Diets of goats grazing oak shrublands of varying cover in northern Greece

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Abstract

The effects of 3 brush cover proportions (Low Brush pasture: 52% brush/32% herbage, Medium Brush pasture: 62% brush/20% herbage, and High Brush pasture: 66% brush/12% herbage) on dietary selection of goats in northern Greece were investigated. Diet samples were collected from esophageally fistulated goats during 14 grazing periods at monthly intervals from June 1987 to July 1988. Kermes oak foliage (*Quercus coccifera* L.) was the main component of the available forage in all pastures during all grazing periods. The herbaceous component contributed more than 50% for the goats' diet during spring for Low Brush pasture, 46% for Medium Brush pasture, and 40% for High Brush pasture. In the remaining grazing periods, goats selected larger quantities of browse. For Low Brush pasture browse contribution ranged from 48% to 66%, for Medium Brush from 54% to 77%, and for High Brush from 66% to 80%. Leaves of all forage species contributed more than 56% during all test periods. The quantities of twigs from shrubs and stems from herbaceous species were low but constant during all test periods. Fruits and flowers, despite representing low percentages of the overall production, were important for the animals' nutrition, since they provided a high percentage of nutrients. Our results indicated that goats adapted diets to forage class availability.

Key Words: shrubs, herbage, botanical composition, goats, Greece

Shrublands dominate the landscape of the low altitude zone of the Mediterranean region, covering 2,000,000 ha (Le Houerou 1980). The kermes oak (*Quercus coccifera* L.) shrubland is the predominant vegetation of a large part of Greece, covering more than 0.4 million ha or 50% of Greece's total shrubland area (Liacos et al. 1980). This vegetation type is vitally important for goat production in the region.

Several studies have suggested management schemes for kermes oak shrublands with the goal of increasing forage and livestock production (Liacos and Mouloupoulos 1967, Liacos et al. 1980, Nastis 1982, Tsiouvaras 1987). Liacos et al. (1980) indicated that reduction of woody plant cover in dense shrublands may be the first step toward increasing the usable forage production of kermes oak shrublands. Changes in vegetation structure and composition are thought to affect dietary selection and forage quality during certain periods of the year (Kirmse et al. 1987a,b). By increasing the proportion of herbaceous species and decreasing the shrubby component, dietary selection of herbaceous species would be favoured (Lopes and Stuth 1984, Stuth and Kamau 1990). Released herbage following canopy reduction of kermes oak has higher nutritive value than browse during the spring (Papachristou and Nastis 1990). However, kermes oak green foliage is better suited to the maintenance requirements of goats (*Capra hircus* L.) during summer, when grasses and forbs are dry (Tsiouvaras 1984) and during winter, when herbaceous plants are dormant. Information on the dietary selection responses of goats to variable shrub cover is generally unavailable for the world's rangelands (Walker et al. 1972, Beale 1973, Scifres 1980). Only very limited data are available for the Mediterranean region (Papachristou and Nastis 1988). No work has been conducted to determine diets using esophageally fistulated goats in Greece.

The objective of this study was to determine forage availability in shrublands with different shrubby cover at monthly intervals, as well as the botanical composition of diets of goats grazing in these shrublands. Such information would be useful for more efficient shrubland management schemes.

Study Area

The study area was located near Serres, in Macedonia, in northern Greece at an altitude of 600 m. Rainfall during the study (June

Table 1. Mean pasture cover (%)¹ of browse, grasses, and forbs for 3 oak shrublands of varying cover during June 1987 and 1988.

Plant species	Cover of pastures		
	Low	Medium	High
	----- (%) -----		
Browse	52.1a ²	61.8a	65.9a
kermes oak	32.5b	57.0a	61.4a
rock-rose sp.	13.7a	3.5a	4.5a
other browse	5.9a	1.3b	0.0b
Grasses	11.4a	5.1b	2.7b
fescue sp.	5.8a	2.1ab	1.1b
orchardgrass	2.2a	1.5b	0.5c
other grasses	3.4a	1.5b	1.1b
Forbs	21.0a	15.2ab	9.2b
vetch sp.	7.2a	4.7ab	3.2b
clover sp.	7.3a	6.2a	2.2b
medick sp.	2.8a	0.2b	1.1ab
other forbs	3.7b	4.1a	2.7c

¹May not add to 100% due to bare soil and litter.

²Means followed by the same letter within category and plant species do not differ ($P \leq 0.05$).

1987–July 1988) was 595 mm which was close to the 25-year average (630 mm).

Vegetation was dominated by kermes oak (Table 1). Other woody species present were a rock-rose species (*Cistus incanus* Rchb.), oriental hornbeam (*Carpinus orientalis* Mill.), manna ash (*Fraxinus ornus* L.), and raspberry (*Rubus idaeus* L.). The dominant grass species were a fescue species (*Festuca valesiaca* Schleich.), orchardgrass (*Dactylis glomerata* L.), and bromes (*Bromus* spp.). Clover species (*Trifolium hirtum* All., *T. arvense* L., *T. campestre* Shreber., *T. dalmaticum* Vis.), medicks (*Medicago* spp.), and vetch species (*Vicia tenuifolia* Roth. and *Vicia cracca* L.) made up the majority of forbs.

The experiment was conducted in three 1-ha pastures, with different proportions of shrubby and herbaceous cover (Table 1). Vegetation of the pastures was manipulated in 1979 through prescribed burning, seeding, and clear cutting in order to obtain various proportions of shrubby and herbaceous species. All pastures had been properly grazed by goats (1.2 ha/animal/year) over the 10 years prior to the study.

Methods

The 3 pastures were grazed by ten 2-year-old meat-type goats (28±8 kg) only during 5 consecutive days at monthly intervals from June 1987 through July 1988. The stocking rate (0.5 ha/animal/year) was heavier than that used in the previous years to insure consumption of kermes oak foliage (percent utilization ≥ 50%, Papachristou 1990). Between collection periods, the goats grazed in an adjacent pasture with similar forage.

Extrusa samples from the 3 or 4 fistulated animals were collected during a 5-day collection period for each pasture. In May during the season of rapid growth 2 samplings occurred during the first and the third week. The sampling time ranged from 30 min. to 60 min., starting at 0800 hr. Samples were frozen at -20° C, and later freeze-dried. Part of each sample was used for the determination of the botanical composition. Dietary composition was determined by the microscope point method (Harker et al. 1964). Plant species, plant parts, and unknown species were recorded at systematically located coordinates (100 points) with a 15X and occasionally 40X magnification as required. A selectivity ratio was calculated by season and pasture for the forage categories (browse, grass and forbs), for vetch species and the most important woody plants. The formula described by Taylor (1973, as mentioned by Durham and Kothmann 1977) was used:

$$\text{Selectivity ratio} = \frac{\% \text{ in diet} - \% \text{ available in pasture}}{\% \text{ in diet} + \% \text{ available in pasture}} \quad (1)$$

Forage availability (kg/ha) was determined for each pasture at the beginning of each grazing period. Standing crop was determined by clipping to ground level all biomass in 15, 1-m² randomly selected plots, since shrub height was within the grazing height of goats (<1.5 m). Available forage was stratified into total herbage, kermes oak, and other browse species. In addition, annual standing crop (twigs and leaves) of woody species was determined. Brush and herbage cover was estimated with the loop method (Cook and Stubbendieck 1986), applied on nine, 100-point permanent transects in each pasture in June 1987 before the start of the experiments and in June 1988.

The experimental design for goat diets was a split-plot in time with an incorporated completely randomized design, while for pasture cover data a completely randomized design was used. Results were evaluated by analyses of variance procedures. The protected LSD test (Steel and Torrie 1980) was used for detecting differences ($P \leq 0.05$) between treatment means. There were 3 pastures (treatments) on which repeated measurements were taken. Pastures and collection periods were considered as fixed effects and animals and measurements on transects were considered as random effects. In the split-plot design, the mean squares for animals/pastures was the error term for testing significance of the main effect, pastures. The mean squares of the residual were used as the error term for testing significance of period effects and the pasture × period interaction.

Results and Discussion

Forage Availability

Kermes oak foliage was the main component of the available forage in the 3 pastures during all test periods (Fig. 1). The highest annual production of kermes oak (2,225 kg/ha) was recorded in High Brush pasture during September. Similar results have been reported by Tsiouvaras (1988). The lowest annual production of kermes oak foliage was for Low Brush pasture during May (200 kg/ha). Browse of other woody species contributed relatively little to the forage of the 3 pastures (Fig. 1). Herbage availability was highest for Low Brush pasture and lowest for High Brush pasture for all seasons (Fig. 1). During winter there was very limited green herbage from orchardgrass and fescue species in all pastures.

Dietary Selection

The average composition of the diets of goats grazing in the 3 pastures is presented in Table 2. Browse content of diets was higher ($P \leq 0.05$) for High Brush pasture followed by Medium Brush pasture, while diet for Low Brush pasture contained the lowest proportion of browse and highest of grass and forbs. The grass and forb contents of diets were not significantly different between Medium Brush and High Brush pastures. Results from 21 studies on the diets of goats summarized by Malechek and Provenza

Table 2. Browse, grasses, and forbs of diets of goats grazing oak shrubland of varying cover.

Forage class	Pastures		
	Low Brush ¹	Medium Brush	High Brush
	----- (%) -----		
Browse	53.0c ^{2,3}	62.0b	65.6a
Grass	22.0a	15.2b	13.1b
Forbs	20.3a	17.6b	16.5b

¹Low Brush: 52% brush/32% herbage, Medium Brush: 62% brush/20% herbage and High Brush: 66% brush/12 herbage.

²Means with same letter, in the same row do not differ ($P \leq 0.05$).

³May not add to 100% due to unidentifiable species in the diet samples.

Fig. 1. Monthly pasture standing crop (kg/ha) for browse and herbaceous (grasses and forbs) plant species for 3 oak shrublands of varying cover, in Northern Greece during 1987 and 1988.

(1983) showed that diet composition averaged 60% shrubs, 30% grass, and 10% forbs. Our results indicated that selection for shrubs was approximately 60% across treatments, but we observed a heavy reliance upon forbs (>16%). These findings were mainly due to the limited abundance of grasses (Table 1). Van Soest (1982)

classified goats as intermediate browsers, a classification that is supported by our study.

Goats selected relatively high but variable amounts of kermes oak browse in the 3 pastures in all grazing periods (Table 3). Although the major proportion of the goats' diet consisted of

Table 3. Browse composition of diets of goats grazing oak shrubland of varying cover, in Northern Greece during 1987 and 1988.

Grazing periods	Kermes oak			Rock-rose			Other woody plants			Total		
	Low ¹	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
	----- (%) -----											
June	19.0	41.1	52.3	5.0	3.6	5.3	15.9	3.7	5.0	39.9a ²	48.4b	62.6c
July	39.9	45.4	61.6	3.7	4.5	4.2	5.0	4.7	1.0	48.6a	54.6a	66.8b
August	67.1	69.5	66.3	4.3	4.0	8.2	1.1	2.1	1.0	72.5a	75.6a	75.5a
September	57.4	61.6	64.2	3.2	4.5	4.2	2.5	2.6	2.0	63.1a	68.7a	70.4a
October	58.6	67.1	70.4	4.6	5.4	3.4	3.3	1.1	1.6	66.5a	73.6ab	75.4b
November	53.5	54.2	54.7	6.8	12.8	13.2	0.6	7.7	3.6	60.9a	74.5b	71.5b
December	60.5	66.2	69.3	4.5	9.3	10.8	1.3	2.0	0.2	66.3a	77.5b	80.3b
January	22.0	49.2	43.4	40.6	26.8	21.6	—	—	14.8	62.6a	76.0b	79.8b
March	40.6	44.1	26.4	17.4	11.0	16.6	—	8.0	24.6	58.0a	63.1ab	67.6b
April	24.2	42.6	60.7	10.5	6.6	1.4	5.7	10.1	3.5	40.4a	59.3b	65.6b
May	12.0	20.7	41.8	8.7	7.4	7.0	7.1	4.8	0.2	27.8a	32.9a	49.0b
May	11.8	29.8	30.1	10.2	8.3	5.8	6.8	2.9	2.7	28.8a	41.0b	38.6b
June	29.5	38.3	41.6	7.9	9.6	4.8	4.9	2.0	0.1	42.3a	49.9a	46.5a
July	51.5	57.2	59.3	8.3	8.4	6.4	4.7	1.9	0.7	64.5a	67.5a	66.4a

¹Low: 52% brush/32% herbage, Medium: 62% brush/20% herbage and High: 66% brush/12% herbage.

²Means of total browse followed by the same letter within grazing period do not differ ($P \leq 0.05$).

Table 4. Grass composition of diets of goats grazing oak shrubland of varying cover, in Northern Greece during 1987 and 1988.

Grazing periods	Orchardgrass			Fescue			Other grass			Total		
	Low ¹	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
	----- (%) -----											
June	4.4	4.0	2.0	11.5	7.5	5.1	11.7	11.0	6.6	27.6a ²	22.5a	13.7b
July	5.0	3.0	0.6	4.0	6.0	6.5	4.8	7.8	3.5	13.8a	16.8a	10.6a
August	1.2	1.1	0.6	4.6	5.8	4.0	5.9	6.0	7.5	11.7a	12.9a	12.1a
September	2.2	1.5	2.2	6.4	6.2	6.0	4.1	3.1	2.3	12.7a	10.8a	10.5a
October	3.7	1.6	0.6	8.0	7.6	6.7	4.9	4.0	4.7	16.6a	13.2a	12.0a
November	2.9	0.9	0.4	10.4	4.1	7.9	4.6	8.4	3.1	17.9a	13.4ab	11.4b
December	3.5	2.0	0.7	8.5	4.0	5.2	6.8	4.2	2.3	18.8a	10.2b	8.2b
January	8.4	0.6	—	13.2	11.0	8.6	6.8	6.0	5.8	28.4a	17.6b	14.4b
March	3.2	—	4.7	7.4	8.5	8.0	11.2	8.4	8.4	21.8a	16.9a	21.1a
April	10.0	2.0	—	9.4	2.8	0.9	23.2	4.3	3.7	40.6a	9.1b	4.6b
May	8.3	5.3	1.8	11.2	9.8	7.2	10.7	8.9	10.4	30.2a	24.0b	19.4b
May	7.7	2.8	1.5	10.6	6.2	6.2	9.6	9.2	7.8	27.9a	18.2b	15.5b
June	4.0	1.3	1.2	12.1	10.2	11.3	9.8	8.3	7.7	25.9a	19.8a	20.2a
July	1.7	1.5	1.1	6.1	6.1	4.3	5.1	4.7	4.3	12.9a	12.3a	9.7a

¹Low: 52% brush/32% herbage, Medium: 62% brush/20% herbage and High: 66% brush/12% herbage.

²Means of total grass followed by the same letter within grazing period do not differ ($P \leq .05$).

browse, there were periods when herbaceous species contributed substantially. Grasses contributed more than 10% (Table 4) to the goats' diet in all pastures and all test periods except for High Brush pasture during December and April and for Medium Brush during April. Maximum contribution of grasses (41%) was observed in Low Brush pasture during April. The proportion of forbs consumed varied considerably from April to September and the leguminous species were the dominant component of them (Table 5). These species are particularly important as forage because their crude protein content is high (Papachristou and Nastis 1990).

The goats' diets were similar for all forage classes in the 3 pastures during August and September. Generally, when the goats' diet consisted of a high proportion of herbaceous species, forbs (especially leguminosae) contributed more than grasses. During winter, when forbs were scarce, the goats' diet contained only browse and a limited amount of newly grown grasses.

Leaves of grasses, forbs and browse constituted the main component (56% to 80%) of goat diets in all pastures for all periods (Fig. 2), while stems were only a minor diet component although they were present during all periods. Only in April and both collections of May did the goats grazing in Low Brush pasture consume more herbage leaves than browse leaves (34% vs 30%, 54% vs 25%, and 47% vs 24%, respectively) and in the first part of May (45% vs 28%) in Medium Brush pasture, while in all other

grazing periods, browse leaves constituted the bulk of the diets. Fruits and flowers were present only sporadically in the goats' diet during specific periods of the study (Fig. 2).

Browse appeared to be the most important class of dietary forage almost all year around. The goats ate large amounts of kermes oak and also selected rock-rose. Selectivity ratios for kermes oak were high (-0.06) for Low Brush pasture during summer, while the lowest selectivity of kermes oak (-0.30 to -0.43) was found for all pastures during spring (Table 6), although its forage was of high quality (Nastis 1982, Tsiouvaras 1984) during this period. Rock-rose was preferred by animals grazing Medium and High Brush during all periods except summer (Table 6). Other woody species, such as raspberry, oriental hornbeam, and manna ash, were the preferred forage class during all seasons (Table 6). During winter, the bulk of other woody species consisted of the needles of *Pinus brutia* Ten., a pine species present only sporadically in Medium and High Brush pastures.

Goats selected grasses and forbs in relatively high proportion during spring (April–June), when their availability was higher. In this period, goats consumed almost equal percentages of browse and herbage species. The herbaceous species most often selected were orchardgrass, fescue species, medick, and clover species. It has been reported (Nudd 1980, Westoby 1980, Malechek and Provenza 1983) that the preference of goats is strongly influenced

Table 5. Forb composition of diets of goats grazing oak shrubland of varying cover, in Northern Greece during 1987 and 1988.

Grazing periods	Vetch species			Clover and medick			Other forbs			Total		
	Low ¹	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
	----- (%) -----											
June	4.4	3.0	1.6	11.0	7.5	7.0	11.4	12.8	9.6	26.8a ²	23.7b	18.2b
July	9.0	6.0	6.5	12.0	8.7	6.2	12.0	8.3	5.3	33.0a	23.0b	18.0b
August	3.9	2.1	4.9	2.2	2.0	0.6	8.0	4.8	4.4	14.1a	8.9a	9.9a
September	6.0	6.2	7.1	5.0	3.8	2.4	8.1	5.8	5.2	19.1a	15.8a	14.7a
October	0.1	—	0.2	—	—	—	14.2	8.4	8.6	14.3a	8.4a	8.8a
November	4.6	2.4	4.3	2.2	1.0	1.7	11.3	5.3	7.8	18.1a	8.7b	13.8ab
December	1.4	1.0	—	—	—	—	9.0	7.0	7.4	10.4a	8.0a	7.4a
January	—	—	—	—	—	—	4.3	2.4	1.0	4.3a	2.4a	1.0a
March	—	—	—	6.0	7.0	2.2	9.0	7.6	6.8	15.0a	14.6a	9.0b
April	1.5	4.7	3.7	3.8	10.6	8.3	8.4	8.7	5.8	13.7a	24.0b	17.8ab
May	2.1	3.3	2.4	15.7	11.6	10.1	17.5	19.5	13.5	35.3a	34.4a	26.0b
May	2.9	3.1	6.8	15.4	15.3	15.8	17.6	15.4	16.9	39.9ab	33.8b	35.9ab
June	2.1	1.9	3.9	12.0	10.5	11.5	13.5	11.3	12.4	27.6a	23.7a	27.6a
July	5.1	6.2	11.1	4.6	2.6	1.2	8.1	7.7	7.1	17.8a	16.5a	17.8a

¹Low: 52% brush/32% herbage, Medium: 62% brush/20% herbage and High: 66% brush/12% herbage.

²Means of total forbs followed by the same letter within grazing period do not differ ($P \leq .05$).

Fig. 2. Plant parts in the diet of goats grazing oak shrublands of varying cover, in Northern Greece during 1987 and 1988.

Table 6. Seasonal selectivity ratios¹ for most important species and classes of forage in diets selected from oak shrublands of varying cover.

Species or classes	Summer			Fall			Winter			Spring		
	Low ¹	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Browse species	-0.02	-0.17	-0.14	-0.17	-0.11	-0.15	-0.17	-0.14	-0.11	-0.27	-0.29	-0.25
kermes oak	-0.06	-0.14	-0.13	-0.08	-0.15	-0.20	-0.32	-0.27	-0.35	-0.42	-0.43	-0.30
rock-rose	-0.66	-0.46	-0.33	-0.57	-0.20	+0.29	+0.09	+0.56	+0.60	-0.13	+0.57	+0.43
other woody	+0.61	+0.87	+0.96	+0.76	+1.00 ³	+0.86	+0.33	+0.67	+1.00	+0.69	+1.00	+1.00
Herbaceous species	+0.17	+0.46	+0.52	+0.49	+0.52	+0.83	+0.50	+0.70	+0.59	+0.28	+0.49	+0.60
Grasses	+0.27	+0.55	+0.57	+0.43	+0.52	+0.79	+0.48	+0.64	+0.78	+0.51	+0.48	+0.49
Forbs	+0.37	+0.48	+0.54	+0.70	+0.65	+0.88	+0.66	+0.89	+0.82	+0.32	+0.62	+0.72
vetch	-0.19	-0.21	-0.20	-0.02	-0.01	+0.51	-0.18	— ⁴	—	-0.47	+0.10	+0.13

¹Selectivity ratios range from a maximum of +1 to a minimum of -1 indicating the selection in proportion to availability.

²Low: 52% brush/32% herbage, Medium: 62% brush/20% herbage and High: 66% brush/12% herbage.

³Species were not in clipped plots, but were identified in diets.

⁴Species were not evident in clipped plots or in diets.

by species availability. In the present experiment vetch species were not consumed in proportion to their abundance for Low Brush pasture (Table 6) in spring. On the contrary, goats selected these species (including their fruits when available) during the remaining seasons when they were dry, irrespective of relative abundance. Vetch species had positive selectivity ratios for High Brush pasture during all seasons and for Medium Brush pasture during spring (Table 6), as a result of the lack of other grass and forbs in the herbage available (Papachristou 1990).

Fruits and flowers were seasonally important for the animals' diets. These plant parts may be crucial to animal survival at times of nutritional stress (Malechek and Provenza 1983), such as late autumn. This may be true even though fruits or flowers represent a small fraction of the diets, because these parts are often high in nutrients (Schwartz and Said 1981, Everitt and Alaniz 1981, Pfister and Malechek 1986). The fruits of vetch species have been found to contain 32% crude protein in late summer and autumn (Papachristou 1990). The kermes oak acorn contained only 4% crude protein but it is considered to have high starch content.

Based on percentages of browse and herbage species in dietary composition, goats have been described as browsers (McMahan 1964; Davis et al. 1975; Wilson et al. 1975; Sidahmed et al. 1981, 1982), grazers (Knight 1965, Somlo et al. 1981), and animals that readily consume both grass and browse (Malechek and Leinweber 1972, Nge'the and Box 1976, and Bryant et al. 1979). In the present experiment, goats were seen to be rather opportunist feeders since they adapted their diet according to forage class availability (Table 6) and forage quality as well (Papachristou 1990).

Management Implications

It is well established that dense shrublands provide limited amounts of usable forage because they are difficult to penetrate. Thus, sparse shrublands are preferred for grazing. On the other hand, absence of the shrub component in the semiarid regions results in poor forage quality, when the herbaceous species are mature. Our findings suggest that the reduction of the shrubby component to 53% cover resulted in a higher consumption of herbaceous species, which constituted 49% of the diet. The overall result was an average increase in forage quality all year around.

We are in the process of investigating economically and ecologically acceptable ways of reducing shrub cover. Also, we intend to determine the minimum shrub cover so as to maintain relatively high forage quality, and how various classes of grazing animals can be used as a tool for maintaining the desired composition.

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