing system is mainly traditional, with transhumance and pasturing as the main feeding resource (Demiruren, 1982; Morand-Fehr *et al*., 1984; Wilson, 1987; Abi Saab & Sleiman, 1995). The morpho-geography of Lebanon is highly diversified. It starts at 300 m above sea level in the coastal zone and reaches 3000 m above sea level in the mountains (PNUE, 1996). This leads to different climates, vegetation, and nutritive value of the natural vegetation that varies with the seasons. Moving goats in vertical transhumance system from coastal area (winter) to the high mountains (summer) is the most applied in the Middle East region. This leads to some problems of energy loss and adaptation to the new environment (Srour *et al*., 2004). Testicular activity of bucks also varies following climatic changes (Abi Saab *et al*., 2001). Moreover, natural pasturing zones are an uncontrollable and over exploited resource (De Wit & Seligman, 1992) and little attention is paid to their nutritive value (Abdallah *et al*., 1988). Growth and reproductive performance, and adaptation mechanisms of the Baladi goat breed in transhumance have not been studied to date. Limited information is available on the productivity and reproductive parameters of this breed (Abi Saab *et al*., 1997; Hajj, 1999; Abi Saab *et al*., 2000). The aim of the present study was to identify the plants grazed by the goats and to determine their nutrient content, to study the effects of long distance walking on body growth and on the testicular activity of reproductive bucks and to determine the animals' responses (respiration and heart rates, rectal temperature) to the climatic conditions over winter (WP) and summer (SP) periods.

MATERIALS AND METHODS

Location, animals and management. The study was conducted from May 2002 to May 2003 in two pasturing regions (Fig. 1), one of high altitude (1500-2000 m, mountainous from June till October, SP), and one of low and middle altitude (200-700 m, coastal from December till April, WP). According to the PNUE (1996), in the coastal or the lower Mediterranean area (thermo mediterranean of Lebanon), the thermophilic series of *Quercus calliprinos* is predominant; in the Mediterranean mountainous vegetation area, the series of *Juniperus excelsa* is predominant.

Thirty-two goats were chosen from a typical herd (n = 700 heads) and divided into 4 similar groups according to age (100 days for 8 male and 8 female kids, and 3-4 years for 8 bucks and 8 does) and sex. Animal weights (±S.D.) at the beginning of the study were 19.4 ± 2.8 kg, 19.7 ± 2.3 kg, 42.1 ± 3.5 and 56.8 ± 5.5 kg for male and female kids, does and bucks, respectively. Bucks and does were separated between August and September, in order to postpone mating and have the parturitions at the beginning of spring. The movement of animals from one pasturing zone to another takes about one month and they stayed 5 months in each pasturing area. Ascending transhumance (mid-May) towards the mountain for the SP and descending transhumance (mid-November) towards the coast which occurs throughout the WP are necessary as a result of climatic conditions, availability and quality of pastures, and Lebanese relief of natural terraces. Sexual activity takes place in the SP and the anestrus period occurs in the WP.

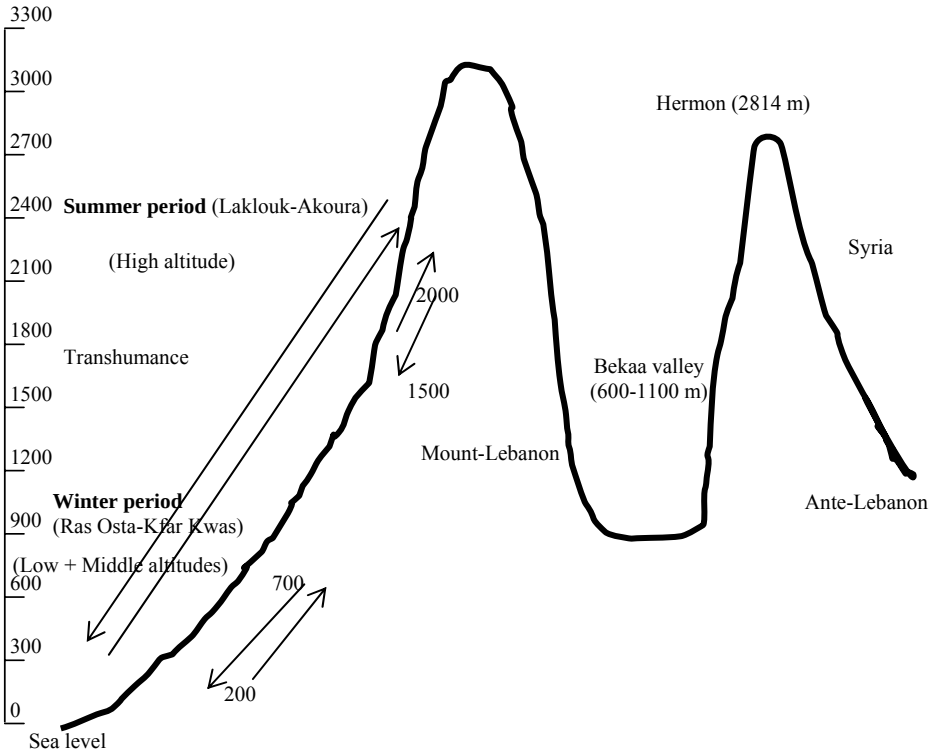


Figure 1. The Lebanese relief showing the two pasturing periods of goats through one year.

Measurements. All measurements were taken once every 21 days. Animals were followed throughout the day (grazing time) to estimate the distance traveled (1 step ~ 1 m) and the rest time objectively. Animals traveled for a distance of 8 and 10 km/day in WP and SP respectively, corresponding to a walking duration of 10 and 12 hours interrupted by a 2-hour rest around noon. The mean traveling speed was 0.8 km/h and 1 km/h in the WP and SP respectively.

Weather conditions in terms of temperature and relative humidity were recorded. Photoperiods were obtained from the meteorological station of Beirut airport. In the WP and SP, the mean temperature ranged between 7 and 18 ºC and 13 and 22ºC respectively; the relative humidity ranged between 68 and 72 % and between 48 and 67 % in the WP and SP respectively. Daylength varied between 10 h and 15 hours.

Once every 21 days, body weight was recorded, rectal temperature, respiration and heart rates were measured every 2 hours between 6:00 a.m. and 6:00 p.m. (Abi Saab & Sleiman, 1995).

Plants grazed and chemical analysis. Every 21 days, four does and four bucks were followed throughout the grazing time of the day for 2 successive days and by direct

observation to record the nature and percentages of the main plants consumed. Samples representative of those grazed were collected; after their identification (Mouterde, 1970), plants were divided into herbaceous (grasses and legumes), and ligneous (shrubs and trees). Four collections of a representative mixture of plants eaten at the SP (June, July, August, September) and 2 from the WP (December, February) were dried, ground to powder and conserved for further analysis. This was performed according to the AOAC (1990) for the determination of dry matter (DM), crude protein (CP), crude fiber (CF) and ether extract (EE) contents.

Testicular activity. Testicular volume of bucks was estimated using a water displacement technique according to Oldham *et al*. (1978). Buck semen was collected every 21 days with an electroejaculator. Volume was measured with a graduated tube, and individual sperm motility was estimated subjectively according to a scale from 0 to 100; concentration and abnormal spermatozoa were evaluated using a haemocytometer (Abi Saab & Sleiman, 1986 ; Abi Saab *et al*., 1997).

Statistical analysis of variance was performed using one-way ANOVA to identify the effect of the variation in the rangelands of the parameters studied within the same period (SP and WP) (MSTATC, 1991); the Newman method was used for comparison of different groups at different zones ($\alpha = 5\%$).

RESULTS

Nature and nutrient content of plants grazed. In the SP, herbaceous plants were predominant in pastures of high altitude (Tables 1-2); they constituted 95 to 100% of the pastures consumed (*Agropyron libanoticum*, *Astragalus echinus*, *Berberis libanotica*…).

TABLE 1

Percentages of Plants Grazed by Goats in the Summer (SP) and Winter (WP) Periods

Periods	Dates of sampling	Herbaceous plants (%)	Ligneous plants (%)
SP	June 26	100	-
	July 16	95	5
	August 5	85	15
	August 25	75	25
	September 14	70	30
	October 4	70	30
WP	December 6	20	80
	December 26	10	90
	January 15	5	95
	February 4	15	85
	February 24	70	30
	March 16	20	80

At the end of the SP, proportions of herbaceous plants decreased to represent 70% of the plants consumed, while trees (*Prunus ursina*) and shrubs (*Rosa glutinosa*) increased

from 5 to 30% between the beginning and end of the animals' stay in the summer period. In the WP, goats consumed mainly trees (*Quercus calliprinos*) and shrubs (*Calycotome villosa*, *Poterium spinosum*) in proportions varying between 80 and 95%.

TABLE 2

Nature of Plants Ingested in the Summer (SP) and Winter (WP) Periods

Periods	Herbaceous Plants	Ligneous Plants
	Agropyron libanoticum	*Prunus ursina*
	Artemesia judaica	*Rosa glutinosa*
	Bromus tomentellus	
	Achillea odorata	
	Salvia acetabulosa	
S	*Notabasis syriaca*	
U	*Cirsium acarna*	
M	*Glaucium leioscarpum*	
M	*Cressa cretica*	
E	*Chrozophora tinctoria*	
R	*Astragalus coluteoides*	
	Astragalus angustifolius	
	Astragalus echinus	
	Onobrychis cornuta	
	Arctostaphylos officinalis	
	Berberis libanotica	
	Convolvulus arvensis	*Calycotome villosa*
	Hordeum hystrix	*Poterium spinosum*
	Trifolium clypeatum	*Rubus sactus*
W	*Trifolium stellatum*	*Quercus calliprinos*
I		*Quercus infectoria*
N		*Crataegus monogyna*
T		*Prunus ursina*
E		*Pistacia palaestina*
R		*Ceratonia siliqua*
		Pyrus syriaca
		Amygdalus orientalis
		Rosa glutinosa

However, at the end of this period, 70% of the plants consumed were herbaceous. Table 3 shows the proximate analysis of plants consumed in both periods. Dry matter increased from 48.9% to 61.2% at high altitudes between the beginning and the end of animal's stay in SP, the percentage of dry matter in the diet being high and remained around 60% in WP. The percentage of crude protein decreased from 15.2% to 8.5% between the beginning and the end of the animals' stay in the mountainous region; it was around 10.4-11.5% for the WP. The percentages of crude fiber showed fluctuations from 27 to 42% in the SP and the lipids varied between 2.8 and 4.7%.

TABLE 3

Chemical Composition (%DM) of a Mixture of Plants ingested in the Summer (SP) and Winter (WP) Periods

Periods	Summer				Winter	
Dates of sampling	Jun. 26	Jul. 16	Aug. 25	Sept. 14	Dec. 6	Feb. 4
Dry matter (%)	48.9	55.4	62.6	61.2	61.8	59.5
Crude protein (CP)	15.2	10.1	8.6	10.2	10.4	11.5
Crude fiber (CF)	30.6	37.6	42.0	27.2	32.0	33.0
Ether extract (EE)	4.7	2.8	3.3	3.6	3.7	3.8
Ash (%)	8.1	6.6	7.0	8.1	5.7	7.1

Growth performance. In the SP, the body weights of male and female goat kids increased by 12 and 7.6 kg, respectively (Fig. 2). While does showed a body weight increment over the whole SP (4.2 kg), bucks gained weight until the middle of their stay in this zone (4.7 kg) then lost weight dramatically between August and October (around 8 kg). During June and July, weight gain in the same zone was 203 ± 11.5 and 141 ± 6.93 g/d for male and female kids, respectively. It decreased enormously in the dry period (August-October, 19 *vs*. 8 g/d for male and female kids, respectively) and reach negative levels towards September-October (-25 ± 4.76 g/d). However, weight loss remained much greater for bucks, who lost 284 ± 39 g/d at the end of this period. In the WP, male and female kids' weights increased by 3.4 kg and 1.8 kg respectively, while does lost 7.5 kg and bucks' weight increased ($p<0.05$) by 3.3 kg (Fig. 2).

Adaptation parameters. In both periods, respiration rate increased from 30 ± 8.2 to 47 ± 10.0 breaths/min after two hours' of walking (Fig. 3). The level decreased and reached a minimum at around noon (40 ± 15.4 breaths/min during the rest period). Does continued grazing with 49 ± 12.0 breaths/min. The respiration rate then increased and remained high for all groups (between 47 ± 17.0 and 50 ± 18.4 breaths/min on return to the enclosure at the end of the grazing time).

Heart rate also presented similar variations, with averages of 90 and 83 beats/min in the morning in SP and WP, respectively, reaching a maximum of 116 to 118 and 112-120 beats/min in the afternoon in each period. The heart rate varied with the distance traveled; After 6 km of walking, it presented a slight decrease, stabilizing at around 83-90 beats/min. Rectal temperatures were in the normal range with 39 ± 0.03°C in the morning and 39.9 ± 0.01°C at noon.

Testicular activity in bucks. Testicular volume showed a significant increase ($p<0.05$) between the beginning and the end of the animals' stay in SP (404 ± 92 to 500 ± 38 ml, Table 4). A significant decrease ($p<0.05$) was then observed, reaching a value of 328 ± 37 ml. Slight modifications ($p>0.05$) were recorded in the WP.

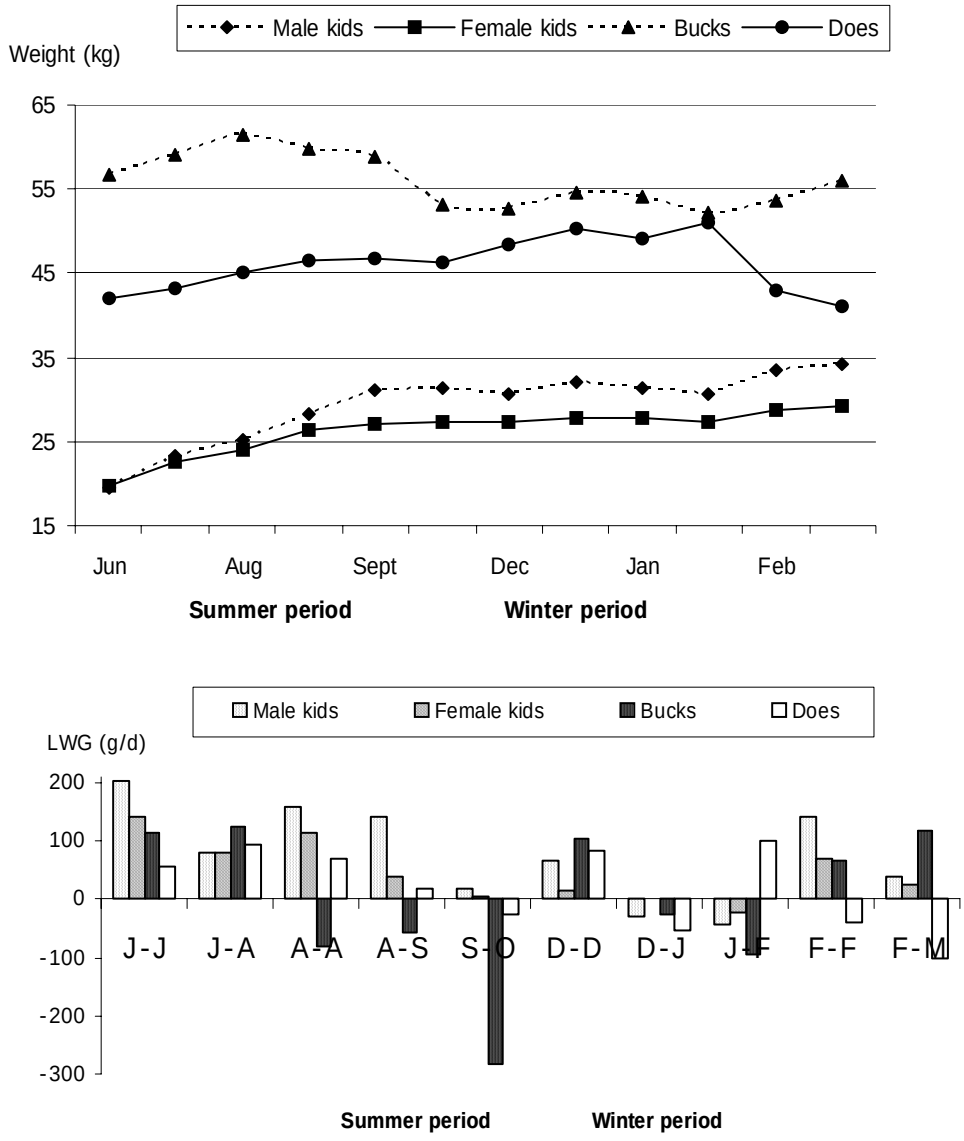
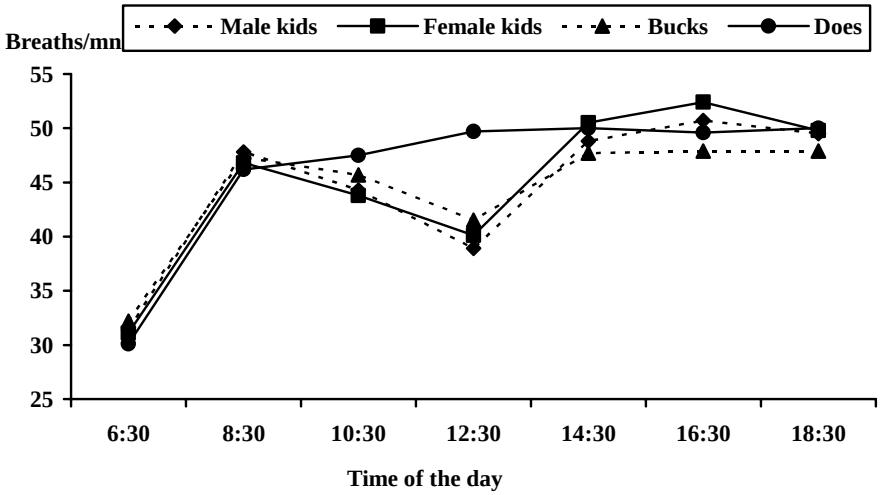


Figure 2. Mean variations of body weights and live body weights gain of animals in the summer (SP) and winter (WP) periods.

(SP)



(WP)

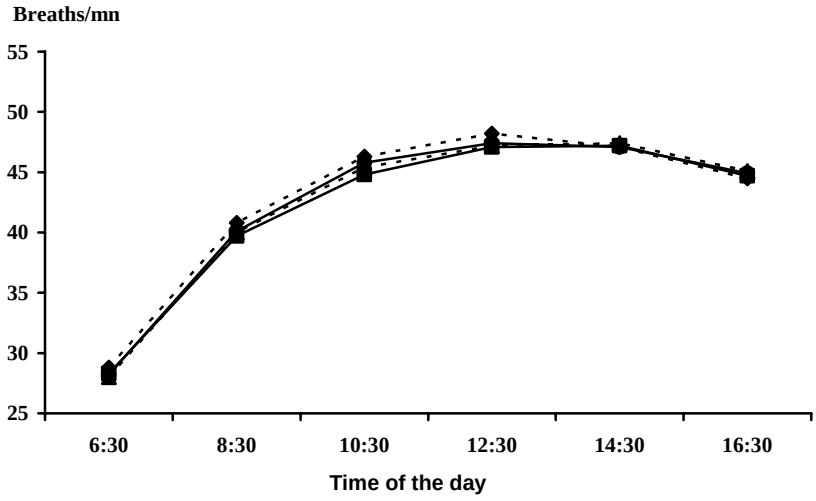


Figure 3. Mean variations of respiration rates in the summer (SP) and winter (WP) periods.

TABLE 4

Changes in Testicular Volume and Semen Characteristics of Bucks in the Summer (SP) and Winter (WP) Periods

Periods	Dates of measurements	Testicular volume (ml)	Semen volume (ml)	Motility (%)	Concentration of semen (10^9/ml)	Abnormalities (%)
SP	June 26	404 ± 92^{bc}	1.1 ± 0.6^{a}	89 ± 7^{a}	3.53 ± 0.67^{a}	16 ± 2^{a}
	July 16	390 ± 58^{bc}	1.3 ± 0.5^{a}	88 ± 9^{a}	3.70 ± 0.34^{a}	11 ± 3^{b}
	August 5	430 ± 68^{ab}	1.3 ± 0.5^{a}	84 ± 10^{a}	3.37 ± 0.58^{a}	11 ± 2^{b}
	August 25	443 ± 56^{ab}	1.6 ± 0.5^{a}	91 ± 7^{a}	3.23 ± 0.57^{a}	8 ± 2^{b}
	September 14	500 ± 38^{a}	1.6 ± 0.4^{a}	86 ± 9^{a}	3.10 ± 0.61^{ab}	9 ± 3^{b}
	October 4	328 ± 37^{c}	1.0 ± 0.2^{a}	81 ± 13^{a}	2.29 ± 0.85^{b}	11 ± 4^{b}
WP	December 6	360 ± 30^{ab}	0.9 ± 0.5^{a}	85 ± 8^{a}	2.77 ± 0.31^{a}	12 ± 3^{a}
	December 26	350 ± 53^{ab}	0.9 ± 0.3^{a}	81 ± 9^{a}	2.69 ± 0.64^{a}	14 ± 2^{a}
	January 15	350 ± 33^{ab}	0.7 ± 0.2^{a}	69 ± 13^{b}	2.04 ± 0.84^{a}	13 ± 3^{a}
	February 4	310 ± 46^{b}	0.6 ± 0.3^{a}	71 ± 5^{ab}	1.74 ± 0.69^{a}	17 ± 3^{a}
	February 24	330 ± 60^{ab}	0.7 ± 0.4^{a}	76 ± 12^{ab}	2.52 ± 0.29^{a}	15 ± 3^{a}
	March 16	413 ± 99^{a}	1.2 ± 0.4^{a}	76 ± 8^{ab}	2.57 ± 0.57^{a}	14 ± 3^{a}

Means (± S.D.) within a column, for each zone, not sharing the same letters (a-c) are different ($p<0.05$).

Semen volume and individual sperm motility decreased slightly in the SP (1.1 ± 0.6 *vs*. 1.0 ± 0.2 ml and 89% *vs*. 81% respectively; $p>0.05$). Spermatozoa concentration showed non-significant fluctuations (3.10 ± 0.61 to 3.7 ± 0.34 spermatozoa x 10^9/ml; $p>0.05$). At the end of animal's stay in this period, a significant reduction was observed (2.29 ± 0.85 spermatozoa x 10^9/ml; $p<0.05$). Abnormal spermatozoa proportions showed non significant fluctuations during the SP ($P>0.05$), however values were acceptable (maximum 16 %).

Semen volume did not show significant variations in the WP ($p>0.05$). Individual sperm motility showed significantly lower values (85 ± 8 *vs*. 69 ± 13 %; $p<0.05$). Semen concentration varied between 1.74 ± 0.69 and 2.69 ± 0.64 spermatozoa x 10^9/ml; $p>0.05$). Similarly, percentages of abnormal spermatozoa did not show significant variations, fluctuating between 12 ± 3 and 17 ± 3 %.

Semen volume showed significant positive correlation with testicular volume ($r = 0.40$, $p<0.01$) and semen concentration ($r = 0.36$, $p<0.05$) in the SP. These correlations were not significant in the WP.

DISCUSSION

The decrease of the percentage of crude protein (15.4% to 8.5%) in the SP is explained by the seasonal dry period and death of annual plants, in agreement with the results of Kababya *et al*. (1998). In the WP, the percentage of crude protein was 10.4-11.5%, a result of the growth of annual plants in this zone during the rainy season. At the end of the animals'

stay in the WP, 70% of the plants consumed were herbaceous becoming available after rain and following the moderate temperature at this period (19°C).

The results of body weight and weight gain are in agreement with the results of Gilboa *et al.* (2000). The positive daily weight gain of male and female kid's during June and July was due to the fact that these animals traveled for short distances at that time (6 km/day), and consumed milk and plants containing 15% crude proteins (Abi Saab *et al*., 1997). Weaning (end of July) then reduced their daily weight gain (around 60 g/d), in agreement with the results of Morand-Fehr *et al*. (1982). The important decrease of weight gain in the dry period (mid-August-October) for male and female kids may be attributed to the poor pastures, the low protein percentages (10.5%), the reduction in proportions of grasses and legumes, and the longer distances traveled (10 km) requiring higher energy expenditure (McFarlane, 1982 ; Sheath *et al*., 1987; Demment & Lacca, 1993). This period also corresponded to the beginning of gametogenetic activity that could have affected growth. Does might have been less influenced, probably because of the beginning of gestation (Morand-Fehr, 1981). The weight losses observed in young and adult goats, whose needs for available feed were greater, could be avoided by supplementing animals in that period, a practice which is not followed to date by farmers. At the end of the stay in the WP, bucks showed a significant increase ($p<0.05$) in the daily weight gain, reaching 116 ± 15 g/d. This could have been due to the increase in protein content (11.5%) in the pastures at this period (Matenga & Shoo, 1990).

Stabilization of the respiration rate around 48 breaths/min indicated that animals are adapted rapidly to the distance travelled (after 5-6 km); results also observed in sheep that travel at a speed of 5 km/h (Abi Saab & Sleiman, 1995; Sleiman & Abi Saab, 1995). At the end of the day, the respiration rate was slightly higher in the SP (52 breaths/min); this could have been due to the greater distances traveled in this period, as the days were longer (15 hours *vs*. 10 in the WP). The respiration and pulse rates showed greater changes then rectal temperature, explained by enhancing the thermoregulation mechanism by animals to avoid an increase in body temperature.

The significant increase in testicular volume observed between the beginning and the end of the animals' stay in the SP is probably due to the sexual activity of the bucks. The subsequent decrease is probably due to the natural anestrus season (Abi Saab and Sleiman, 1986; 1987) and to a decrease in the nutritive value of the vegetation available in this period or both. The significant reduction in spermatozoa concentration at the beginning of october is explained by their enhanced sexual activity during the breeding season. These results are in agreement with those obtained for different goat breeds (Nelson *et al*., 1987). A decrease in semen quality has also been observed at the end of the breeding season in sheep (Abi Saab & Hamade, 1984; Abi Saab & Sleiman, 1986). The reductions in ejaculation volume and spermatozoa concentration observed at the end of the animals' stay in SP and WP indicate a slight difference in sexual activity due to the photoperiod existing in the Middle East (Corteel, 1977; Abi Saab & Hamade, 1984; Abi Saab & Sleiman, 1986; Ahmad & Noakes, 1996; Abi Saab *et al*., 1997; 2000).

The positive correlation between sperm volume and semen concentration indicates more intense spermatogenetic activity in summer period, which corresponds to the mating season. These correlations were not significant in the WP, corresponding to the anestrus period.

CONCLUSION

Transhumance from WP to SP is beneficial for only two months (end of spring-beginning of summer) when pastures are rich, with a protein percentage of around 15%. It is harmful for the rest of the period because of the long distances traveled by the animals, poor pastures (around 8% proteins) and the sexual activity at this period, leading to weight loss. Nutritional supplementation is therefore necessary from the middle of the SP, where it would be preferable that animals' stay in stable and more favorable conditions to maintain weight gains. Baladi breed is tolerant to changes in environmental temperature and to distances traveled through trnshumance and daily pasturing.

Testicular activity and semen quality values decreased outside of the breeding season but remained acceptable, showing the slight modification in sexual activity for bucks of the Baladi goat breed with seasonal fluctuations. However, in order to have higher doses for artificial insemination, it would be valuable to increase feed support for males. Further studies on productive and reproductive traits based on larger sample size under varying environmental conditions would be important for breeding strategies.

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