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Influence of feeding supplementation on goats grazing behaviour

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SUMMARY - Twenty-four female pluriparous crossbred Maltese goats were used to study the effect of supplementary feeding on goats grazing behaviour. The experiment was carried out between 11 May and 7 June 1992. The goats were allocated to three groups: group 1, receiving 2.4 kg of rehydrated chick-pea grain (300 g dry matter per goat per day); group 2, receiving 2.4 kg crushed whole barley grain (300 g dry matter per goat per day); group 3 (control group), without food supplementation. Within each group the goats were randomly and equally allocated to either treatment 1, with rumen fistula or treatment 2, with faecal rectal bag. The goats grazed during the day from 10:00 to 16:00 h, Italian Summer Time and were penned in the evening in large strawed pens. The grazing activity was recorded by a time sampling technique every ten minutes. Grazing activity significantly increased over the experimental period ($P<0.001$). Control goats showed higher grazing activity than supplemented animals ($P<0.001$). Ruminating levels were generally low, but control goats showed higher levels in the afternoon compared to supplemented goats ($P<0.01$). In general, we conclude that foraging activity is affected by feeding supplementation.

Key words: Goats, grazing behaviour, feeding supplementation

RESUME - "Influence de la supplémentation alimentaire sur le comportement des chèvres au pâturage". 24 chèvres multipares de race Maltaise ont été utilisées pendant la période 11/5/92-7/6/92 afin de déterminer l'influence de la supplémentation alimentaire sur le comportement au pâturage. Les chèvres étaient réparties dans 3 lots: le 1er recevait chaque jour 2,4 kg de pois chiche en grains réhydratés (300 g MS par sujet), le 2e 2,4 kg de remoulages d'orge (300 g MS par sujet), le 3e (témoin) était sans supplementation. Dans chaque lot, les chèvres étaient réparties aléatoirement en deux traitements, avec fistule ruminale et avec sac rectal. Les chèvres pâturaient de 10 h à 16 h chaque jour et le soir étaient conduites en bergerie sur litière paillée. L'activité de pâturage augmente progressivement dans la période expérimentale ($P<0.001$). Le lot témoin a une activité de pâturage supérieure à celle des lots supplémentés ($P<0.001$) et un niveau de rumination plus élevé dans l'après-midi ($P<0.01$). En général, la supplémentation alimentaire influence le comportement au pâturage des chèvres.

Mots-clés: *Chèvres, comportement au pâturage, supplémentation alimentaire.*

Introduction

It has been recognized that goats show a different grazing style from sheep and cattle (Gordon and Iason, 1989). Goats have been indicated as browsing species (Provenza and Malechek, 1986) and they have a high degree of selectivity due to a narrower pointed dental arcade (Gordon and Illius, 1988).

It has been shown that herbage intake is reduced in fat sheep, whilst lactation increases intake, mainly through an increase in grazing time rather than in the bite rate or bite mass (Milne *et al.*, 1981; Gunn *et al.*, 1991). Furthermore, the composition of sheep diet is influenced by starvation (Arnold *et al.*, 1964), which can be considered as an alteration in metabolic state (Milne, 1991). The addition of readily available carbohydrate to the diet in the form of supplementation often reduces the time spent grazing, the substitution effect, while the addition of a protein-rich supplement increases voluntary intake and presumably grazing times, of a low-quality roughage pasture (Lynch *et al.*, 1992). Supplementation can also reduce the level of hunger, increasing the diet quality and presumably selectivity of grazing sheep (Jung and Koong, 1985). However, the extent to which diet selection is influenced by the metabolic state of the goats has not been studied in any detail (Milne, 1991).

Our research is a part of a joint project set up with Istituto Sperimentale per la Zootecnia, Potenza, Italy. The project aims to acquire more information on goats grazing behaviour and on the role of food supplementation on the pasture utilization and performance of goats. The objective of this study was therefore to evaluate the effect of supplementary feeding on goats grazing behaviour.

Materials and methods

Location

The study was carried out at Istituto Sperimentale per la Zootecnia, Bella, Italy. Elevation is ~351 m above sea level. Precipitation, occurring mainly in spring and winter, averages 900 mm. The study area was a natural fenced pasture. Its size was ~6600 m^2 in the previous year a trimming cut was done in the summer and 40 kg P_2O_5 per ha of a fertiliser was given in autumn. In order to locate animals, the study area was divided in square grids of 16 m^2 by means of wooden poles (height = 2 m). Poles were alternately painted white and red. The pasture was therefore split in 20 rows and 12 columns. Rows and columns were respectively identified with numbers and letters by means of wooden boards nailed on the top of poles. In this way animals were easily located in the field. This has also allowed the distance covered during grazing to be estimated. Five squares (1 m x 1 m) were cut to ground level on two occasions on the pasture to estimate the herbage biomass. Samples were dried at 100°C and ashed overnight at 450°C. The floral composition of each grid was also determined. A watering place was situated in a corner of the field.

Animals

Twenty-four female pluriparous crossbred Maltese goats were used. Animals were empty and non-lactating. Initial live weight ranged from 30 to 45 kg (mean = 37 kg).

Treatments

The experiment was carried out between 11 May and 7 June 1992. The goats were allocated to three groups balanced for live weight and body condition score: group 1 (chick-pea group), receiving 2,4 kg of rehydrated chick-pea grain (300 g dry matter (DM) per goat per day); group 2 (barley group), receiving 2.4 kg crushed whole barley grain (300 g DM per goat per day); group 3 (control group), without food supplementation. Supplementation was given inside a barn during the evening. The goats grazed during the day from 10:00 to 16:00 h Italian Summer Time (IST) and were penned in the evening in the barn, where water was available ad libitum. Each group was kept in large strawed pen.

Within each group the goats were randomly and equally allocated to either treatment 1, with rumen fistula, or treatment 2, with faecal rectal bag. Samples of rumen boluses were taken 12 times during experiment to determine their botanical composition. The animals grazed for 40-60 min prior to collection of the samples. The samples were subsequently frozen, freeze-dried and determination were made of *in vitro* digestibility (Tilley and Terry, 1963). The rectal bags were fitted on the first and the last week of the experimental period by means of belts. Faecal output of each goat was collected daily, weighed, dried at 64°C and subsequently bulked for each week. Further details on the feeding variables recorded and the results related to them will be reported in a next paper.

All animals were individually identified by a coloured plastic jacket leaning on both flanks of them. Coloured plastic numbers were stamped on both sides of jacket. For each group a jacket of different colour was used. The goats were fitted with jacket before going to the grazing area.

Live weight and body condition score were recorded at 7 days intervals.

Behavioural recording

The grazing activity was recorded by direct observation. During the four weeks of the experiment, every week, behaviour was recorded by a time sampling technique on four consecutive days from 10:00 to 16:00 h (Altmann, 1974; Martin and Bateson, 1987). The eighteen morning sample periods (10:00 to 13:00 h) and eighteen afternoon sample periods (13:00 to 16:00 h) were performed on separate days. No behavioural recordings were performed when the rumen boluses were collected. The data were initially collected onto a auditory tape and subsequently transcribed onto checksheets. On observation days, two observers, using binoculars, recorded each goat's activity every ten minutes. The observers were standing outside the field so as not to disturb the animals. Each behavioural record consisted of goat number, posture, activity and location in the field.

Environmental temperature and relative humidity were measured each hour by means a digital hygrothermometer.

Data analysis

Each data record was allocated to one of the six behavioural categories described in Table 1. Each day was divided into 6 periods: period 1 (10:00-11:00 h); period 2 (11:10-12:00 h); period 3 (12:10-13:00 h); period 4 (13:10-14:00 h); period 5 (14:10-15:00 h) and period 6 (15:10-16:00 h). For each day, separately for each of the periods of day, average values were calculated of the proportions of observations each goat was recorded in each behavioural category. In addition, for each animal, separately for each period of day, number of square grids crossed was determined by connecting its position in each six sample periods with segments (i.e. counting the square grids intersected by the segments). This variable could be an estimation of the distance covered by the animal within a period of day. Average values of four consecutive days within a week and period of day were used.

Table 1. Behavioural categories recorded by direct observation

Category	Description
Grazing	Goat standing or lying down; head down taking mouthfuls of herbage, searching for herbage, manipulating it in the mouth
Ruminating	Goat standing or lying down; chewing at regular intervals followed by swallowing one bolus and regurgitation of the next
Idling	Goat standing or lying down; opened or closed eyes, but no other overt activity
Walking	Goat standing; head up and moving from one place to another
Interaction	Goat standing or lying down; aggressive or non-agonistic behaviour
Other	Goat standing or lying down; drinking, scratching, self-grooming

In order to reduce skewness of the data, these averages were transformed by angular (for proportions) or square root (for number of square grids crossed) transformation and analyzed by analysis of variance for repeated measures (nested structures for goat, week and time of day) with two factors (group and treatment). Where significant effects were found the Least Significant Difference test (LSD) was used to locate significant differences between means.

Results

Herbage biomass at beginning of the experiment was 3770 kg DM ha^{-1}, while at the end was 3030 kg DM ha^{-1}. Therefore, the DM ha^{-1} consumed by the animals during the study was 740 kg. Tables 2 and 3 show the average values of each behavioural category for each group for weeks 3 and 4 across the periods.

Table 2. Average proportion of observations (± S.E.) spent in each behavioural category during week 3. A, B and a, b indicate significant differences (P<0.05 and P<0.01 respectively) within a row

Activity	Group					
	Control		Chick-pea		Barley	
Grazing	0.760	0.032 a	0.673	0.019 Ab	0.739	0.029 B
Ruminating	0.056	0.018	0.080	0.010	0.050	0.015
Idling	0.061	0.012 A	0.081	0.009 B	0.074	0.025
Walking	0.076	0.006	0.094	0.011	0.073	0.010
Interaction	0.017	0.004	0.020	0.007	0.019	0.005
Other	0.028	0.008	0.037	0.011	0.047	0.009

Grazing activity has significantly increased (F = 12.8; df = 3,25; P<0.001) over the experimental period. A group x week interaction was found (F = 3.4; df = 6,54; P<0.01), due to the higher activity showed by the control goats in the last two weeks than other two groups (LSD: P<0.001; see Tables 2 and 3). There was also a treatment x week interaction as the fistulated animals decreased their grazing levels in the first week of the experiment (mean proportion of observations (MPO): 0.61 *vs* 0.75, 0.72 and 0.78 for weeks 1, 2, 3 and 4 respectively; LSD: P<0.01) and no-fistulated animals increased their grazing levels over the experimental period (MPO: 0.55 *vs* 0.62, 0.72 and 0.74 for weeks 1, 2, 3 and 4 respectively; LSD: P<0.001).

Ruminating levels were generally low (see Tables 2 and 3), but were strongly influenced by week (F = 5.8; df = 3,54; P<0.001), with highest levels being observed during the third week of the experiment (MPO: 0.06 *vs* 0.03, 0.03 and 0.04 for weeks 3, 1, 2 and 4 respectively; LSD: P<0.001). Period also had a significant effect on this activity (F = 11.5; df = 5,90; P<0.001) with higher levels showed from 11:00 to 13:00 h compared to other periods of the day (MPO: 0.05 and 0.08 *vs* 0.04, 0.02, 0.02 and 0.02 for periods 2, 3, 1, 4, 5 and 6 respectively; LSD: P<0.01). There was a group x period interaction (F = 3.8; df = 10,90; P<0.001), due to the control group not showing the strong decline in ruminating levels between 13:00 and 15:00 hrs (LSD: P<0.01; Fig. 1).

Table 3. Average proportion of observations (± S.E.) spent in each behavioural category during week 4. A, B and a, b indicate significant differences (P<0.05 and P<0.001, respectively) within a row

Activity	Group					
	Control		Chick-pea		Barley	
Grazing	0.815	0.035 a	0.692	0.038 Ab	0.762	0.033 B
Ruminating	0.042	0.015	0.040	0.008	0.030	0.011
Idling	0.073	0.030 Aa	0.207	0.038 b	0.162	0.050 B
Walking	0.036	0.004	0.038	0.011	0.032	0.006
Interaction	0.005	0.003	0.005	0.005	0.003	0.002
Other	0.023	0.008	0.030	0.012	0.030	0.007

Non-fistulated goats spent more time idling than fistulated goats (MPO: 0.15 *vs* 0.09 for animals no-fistulated and fistulated respectively; F = 7.94; df = 1,18; P<0.01). There was a strong week effect (F = 12.7; df = 3,54; P<0.001) with highest levels of idling during the first and fourth week and the lowest during the second and third week of the experiment (MPO: 0.18 and 0.15 *vs* 0.09 and for weeks 1, 4, 2 and 3 respectively; LSD: P<0.01). Goats spent more time idling from 11:00 to 13:00 h than the others periods of the day (F = 8.0; df = 5,90; P<0.001). There was a group x week interaction (F = 2.30; df = 6,54; P<0.05) as the unsupplemented goats manifested higher levels during the first week (LSD: P<0.001), whilst supplemented goats showed higher levels during the first and the last week of the experiment (LSD: P<0.01, see Table 3).

Walking was another behavioural category on which week had a significant effect (F = 20.2; df = 3,54; P<0.001) and occurred more often in the first three weeks than in the last week of the experiment (MPO: 0.03 *vs* 0.10, 0.10 and 0.08 for weeks 4, 1, 2, and 3 respectively; LSD: P<0.001). A period effect was found (F = 2.8; df = 5,90; P<0.05) with higher levels in the periods 2 and 6 compared to periods 1 and 3 (MPO: 0.10 and 0.09 *vs* 0.07 and 0.07 for periods 2, 6, 1 and 3 respectively; LSD: P<0.05). A two-way group x period interaction (F = 3.1; df = 10,90; P<0.001) was caused by chick-pea goats showing nearly constant levels throughout the day, whilst control goats showed a strong increase in the period 6 compared to other periods of the day (LSD: P<0.05, Fig. 2).

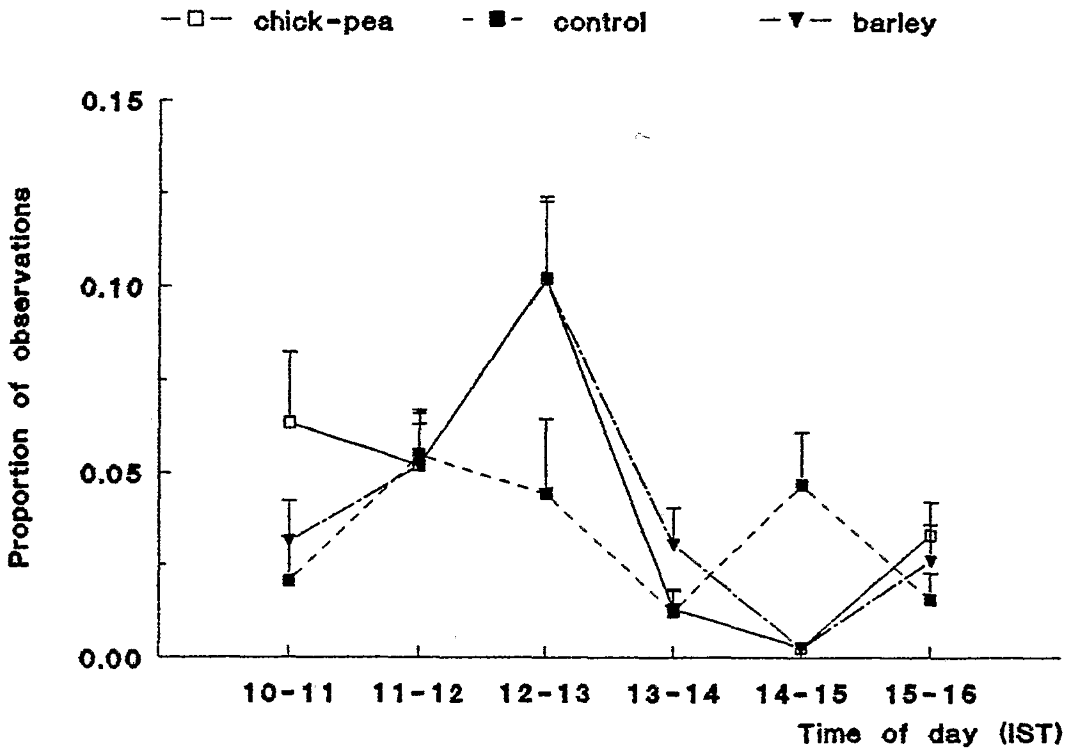

Fig. 1. Proportion of observations (mean + S.E.) spent in ruminating.

Control goats crossed more square grids ($F = 3.8$; $df = 2,18$; $P<0.05$) than the other two groups (23 *vs* 21 and 21 for groups control, chick-pea and barley respectively; LSD: $P<0.05$). There was a strong week effect ($F = 32.7$; $df = 3,54$; $P<0.001$) with the highest levels in the first two weeks and the lowest in the last two weeks of the experiment. Higher levels of this variable were observed between 12:00 and 15:00 h than other times of the day ($F = 77.4$; $df = 5,90$; $P<0.001$). A two-way group x week interaction ($F = 3.3$; $df = 6,54$; $P<0.01$) was caused by control goats showing higher levels in weeks 1 and 4 of the experiment than the other two groups (LSD: $P<0.01$). There was also a group x week x period interaction ($F = 1.8$; $df = 30,270$; $P<0.01$), due to higher levels in control goats between 11:00 and 16:00 h in the last week of the experiment than supplemented groups (LSD: $P<0.05$, Fig. 3).

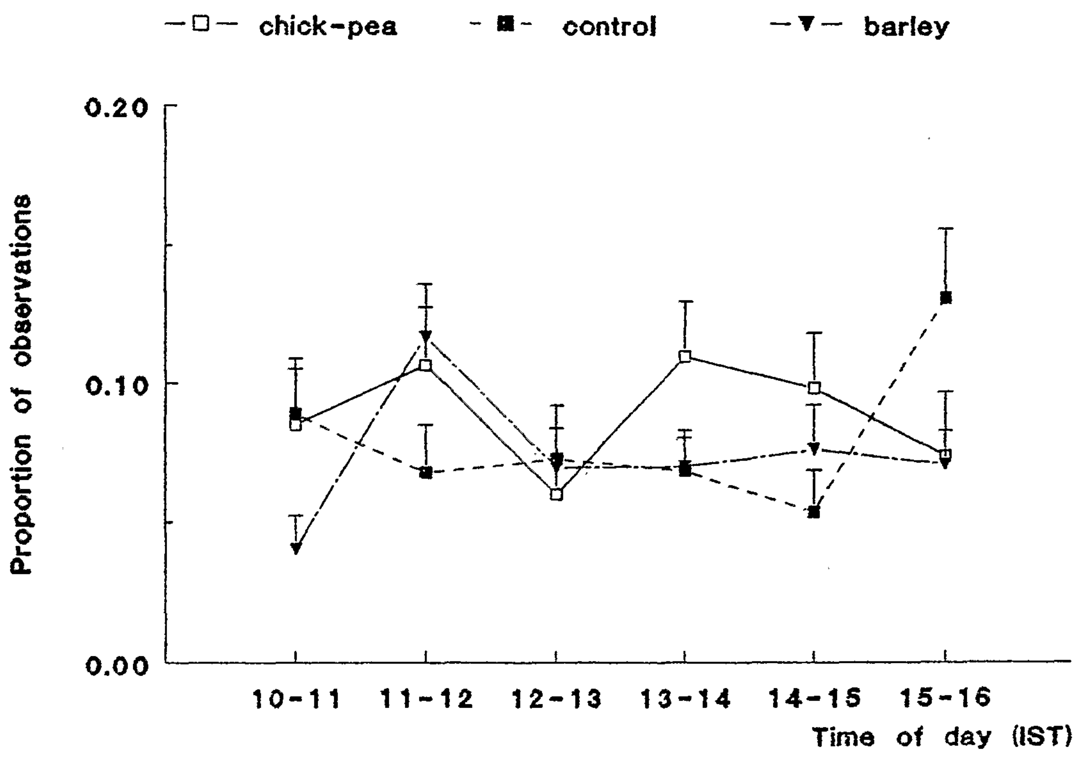

Fig. 2. Proportion of observations (mean + S.E.) spent in walking.

Discussion

This study indicates that the behavioural patterns of grazing goats change with time. Previous works have shown that sward state changes under continuous grazing (Jamesion and Hodgson, 1979; Walker and Heitschmidt, 1989; Penning *et al.*, 1991a). Therefore, it may be hypothesized that the behavioural responses in this experiment appear to be affected by sward state.

The results also show that foraging activity decreases with feeding supplementation. It has previously demonstrated that grazing time was greater at a lower herbage mass (Allden and Whittaker, 1970; Milne *et al.*, 1981; Provenza and Malecheck, 1986). Grazing times and total number of bites are significantly and negatively related to herbage mass (Milne *et al.*, 1981). Penning *et al.* (1991a) found that sheep decreased grazing time and prehension rate with increasing height of a ryegrass swards, while mastication and rumination rate increased. It has also been shown that grazing time usually increases with progressive defoliation under continuous grazing (Chacon and Stobbs, 1976; Walker and Heitschmidt, 1989). When longer grazing times have been associated with defoliation there has been a concomitant change in diet quality (Chacon and Stobbs, 1976; Jamesion and Hodgson, 1979). A possible explanation for this is that increases in grazing time appear to be a compensating response on the part of the animal to a decline in the intake per bite (Hodgson, 1985).

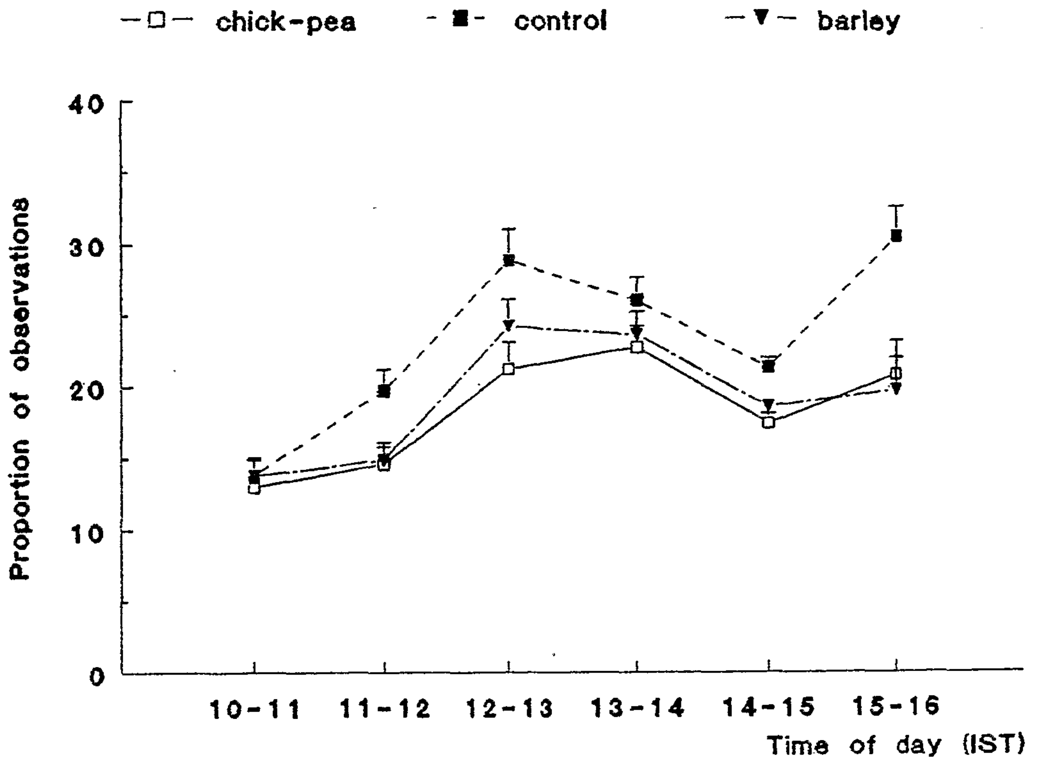

Fig. 3. Number of square grids crossed mean + S.E.) during week 4.

In this experiment grazing activity did not differ between fistulated and non fistulated goats, which is consistent with the conclusions of Arnold *et al.* (1964) and the results of Provenza and Malechek (1986).

The relatively longer time that unsupplemented goats spent grazing may have been caused by attempt to select more nutritious diets (Provenza and Malechek, 1986) or to harvest more forage. An experiment by Arnold (1981) showed that grazing activity and herbage intake per unit of body weight were increased in underfed ewes compared with well-fed ewes. It has been also reported that in lactating ewes herbage intake declined with increasing amount of supplement (Milne *et al.*, 1981). It has been reported that social facilitation influences the behavioural patterns of grazing herbivores (Arnold and Dudzinski, 1978). Previous experiments (Tribe, 1950; Holder, 1962) have found the presence of supplemented and the unsupplemented ewes on the same area to be a major influence on grazing time. The grazing time of supplemented ewes can be increased in the presence of the other unsupplemented animals. The increase in grazing activity in the present experiment suggests that the effects of food restriction on feeding motivation in unsupplemented goats increased with time, presumably as result of an accumulating nutrient deficit.

In this study the supplemented goats decreased and the unsupplemented goats increased their ruminating levels throughout the day. Furthermore, both ruminating and idling occurred more frequently during the hotter times of the day, in accordance with finding of Rook and Penning (1991). Penning *et al.* (1991b) have reported that ewes on grass spent proportionately more time ruminating than those on clover. They stated that the shorter ruminating time exhibited by animals grazing clover can be explained by the higher rate of particle breakdown during mastication of clover compared with grass.

Further work is needed to understand how goats adjust their grazing activity and diet selection to feeding supplementation. The outcome could be use for the development of extensive grazing systems in Mediterranean areas.

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