International Scholars Journals

African Journal of Agronomy ISSN 2375-1177 Vol. 8 (10), pp. 001-009, October, 2020. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Shrub yield and forage quality in Mediterranean shrublands of West Turkey for a period of one year

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Accepted 22 July, 2020

Shrublands are important habitats for ruminants in the Mediterranean area. The purpose of this study was to evaluate the shrub yield, quality (between November 2006- November 2007) and preferences of goats for the six shrubs (*Quercus coccifera* L., *Phillyrea latifolia* L., *Juniperus oxycedrus, Cistus creticus* L., *Sarcopoterium spinosum* (L.) Spach and *Thymus longicaulis* C. Presl.) of Mediterranean shrublands in Turkey. In the shrubland the highest yield was obtained from kermes oak and prickly juniper. Yield in May was higher than that of in October. Dry matter (DM), Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were low and Crude protein (CP), Dry matter digestibility (DMD), ME, P, and Ca were high during the spring in the kermes oak, thyme and mock privet. Reverse situation was observed during the summer and winter months. Changes in the prickly juniper, pink rockrose and prickly burnet were not stable. When production and nutritive values of the shrubs were considered, goats showed deficiency in CP and ME throughout the year except in the spring. P and Ca were found sufficient. As a conclusion, in Mediterranean shrublands, goats should be fed with supplementary energy feed throughout the year except for spring months, and with CP during summer months in order to obtain satisfactory productivity.

Key words: Mediterranean shrublands, shrub yield, forage quality, evergreen shrubs.

INTRODUCTION

Areas in which Mediterranean climate is experienced cover approximately 100 million ha (Le Houerou, 1981). 30 million ha of these are in the countries that have a shoreline to Mediterranean Sea. Plant vegetation formed under the effect of Mediterranean climate is about 7.5 million ha. These shrublands are classified as maquis, garrigues and phrygana according to Papanastasis (2000). Evergreen and 1.3 m tall kermes oak (*Quercus coccifera* L.), mock privet (*Phillyrea latifolia* L.) and prickly juniper (*Juniperus oxycedrus*) are in the maquis group, while evergreen shorter than 1 m pink rockrose (*Cistus creticus* L.), prickly burnet (*Sarcopoterium spinosum* (L.) Spach) and thyme (*Thymus longicaulis* C.Presl.) are placed in the phrygana group. These shrubby areas are considered as natural grazing lands especially for goats all year round (Papachristou et al., 1999; Rogosic, 2000) and are essential for goat husbandry. Grazing studies done in the shrublands of Mediterranean region showed that shrubs take up more than 60% of goat feed (Perevolotsky et al., 1998). For example, kermes oak is valuable land resource in Turkey (Tolunay et al., 2009) and Greece (Vrahnakis et al., 2005). Despite its low commercial value in terms of wood production, it is an important feeding resource for domestic and wild animals.

During winter or summer in which herbaceous species stop growing due to unfavorable weather conditions, woody species could decrease feed shortage or even fill in the gaps in feed supply. High nutritional values are maintained by shrubs even in unfavourable climate conditions, therefore, their incorporating in livestock feeding should be normally accomplished (Foroughbackhch et al., 2007). Feed production and nutrition values of shrubs change greatly depending on the species, variety and maturity stage (Mountousis et al., 2008). Generally these species, that change by the season, with progressive growth, contain low crude protein and high fiber and ash contents (Mountousis et al., 2008; Atasoglu et al., 2010). They have high fiber and

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ash contents and low crude protein, especially in summer (Atasoglu et al., 2010). The objective of this study was, therefore, to determine the yield of evergreen shrubs, changes in their nutritive value, nutritional aspects of the common shrubs and to show the period of feed deficiency in the maquis vegetations.

MATERIALS AND METHODS

Study area

The study was conducted in Çanakkale, located in Northwest part of Turkey. Çanakkale has a typical Mediterranean climate. The mean annual precipitation is 615.5 mm, with the primary precipitation falling in winter and spring. The rainy season typically begins in October and ends in May, while summers are dry and hot. The mean annual temperature is 15°C.

Shrubland soil was sandy loam, calcareous ($CaCO_3$1.26%), neutral (pH 7.27), contained medium organic matter (2.44%) with no salinity (EC 0.39 dS m^{-1}) and sufficient phosphorous content (13.42 mg kg^{-1}). It is covered by 47.26% shrubs, consist of 28.90% kermes oak (*Q. coccifera* L.), 13% prickly juniper (*J. oxycedrus*), 4.32% thyme (*T. longicaulis* C.Presl.), 0.94% mock privet (*P. latifolia* L.), 0.05% pink rockrose (*Cistus creticus* L.) and prickly burnet (*S. spinosum* (L.) Spach) (Özaslan-Parlak et. al., 2011). They all are evergreen, making their twigs and leaves available year-round.

Vegetation measurements

This shrubland was previously heavily grazed by goats. Two different areas in the shrubland were surrounded with 50 x 20 m fences to prevent grazing. Sampling was carried out every mid-month between November 2006 and November 2007 on the same individual plants (a total of ten) of each species labeled with metal tags.

In order to find out dry matter (DM) productivity of shrubs, the number of main and lateral branch on a plant and fresh twigs facing outward on a lateral shoot with average length were counted in the ten randomly selected plants. Then, ten twigs with leaves were removed and placed in paper bags. These were first dried in air and then in an oven at 60°C (Cook and Stubbendieck, 1986). Average grazable twig weight was calculated. Grazable DM content of shrubs were found by using the formula:

GDM = NMB x NSB x NGT x TW

GDM : Grazable DM weight, NMB : Number of main branch, NSB : Number of secondary branch, NGT : Number of grazable twig, TW : Twig weight

No samples were taken from the mock privet for yield determination, because it had been heavily grazed before the experiment was started. Only samples for chemical analyses were obtained.

Representatives plucked browse (leaves and twigs of up to 2 mm diameter) (Cook, 1964) similar to those consumed by animals, which were collected for the assessment of their nutritive value. Samples were died at 60°C for 48 h, and then ground in a mill to pass through 1 mm screen prior to analyses. All analyses were carried out on duplicate samples and results were reported on DM basis. The DM content was determined by oven drying at 105°C for 24 h and ash was determined by ashing samples in a muffle furnace at 600°C for 16 h (AOAC, 1990). Nitrogen content was measured by the Kjeldahl method (AOAC, 1990). Crude protein (CP) was calculated as N x 6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were measured using the procedure described by Van Soest et al. (1991). As Weiss (1994) suggested, accurate data on digestibility of forages would greatly assist diet formulation and economic valuation of different collection period. Although the value of accurate digestibility data is unequivocal, obtaining actual data is time consuming, expensive, and requires large amounts of the forage samples that was not feasible in this study. Dry matter digestibility (DMD) was estimated using the formula developed by Oddy et al. (1983): DMD% = 83.58-0.824 ADF%+2.626 N%.

Dry matter digestibility values were used to estimate digestible energy (DE, kcal kg^{-1}) using the regression equation reported by Fonnesbeck et al. (1984): DE (Mcal kg^{-1}) = 0.27+0.0428 (DMD%). Then DE values were converted to ME using the formula reported by Khalil et al. (1986): ME (Mcal kg^{-1}) = 0.821 x DE (Mcal kg^{-1}).

P and Ca elements were determined using ICP-OES (Inductively coupled plasma-optical emission spectrometry) method (Kacar and Inal, 2008).

Statistical analysis

All data were subjected to analysis of variance (ANOVA) based on general linear models for repeated measurements. A SPSS statistical package was used for all statistical calculations. Means were separated using the comparisons based upon the least significant difference (LSD) (level of significance $P<0.05$).

RESULTS AND DISCUSSION

Forage production and nutritional composition

Yields of the shrub species were significantly different from each other. Highest yields were obtained from prickly juniper (68.2 g m^{-2}), followed by kermes oak (50.9 g m^{-2}). Thyme, pink rockrose, and prickly burnet were the lowest yielding species. Prickly juniper and kermes oak had the highest yield in May while prickly burnet and pink rockrose provided lower yields. In all the shrub species, dry forage yield was higher at the end of the growth period in spring than in the fall when the plants stopped their growth (Table 1).

Nutritional compositions of the shrubs (DM, ash, CP, NDF, ADF, ADL, DMD, ME, Ca, and P) studied changed significantly depending on the months (Tables 2 to 4).

Dry matter ratio, NDF, ADF, and ADL of the kermes oak decreased in April at a significant level and increased in the other months. CP, DMD and ME distinctly increased in April, generally being lower in the summer and winter months. P ratio of the plant reached a peak during first sprouting (April) decreasing later in the following months. Calcium, on the contrary, were lowest in April and May, being the highest earlier in time (Table 2).

In the prickly juniper , the least DM was in May and June, and it was over 50% in the rest of the year. Ash content was the highest in February (60.0 g kg^{-1}), and the lowest in August (37.7 g kg^{-1}). High protein content was only obtained in the spring. Highest crude protein content

Table 1. Dry matter yield of shrubs in the Mediterranean shrubland (g m^{-2}).

Species	October, 2006	May, 2007
Quercus coccifera L.	50.9 b*	77.2 a
Juniperus oxycedrus L.	68.2 a	74.5 a
Thymus longicaulis C. Presl.	5.1 c	28.6 b
Cistus creticus L.	1.5 c	3.2 c
Sarcopoterium spinosum L.	0.1 c	0.2 c
Total	125.8	183.66
Significance	0.000	0.000

* Different lettering in a column indicates differences in the means at p= 5% significance level.

(105.4 g kg^{-1}) was attained in May. On the other hand, it decreased more than half reaching to 31.5-43.6 g kg^{-1} between September and February. NDF showed a generally stable decrease from November 2006 (560.9 g kg^{-1}) to March 2007 (413.0 g kg^{-1}). Increase in April, and generally stayed in a close range until the end of the sampling times. Similar situation was observed for ADF and ADL. DMD and ME were most prominent in March (57.44% and 2.24 Mcal g^{-1}, respectively) than in the other months. Highest P content (1.240 mg kg^{-1}) in the prickly juniper was achieved at the beginning of the summer (June), and it was the lowest during fall and winter months. A reverse situation was observed for Ca (Table 2).

Lowest DM in the thyme plants was found in April (335.7 g kg^{-1}), reaching more than 900.0 g kg^{-1} in September. Total ash content increased in the spring and were considerably higher in April (91.8 g kg^{-1}) and in May (88.1 g kg^{-1}). On the other hand, the lowest ash content (60.9 g kg^{-1}) was received in February. Crude protein ratio was high in April (69.6 g kg^{-1}), in May (64.1 g kg^{-1}), and in June (73.3 g kg^{-1}). Thyme, generally containing more fibrous compounds than the other shrub species, had the lowest NDF in May (544.8 g kg^{-1}), and significantly higher contents in the fall and winter. Changes in ADF and ADL were generally similar to the change in NDF. Most prominent DMD (46.92 %) and ME (1.87 Mcal g^{-1}) were obtained in May. Phosphorus content in this plant also started to increase in April, being at the lowest level in the fall and winter months. Calcium increased in April and reached to maximum in the summer (Table 3).

In the mock privet, lowest contents of DM, NDF, ADF, and Ca and highest contents of CP, DMD, ME, and P were obtained in May. Ash content was most elevated in December, and atypical in the other months (Table 3).

Dry matter of pink rockrose plants decreased between February and May, and increased in the other months. Ash content was 80.5 g kg^{-1} (highest) in January, and significantly decreased to 52.5 and 55.3 g kg^{-1} in August and September, respectively. CP was especially high in April, May and June (95.3, 104.5, and 98.6 g kg^{-1}, respec-tively). It was within the range of 58.3-81.8 g kg^{-1} in the other months. NDF and ADF were the lowest in January, and the highest in July. DMD and ME followed an inverse pattern. Changes in ADL were not stable. P and Ca started to increase in February and April, respectively. These elements were generally low during the summer, fall and winter months (Table 4).

Dry matter increased highly in the prickly burnet between July and November, dropping to minimum level in April (530.5 g kg^{-1}). Highest ash content was received in December, 2006 (72.0 g kg^{-1}) and in November, 2007 (71.2 g kg^{-1}), while it was at the lowest level in January (38.0 g kg^{-1}) and in September (42.1 g kg^{-1}). CP rose to 77.5 g kg^{-1} in June and fell significantly in the other months. NDF diminished a little between March and May (582.3-595.1 g kg^{-1}) and increased in the other times (612.0-706.6 g kg^{-1}). ADF was low between April-August, but it was significantly high especially between November, 2006 and January, 2007 (570.6-595.7 g kg^{-1}). ADL stayed high between November 2006 and February 2007 and showed no significant changes at the other sampling times. Digestibility and ME were high in the April-September period. Phosphorus was most prominent in April, while Ca was high between March and May (Table 4).

Starting growth in the spring after winter dormancy plants continue their fast growth. They also increase the organic mass. Depending on the species, this fast growth slows down with the summer drought. Therefore, the dry matter yield of the shrubs in this study was significantly higher after the fast growth in the spring compared to that at fall. Shinde et al. (2000) determined the changes in the feed quantity depending on the season and plant growth, reported that supplementation of shrub forage to the grassland forage was 3.81, 1.64, and 9.98% during monsoon, winter and summer, respectively.

DM was the lowest in April in the shrubs of Kermes oak, thyme, pink rockrose , and prickly burnet, and in May in the prickly juniper and mock privet. Shoots started to develop in March in the former shrubs and in April in the latter shrubs. Protoplasm contains more water because cell wall is not completely formed in these types of physiologically active tissues. Furthermore, there is tight relationship between physiological activities of plants

Table 2. Nutritional composition of *Quercus coccifera* L and *Juniperus oxycedrus* L. in the Mediterranean shrubland (mean, DM basis).

Month	DM ($g\ kg^{-1}$)	Ash ($g\ kg^{-1}$)	CP ($g\ kg^{-1}$)	NDF ($g\ kg^{-1}$)	ADF ($g\ kg^{-1}$)	ADL ($g\ kg^{-1}$)	DMD (%)	ME ($Mcal\ g^{-1}$)	Ca ($g\ kg^{-1}$)	P ($g\ kg^{-1}$)
					***Quercus coccifera* L**					
November	554.6 b*	32.4 e	80.2 bc	613.7 ab	482.4 ab	237.1 ab	47.2 bc	1.88 bc	12.660 a	1.486 c
December	566.2 ab	34.9 e	75.4 bc	649.2 a	523.7 a	255.6 a	43.6 c	1.75 c	11.034 abc	1.456 c
January	588.7 a	48.9 abc	69.0 bc	617.7 ab	486.5 a	195.1 b	46.4 bc	1.85 bc	11.890 ab	1.550 c
February	590.9 a	47.1 bcd	78.1 bc	591.1 ab	463.2 ab	204.0 ab	48.7 bc	1.93 bc	11.374 abc	1.523 c
March	593.5 a	51.1 ab	88.3 b	613.9 ab	478.4 ab	194.4 b	47.9 bc	1.90 bc	11.216 abc	1.440 c
April	313.0 e	53.1 a	136.2 a	297.9 c	224.9 c	101.6 c	70.7 a	2.71 a	6.690 e	3.744 a
May	437.2 d	51.5 ab	82.9 bc	571.5 b	459.9 ab	195.1 b	49.2 bc	1.95 bc	5.850 e	1.890 b
June	513.6 c	34.9 e	72.5 bc	582.9 b	427.5 ab	196.3 b	51.4 b	2.03 b	9.578 cd	1.566 c
July	492.5 c	36.8 e	56.3 c	553.6 b	439.3 ab	190.8 b	49.7 bc	1.97 bc	6.328 e	1.557 c
August	566.5 ab	51.2 ab	64.9 bc	596.1 ab	450.3 ab	196.7 b	49.2 bc	1.95 bc	8.880 d	1.378 c
September	591.5 a	44.9 cd	63.1 bc	575.5 b	450.0 bc	185.5 b	49.1 bc	1.95 bc	9.691 cd	1.375 c
October	578.4 ab	42.4 d	61.0 c	562.9 b	447.3 ab	188.0 b	49.3 bc	1.95 bc	10.064 cd	1.401 c
November	570.7 ab	49.3 abc	72.7 bc	608.1 ab	470.4 ab	195.2 b	47.9 bc	1.90 bc	9.623 cd	1.551 c
Mean	496.6	44.5	76.9	571.9	438.2	195.0	50.0	1.98	9.606	1.685
					***Juniperus oxycedrus* L.**					
November	560.4 bc	51.8 abc	42.6 cd	560.9 a	428.5 ab	219.5 ab	50.03 d	1.98 cd	11.933 abc	1.027 cd
December	545.9 c	50.4 abc	43.0 cd	539.9 ab	439.9 a	234.9 a	49.13 d	1.95 d	11.666 bc	1.034 cd
January	561.0 bc	59.4 ab	43.6 cd	525.7 abc	439.4 a	203.7 bcd	49.20 d	1.95 d	12.139 abc	1.002 d
February	592.1 a	60.0 a	38.5 cd	512.6 bcd	426.0 ab	205.8 bcd	50.09 cd	1.98 cd	13.073 ab	1.066 bcd
March	579.4 ab	51.3 abc	57.1 bc	413.0 e	346.2 c	171.1 e	57.44 a	2.24 a	12.002 abc	1.088 bcd
April	507.0 de	50.9 abc	63.9 b	487.7 d	381.3 bc	206.7 abc	54.84 ab	2.15 ab	12.572 ab	1.152 abc
May	478.9 ef	52.8 abc	105.4 a	480.6 d	405.8 ab	189.3 cde	54.56 abc	2.14 abc	12.249 abc	1.114 bcd
June	452.8 f	49.5 bc	57.8 bc	505.3 bcd	428.3 ab	168.9 e	50.71 bcd	2.00 bcd	9.877 de	1.240 a
July	560.8 bc	45.2 cd	55.3 bc	510.9 bcd	444.2 a	185.8 cde	49.30 d	1.95 d	9.770 de	1.193 ab
August	583.6 ab	37.7 d	50.2 bcd	511.6 bcd	421.1 ab	189.7 cde	50.99 bcd	2.01 bcd	8.710 e	1.084 bcd
September	595.3 a	43.9 cd	42.2 cd	484.1 d	422.1 ab	196.7 b-e	50.57 bcd	2.00 bcd	13.412 a	1.067 bcd
October	559.0 bc	45.8 cd	38.0 cd	491.3 cd	407.3 ab	177.4 de	51.61 bcd	2.04 bcd	10.869 cd	1.073 bcd
November	537.2 cd	47.4 cd	31.5 d	482.0 d	414.5 ab	189.5 cde	50.75 bcd	2.00 bcd	10.853 cd	1.066 bcd
Mean	54.71	49.7	51.5	500.4	415.7	195.3	51.47	2.03	11.471	1.092

*Different lettering in a column indicates differences in the means at p= 5% significance level. DM, Dry matter; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; ADL, acid detergent lignin; DMD, dry matter digestibility; ME, Metabolizable energy.

Table 3. Nutritional composition of *Thymus longicaulis* C.Presl. and *Phillyrea latifolia* L. in the Mediterranean shrubland (mean, DM basis).

Month	DM (g kg^{-1})	Ash (g kg^{-1})	CP (g kg^{-1})	NDF (g kg^{-1})	ADF (g kg^{-1})	ADL (g kg^{-1})	DMD (%)	ME (Mcal g^{-1})	Ca (g kg^{-1})	P (g kg^{-1})
					***Thymus longicaulis* C.Presl.**					
November	570.2 bcd	63.9 bc	46.8 cd	702.7 abc	504.6 cd	250.3 abc	43.96 ab	1.77 ab	15.426 ef	1.366 bcd
December	534.6 cde	64.8 bc	42.3 cd	742.9 a	627.0 a	275.6 a	33.69 d	1.40 d	14.254 fg	1.377 bcd
January	584.0 bcd	63.2 bc	44.6 cd	676.0 b-e	571.2 abc	237.8 bcd	38.38 bcd	1.57 bcd	13.009 g	1.500 b
February	492.0 cde	60.9 c	49.6 cd	645.6 def	547.7 bcd	229.6 cd	40.53 bc	1.65 bc	16.140 de	1.394 bc
March	537.2 cde	64.6 bc	53.6 bc	670.8 b-f	570.0 abc	251.6 abc	38.86 bcd	1.59 bcd	16.213 de	1.436 bc
April	335.7 e	91.8 a	69.6 a	623.8 f	518.4 bcd	226.7 cde	43.79 ab	1.76 ab	19.792 abc	1.722 a
May	413.1 de	88.1 a	64.1 ab	544.8 g	477.5 d	194.5 f	46.92 a	1.87 a	19.555 bc	1.423 bc
June	450.2 de	73.0 bc	73.3 a	636.1 ef	530.1 bcd	198.5 ef	42.97 abc	1.73 abc	19.620 bc	1.507 b
July	575.9 bcd	74.7 b	47.5 cd	664.5 c-f	562.4 abc	217.7 def	39.23 bcd	1.60 bcd	19.795 abc	1.323 bcd
August	761.6 ab	70.8 bc	37.8 d	570.5 g	501.0 cd	200.6 ef	43.88 ab	1.76 ab	21.534 a	1.290 cd
September	924.9 a	67.9 bc	38.1 d	691.3 bcd	553.8 bc	247.6 abc	39.54 bcd	1.61 bcd	18.122 cd	1.300 cd
October	675.5 bc	68.0 bc	44.4 cd	696.1 abc	564.1 abc	252.3 abc	38.96 bcd	1.59 bcd	16.761 de	1.202 d
November	584.4 bcd	71.8 bc	48.7 cd	712.2 ab	586.5 ab	261.1 ab	37.29 cd	1.53 cd	18.058 cd	1.327 bcd
Mean	572.2	71.0	50.8	659.8	547.2	234.1	40.61	1.65	17.559	1.397
					***Phillyrea latifolia* L.**					
November	565.4 f	38.1 b	62.6 cde	583.6 bc	441.7 bc	210.8 a	49.80 c	1.97 cd	8.222 ef	0.970 c
December	580.5 def	47.1 a	48.5 f	660.5 a	497.4 a	205.3 ab	44.63 d	1.79 e	9.336 de	0.997 c
January	572.8 ef	41.8 ab	69.8 bcd	595.0 abc	443.7 bc	191.9 a-d	49.95 c	1.98 cd	9.961 cd	1.218 b
February	562.5 f	43.1 ab	69.5 bcd	606.6 ab	452.6 ab	204.5 ab	49.20 c	1.95 d	9.329 de	1.007 c
March	592.6 cde	41.2 ab	64.4 b-e	605.4 ab	449.1 ab	174.8 d	49.27 c	1.95 d	9.221 de	1.039 c
April	485.5 g	40.5 ab	74.1 bc	545.6 b-e	406.1 bcd	202.0 abc	53.23 abc	2.09 abcd	8.674 de	1.372 ab
May	426.0 h	40.3 ab	96.6 a	461.1 f	370.7 d	185.3 a-d	57.09 a	2.23 a	6.117 g	1.443 a
June	495.7 cd	38.7 b	76.1 b	536.3 cde	419.5 bcd	196.9 a-d	52.21 bc	2.06 bcd	6.847 fg	1.241 b
July	594.8 cde	41.6 ab	60.0 def	547.6 b-e	416.9bcd	183.0 bcd	51.75 bc	2.04 bcd	7.831 ef	1.284 b
August	634.9 ab	40.6 ab	60.0 def	508.0 def	381.8 d	175.9 cd	54.64 ab	2.14 ab	10.244 bcd	1.353 ab
September	650.8 a	39.3 ab	55.6 ef	481.1 ef	369.6 d	186.7 a-d	55.45 ab	2.17 ab	11.644 ab	1.283 b
October	614.2 bc	40.9 ab	53.5 ef	511.0 def	392.8 cd	206.9 ab	53.45 abc	2.10 abc	12.061 abc	1.290 ab
November	558.9 f	38.7 b	60.4 def	559.5 bcd	437.1 bc	197.4 a-d	50.10 c	1.98 cd	11.001 a	1.444 a
Mean	564.2	47.5	65.5	553.9	421.5	193.9	51.59	2.03	9.268	1.226

* Different lettering in a column indicates differences in the means at p= 5% significance level.

Table 4. Nutritional composition of *Cistus creticus* L and *Sarcopoterium spinosum* in the Mediterranean shrubland (L.) Spach (mean, DM basis).

Month	DM (g kg^{-1})	Ash (g kg^{-1})	CP (g kg^{-1})	NDF (g kg^{-1})	ADF (g kg^{-1})	ADL (g kg^{-1})	DMD (%)	ME (Mcalg^{-1})	Ca (g kg^{-1})	P (g kg^{-1})
***Cistus creticus* L**										
November	393.8 d	55.2 e	66.1 cd	546.8 ab	435.7 ab	216.6 a	50.45 bc	1.99 bc	11.274 f	1.710 d
December	408.2 d	64.5 b-e	66.4 cd	516.5 abc	426.1 abc	155.3 abc	51.26 abc	2.02 bc	13.150 de	1.766 d
January	478.6 c	80.5 a	74.1 c	407.9 c	325.7 c	136.7 bc	59.85 a	2.33 a	13.348 cde	2.176 bc
February	378.6 de	61.2 cde	74.8 c	429.3 bc	343.5 bc	133.2 bc	58.41 ab	2.27 ab	14.426 c	2.423 ab
March	366.4 de	76.5 ab	74.5 c	517.1 abc	437.2 ab	190.6 ab	50.68 bc	2.00 bc	14.500 c	2.180 bc
April	289.6 f	72.2 abc	95.3 ab	525.9 abc	416.6 abc	161.7 abc	53.25 abc	2.09 abc	17.256 a	2.590 a
May	337.3 e	67.8 bcd	104.5a	488.1 abc	389.0 abc	124.3 c	55.91 abc	2.19 abc	15.885 b	2.314 bc
June	403.6 d	72.8 abc	98.6 a	487.6 abc	381.4 abc	123.6 c	56.29 abc	2.20 abc	16.402 ab	2.297 bc
July	568.4 b	58.1 de	73.2 cd	561.3 a	452.0 a	163.7 abc	49.41 c	1.96 c	12.975 de	2.088 c
August	612.5 a	52.5 e	79.3 c	514.7 abc	340.2 bc	132.3 bc	58.87 ab	2.29 ab	12.217 ef	2.149 c
September	618.9 a	55.3 e	58.3 d	504.6 abc	421.1 abc	133.7 bc	51.33 abc	2.03 abc	12.221 ef	2.255 bc
October	545.7 b	61.6 cde	70.3 cd	495.2 abc	403.7 abc	128.0 bc	53.27 abc	2.09 abc	12.662 de	2.117 c
November	384.9 d	62.2 cde	81.8 bc	478.9 abc	387.7 abc	172.9 abc	55.07 abc	2.16 abc	13.781 cd	2.335 bc
Mean	445.1	64.6	78.2	497.9	396.9	151.7	54.15	2.12	13.85	2.184
***Sarcopoterium spinosum* (L.) Spach**										
November	677.7 b	64.0 abc	39.9 d	700.7 a	573.1 ab	204.2 abc	38.02 de	1.56 de	11.934 cde	1.194 a-d
December	650.6 bc	72.0 a	45.6 cd	676.6 ab	570.6 ab	195.2 bc	38.47 de	1.57 de	10.951 de	1.115 d
January	673.2 b	38.0 g	38.5 d	706.6 a	595.7 a	243.2 a	36.11 e	1.49 e	10.510 e	1.186 a-d
February	672.4 b	46.5 efg	47.6 bcd	641.9 ab	540.0 abc	220.3 ab	41.07 cde	1.66 cde	12.251 bcd	1.175 bcd
March	597.4 cd	58.0 bcd	50.3 bcd	595.1 b	486.0 cde	170.7 cd	45.64 abc	1.83 abc	12.896 abc	1.317 abc
April	530.5 e	57.5 cde	59.4 b	591.6 b	462.1 de	170.7 cd	47.99 a	1.91 a	13.670 ab	1.328 a
May	547.5 de	48.9 defg	56.1 bc	582.3 b	469.7 de	163.9 cd	47.23 ab	1.88 ab	14.392 a	1.242 a-d
June	629.9 bc	46.8 efg	77.5 a	643.8 ab	480.2 cde	165.6 cd	47.27 ab	1.88 ab	13.885 ab	1.208 a-d
July	768.1 a	48.4 defg	49.2 bcd	616.5 ab	445.8 e	171.2 cd	48.91 a	1.94 a	12.388 bcd	1.230 a-d
August	817.2 a	50.6 def	48.1 bcd	612.0 ab	451.5 e	147.2 d	48.39 a	1.92 a	12.704 bc	1.167 cd
September	789.6 a	42.1 fg	36.9 d	647.2 ab	491.6 cde	173.0 cd	44.62 abc	1.79 abc	10.811 de	1.223 a-d
October	784.6 a	68.7 ab	43.8 cd	650.5 ab	486.8 cde	174.2 cd	45.30 abc	1.81 abc	11.478 cde	1.155 d
November	611.3 c	71.2 a	38.0 d	634.2 ab	519.8 bcd	194.6 bc	42.33 bcd	1.71 bcd	10.257 e	1.320 ab
Mean	673.0	54.8	48.5	638.3	505.6	184.1	43.95	1.76	12.160	1.220

* Different lettering in a column indicates differences in the means at p= 5% significance level.

and water content. A significant relationship exists between DM ratio and growth season for that reason(Mountousis et al., 2008) and as the plant matures DM ratio also increases (Bakoğlu et al., 1999; Khorchani et al., 2000). Although no com-pareson was made between the species, prickly burnet has the highest dry matter content due to having very small leaves and thorny shoots, which prevent the grazing.

Kermes oak, prickly juniper, thyme, and pink rockrose had their ash contents high in the spring and low in the summer. These plants grow fast in the spring, causing them to absorb the mineral elements more intensively. On the other hand, Frost et al. (2008) reported that ash values declined for all species as the season progressed. Tolunay et al. (2009) and Haddi et al. (2003) recorded that ash content increased significantly with maturation in kermes oak and halophyte shrubs, respectively. Gonzalez-Andres and Ceresuela (1998) also reported that *Hippocrepis balearica* shrubs had ash content high in the spring and low in the summer.

Protein content was significantly high in the spring for all the plants. It decreased in the summer and winter. It ranged between 47.0 and 78.2 g kg^{-1}. Protein synthesis is stimulated as the plants starts to grow in the spring. Number of young cells increase and the physiological events are induced (Kacar et al., 2006). These events are the results of enzyme activities derived from proteins. Young cells also have high ratio of protoplasm. Most of the proteins in a cell are located in the protoplasm. In general, woody species have low contents of CP and are high in fiber and ash. These nutrients vary greatly according to season, with a higher concentration of fiber and ash and a lower content of CP during summer (Papanastasis et al., 2008). Gonzalez-Andres and Ceresuela (1998), Papachristou (1997) and Papachristou et al. (2005) stated in their studies about shrubs that protein increased in the spring and decreased considerably during summer. Rogosic et al. (2006) reported that protein contents in the Mediterranean maquis changed between 4.9 to 7.8%.

Contents of NDF, ADF, and ADL in the prickly juniper and pink rockrose did not show a stable change, and they were at the lowest level between April and May during which shrubs generally grow fast. Fibrous compounds are found in the cell wall. Cell wall components are more abundant in the older cells than the younger ones (Lyons et al., 1999). Cell wall development is related to plant development and as the plant matures wall compounds, such as NDF and ADF, increases and protoplasm compounds like crude protein decreases (Haddi et al., 2003; Parissi et al., 2005). In addition, stem/ratio increases more than leaf/ratio over time with plant development (Frost et al., 2008). Results in fibrous compounds like NDF, ADF, and ADL are lower at the beginning of plant development and higher as the development progresses. For instance, oaks have high significant contents of ADF and NDF and low CP contents as they mature (Papachristou et al., 2005). In a study carried out in Spain with 6 shrubs species (Gonzalez-Andres and Ceresuela, 1998), NDF and ADF indicated a decrease in the early spring and a fast increase in the late spring, summer and fall, and ADL did not present a stable variation.

Thyme and prickly burnet had higher levels of NDF, ADF, and ADL. These species have small leaves. These characteristics cause lower leaf to stem ratio in the plant, making the plant to have higher stem ratio, therefore higher compounds. Stems contain more cellulose compounds (Buxton, 1990; Claessens et al., 2005).

DMD and ME were the highest in April in the kermes oak, in March in the prickly juniper and in May in the thyme and mock privet. An irregular variation wasobserved in the pink rockrose and prickly burnet. The lowest DMD and ME were obtained during winter in all the shrubs except for the pink rockrose. DMD and ME contents of grazable plant material is related inversely to cell wall compounds, and linearly to CP and ash ratios (Mountousis et al., 2008). Therefore browse had low DMD and ME, both generally associated with thick cell walls (Cutler et al., 1977), highly lignified NDF, and low level of protein. Prickly juniper had the youngest tissues due to its early growth following March, while mock privet had the highest digestibility in May because it was the latest growing species. Digestibility was low during winter in all the species other than pink rockrose. Maturation was complete during winter months and young shoots were lignified, leading to low digestibility. Papachristou et al. (2005) stated that digestibility of kermes oak was the highest in May.

P contents of the shrubs increased significantly in spring. This was the result of plants starting to grow and their physiological activities being at maximum levels. P is the core element of energy systems (ATP) and nucleic acids (DNA and RNA) (Kacar et al., 2006). These compounds enhance physiological events. At the beginning of plant growth during which cells divide and elongate rapidly P content increased. Ca involves in the structure of harder tissues (cell walls) (Spears, 1994). High cell protoplasm compounds and low cell wall components at the beginning of growth caused low Ca content in the young shoots of the shrub during April and May. Rogosic et al. (2006) determined that in the 6 shrubs in the Mediterranean, Ca changed between 0.4-2.04%, and P ranged from 0.07 to 0.10%.

Subjects in the research were interpreted on the basis of the requirement for maintenance of goats that benefit from shrubby areas. The intake of a goat with 50 kg average weight should be minimum of 75 g CP (NRC 2007), 2.25 Mcal ME (NRC 2007), 0.96 g P (Pfeffer, 1989), and 2.13 g Ca (Meschy, 2000). After a calculation using this information, there is a CP deficiency in the kermes oak in January and between July and October; in the prickly juniper, all the time except for May; thyme and mock privet, in all the seasons other than spring; September, October and December for pink rockrose, and all months for other prickly burnet except June. Inadequate ME was observed in kermes oak in all the months except April; in the prickly juniper in all the seasons other than spring; in the whole year in thyme and prickly burnet; between November and March in mock privet, and in November and July in the pink rockrose. No P and Ca deficiency was observed in the shrubs.

Conclusion

Highest yielding shrubs in the shrubland were kermes oak and prickly juniper. Yields in May were higher than those in October. In the shrubs of kermes oak, thyme and mock privet DM, NDF, ADF , and ADL were low, and CP, DMD, ME, P, and Ca were high in April and May. Changes in these chemical properties were not stable in the prickly juniper, pink rockrose and prickly burnet. When production and nutrition value of these shrubs were considered, they did not provide goat's demand for HP and ME in the months other than spring. Phosphorus and Ca were sufficient throughout the year. Consequently, goats should be fed with supplementary energy feed with CP in the Mediterranean shrub lands.

ACKNOWLEDGEMENT

This paper contains some results of a research project (106O458) financed by the TUBITAK.

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