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FODDER VALUES OF SHRUB SPECIES IN MAQUIS IN DIFFERENT ALTITUDES AND SLOPE ASPECTS

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ABSTRACT

The study was conducted to determine the nutritional value of the shrub species in the district of Erdemli-near the Taurus Mountains in Turkey during the period of April 2005 to April 2007. The samples were collected from three different altitudes (0-400 m, 400-800 m and over 800 m) and two geographical sides (north and south). In the study, CP (Crude Protein), NDF (Neutral Detergent Fibre) ve ADF (Acid Detergent Fibre) contents of the species were evaluated. The CP content in leaves of the shrub species ranged from 8.13% to 21.58%. NDF ratios were 27.38% to 52.62% and ADF ratios were 12.08% to 37.21%. The highest CP content (11, 98%) among altitudes was detected at 0-400 meters, and the highest NDF (43.98%) and ADF (30.07%) values were measured at 400-800 m elevation. Both CP (11.95%) and ADF (29, 95%) ratios in the northern slopes found to be higher than those in the southern slopes. However, we did not find statistically significant differences in NDF values of slope aspects.

Key words: CP, NDF, ADF, shrub species, altitude, slope aspect

INTRODUCTION

Besides conventional food sources (grass-pasture, fodder crops and farm residues), there are also important feed resources such as trees and shrubs in natural and semi-natural vegetation of the Mediterranean climate. Leaves and fruits of tree and shrub species have been reported as the source of important nutrients for feeding goats, sheep, cattle, deer and wild animals, during the critical summer period in semi-arid and sub-humid Mediterranean environments (Holechek 1984; Silva-Pando et al. 1999). These shrubs and trees growing in arid and semi-arid ecosystems are durable to extreme drought occurring in summer period owing to the strong root system and vigorous sprouts from the stump and the roots and therefore, play an important role in supplying the fodder for animals at the absence of grass-pasture (Papachristou and Papanastasis 1994).

The chemical composition and yield of the plants growing in natural conditions are affected by the factors such as the region's topography (Oberhuber and Kofler 2000), soil (Adams and Rieske 2003) and climate (Burke *et al*. 1997). Similar to the forage crops, an increase in the ADF, NDF and ADL composition and a decrease in crude protein (CP) content of shrub and tree species was reported as the plant matures (Papachristou and Nastis 1990; Papachristou and Papanastasis 1994). It has also been emphasized that plants had different nutrient contents at different growth stages (Nastis 1982). The feeding value and composition of the tree and shrubs has attracted some research recently in a variety of regions. Karabulut *et al*. (2006) determined the feeding value of *Quercus coccifera*, *Arbutus andrachne* and *Olea europaea* species growing in the southern of Turkey and reported that the crude protein contents of species were 9.2%, 10.5% and 10.4%, NDF values were 50.6%, 49.2%, 34.0%, and ADF values were38.7%, 37.0%, 25.8% respectively. Ben Salem *et al*. (2000) reported the range of NDF from 44.7% to 60.8%, ADF from 24.5% to 44.8%, ADL from 11.0% to 17.9%, and CP from 7.7% to 13.8% content of six fodder shrubs growing in Mediterranean Region. Corleto *et al*. (1994) investigated the feeding value of 25 trees and shrubs and reported a wide variation among species in terms of CP and NDF rates. The average CP for NDF content of species was measured as 12.2% and 38.0%, respectively. The feeding value of that crude protein ratio of ten species of shrubs adapted to Mediterranean Region ranged from 10.5% to 21.7% and NDF ratio have varied from 36.0% to 48.2% (Papachristou and Papanastasis 1994).

Nutrient contents of species differ in different environments (altitude, exposure, etc.). The difference originates from the variability of climate and soil properties of species habitat mainly due to the variation of the topographic structure (Stephens and Krebs 1986). The effect of altitude and slope aspect in relation to temperature and rainfall on plant forage quality has been reported extensively (Burke *et al*. 1997; Adams and Rieske 2003; Kraus *et al*. 2004b).

So as to improve animal production in the Mediterranean Ecosystems, it is essential to know the forage quality of additional feed produced by shrub ecosystem (Hobbs *et al*. 1982). In this study, we determined the feeding values of shrub species in maquis

in different altitude and slope aspects in the district of Erdemli, Mersin Province of Turkey.

MATERIALS AND METHODS

This study was conducted in a time period from April 2005 to April 2007. The selected 18 sampling areas all located west of Mersin Province of Turkey with varying in size anywhere from 1 ha to 20 ha. The sampling areas are also selected from different altitudes (0-400 m, 400-800 m and over 800 m) and slope aspects (north and south) in the west of Mersin in Mediterranean region of Turkey. In order to assess the effect of exposure on forage quality of the plants in the same aspect, we selected the sampling sites either from regions facing each other of two different hills or regions that are opposing one another from the same hills. A total of 38 species with forage value were identified in the sampling areas. Not all the 38 indentified species distributed among all the sampling areas. In order to deduce unbiased effect of altitude and slop aspect, we used only ten species represented the entire sampling of areas. We determined the CP, NDF and ADF contents ten species of from 18 number of sampling areas (Table 1). Leaf samples were collected from the selected species and subsequently used for chemical analysis and the analysis conducted in the Faculty of Agriculture laboratories, Ataturk University in Erzurum, Turkey.

Table 1: Shrubs species evaluated in this study along with the common names and families.

Species	Common name	Family
Arbutus andrachne L.	Eastern strawberry tree	*Ericaceae*
Cistus creticus L.	Pink rockrose	*Cistaceae*
Gonocytisus angulatus (L) *Spach.*	Golden rain	*Leguminosae*
Paliurus spina-christi Mill.	Jerusalem thorn	*Rhamnaceae*
Phillyrea latifolia L.	Mock privet	*Oleaceae*
Phlomis armeniaca Willd.	Jerusalem sage	*Lamiaceae*
Pistacia terebinthus L.	Turpentine tree	*Anacardiaceae*
Quercus coccifera L.	Kermes oak	*Fagaceae*
Quercus infectoria ssp. *boissieri* O.Schwarz	Oyer's oak	*Fagaceae*
Smilax aspera L.	Rough bin weed	*Liliaceae*

The average annual rainfall for all 18 research areas is 602.7 mm with the average annual temperature being 19.2^{o}C and mean relative humidity of 70.4%. However, during the study period these values were measured at as 423.2 mm, 19.9^{o}C and 65.50%, respectively. The soil in the research area soil is identified as reddish Mediterranean soils (Terra-rossa) in region up to 1000 m, of reddish-brown Mediterranean soils in the grounds above 1000 m (Atalay 1987). In accordance with the results obtained from all testing ground soils, it was obtained similar results in terms of salinity, soil reaction (pH) and saturated with water and determined that the land area of research was loam, unsalted and slightly alkaline. Plant samples were taken without prearranged plots as of three replications in three different altitudes (0-400 m, 400-800 m and over 800 m) and in two different geographical sides (exposures) (north vs. south) in which scrub density was different.

Leaf samples were collected by hand in full-foliation stage of plants, dried and ground for chemical analysis. Nitrogen (N) content of leaf samples collected from shrub species was measured by the Kjeldahl method at ground-samples of 0.25 g taken by weighing in assay balance, and crude protein ratios of leaves were calculated as N X 6.25. Crude protein ratios were determined in accordance with the principals indicated by Kacar (1972) and Akyıldız (1984). Leaf materials were collected from their branches in full leaf stage of shrubs were ground and dried air-dried in an oven at 70 ^{o}C for 24 h, and it ADF and NDF analyses were conducted using samples weighed about 0.50 g in assay balance. Samples put into filterbag were boiled for one hour and separately treated with solutions for ADF and NDF in Ankom Fiber Analizer device. The samples flushed with hot-distilled water, and then cooled. The samples were dried at 105 ^{o}C for one night after washed with acetone using desiccators and then NDF and ADF ratios were determined by weighing. NDF and ADF contents of leaves were determined by using method modified by Van Soest *et al*. (1991).

Statistical Analysis: The obtained data were analyzed using three-way ANOVA. Significant differences were determined by Duncan's Multiple Comparison Test (Yıldız and Bircan, 1994).

RESULTS

The crude protein ratios of the plants are shown in Table 2. There was a huge variation in crude protein contents of shrub species. While the highest CP content was measured in *Gonocytisus angulatus* (L) *Spach.* (21.58%), the lowest CP ratio has been deduced from *Smilax aspera* L. (8.13%), *Q. infectoria sp*. Boissieri (8.36%) and *Q. coccifera* L. (8.41%). Overall CP content of plants ranged from 8.13% to 21.58% with a mean of 11.84%. The highest crude protein ratio among altitudes was detected at 0-400 meters elevation; crude protein rate was to decreased continuously with an increase in altitute. The differences in crude protein content between slope aspects were found to be very significant. The CP (11.95%) ratio in the northern slopes remained higher than in the southern slopes.

The NDF ratios of the plants are presented in Table 3. NDF ratios due to plant species were found very significant ($P < 0.01$). The highest NDF content was

Table 2: The CP ratios of shrub species in different altitudes and aspects (%).

Species	0-400 m		Mean	400-800 m		Mean	800 m above		Mean	South	North	Species
	South	North		South	North		South	North		Mean	Mean	Mean
Pistacia terebinthus	10,33	9,10	9,71	10,24	10,68	10,46	12,15	11,98	12,06	10,90	10,58	10,74E
Cistus creticus L.	11,36	9,20	10,28	9,02	7,86	8,43	9,81	8,49	9,15	10,06	8,52	9,29F
Arbutus andrachne	8,78	9,72	9,25	8,22	8,85	8,53	7,54	7,35	7,44	8,18	8,64	8,41H
Quercus coccifera L.	9,01	7,88	8,44	7,23	8,53	7,88	8,46	9,05	8,75	8,23	8,48	8,36H
Q.infectoria sp.*boissieri*	13,25	14,52	13,89	12,16	14,37	13,26	12,52	12,17	12,34	12,64	13,68	13,16C
Phlomis armeniaca	10,60	11,44	11,02	11,86	12,83	12,34	10,94	10,27	10,61	11,13	11,51	11,32D
Smilax aspera L.	8,48	7,23	7,85	6,79	8,72	7,75	8,73	8,81	8,77	8,00	5,25	8,13H
Phillyrea latifolia L.	10,47	8,35	9,41	8,85	8,07	8,46	8,49	9,25	8,77	9,27	8,55	8,91G
Paliurus spina christi	18,40	18,72	18,56	20,88	21,05	20,97	15,25	16,75	16,00	18,17	18,84	18,51B
Gonocytisus angulatus .	21,88	20,89	21,38	19,34	21,58	20,46	20,93	24,86	22,90	20,71	22,44	21,58A
Mean	12,26	11,70	11,98^{A}	11,46	12,25	11,86^{AB}	11,48	11,90	11,69^{B}	11,73^{B}	11,95^{A}	

LSD: Species = 0.35**; Altitude = 0.19**; Aspect = 0.15**; Species x Altitude = 0.60**; Species x Aspect = 0.49**; Altitude x Aspect = 0.27**; Species x Altitude x Aspect = 0.85**.
Values followed by capital letter in a column show significantly different at level P: 0.01. **: Significant at 1% level.

Table 3: The NDF ratios of shrub species in different altitudes and aspects (%).

Species	0-400 m		Mean	400-800 m		Mean	800 m above		Mean	South	North	Species
	South	North		South	North		South	North		Mean	Mean	Mean
Pistacia terebinthus	47,80	46,72	47,26	46,22	54,03	50,12	46,80	50,70	48,75	46,94	50,48	48,71B
Cistus creticus L.	37,73	36,45	37,09	36,10	39,70	37,90	37,08	42,06	39,57	36,97	39,40	38,19E
Arbutus andrachne	43,58	40,06	41,82	45,76	44,15	44,96	42,78	43,83	43,30	44,04	42,68	43,36D
Quercus coccifera L	56,38	51,59	53,99	58,12	54,09	56,10	52,16	43,37	47,76	55,55	49,68	52,62A
Q.infectoria sp.*boissieri*	46,32	49,89	48,10	49,69	51,00	50,35	46,86	50,10	48,48	47,62	50,33	48,98B
Phlomis armeniaca L.	53,30	39,89	46,59	46,72	46,59	46,65	52,66	54,56	53,61	50,89	47,01	48,95B
Smilax aspera L.	41,94	37,91	39,93	46,01	50,17	48,09	42,96	39,39	41,18	43,64	42,49	43,06D
Phillyrea latifolia L.	42,91	43,18	43,04	45,57	48,07	46,82	46,30	51,30	48,80	44,92	47,51	46,22C
Paliurus spina christi	34,79	37,20	36,00	30,28	33,08	31,68	32,99	37,50	35,24	32,68	35,92	34,30F
Gonocytisus angulatus.	28,68	32,38	30,53	26,70	27,59	27,14	26,27	22,69	24,48	27,22	27,55	27,38G
Mean	43,34	41,53	42,43b	43,12	44,85	43,98a	42,69	43,55	43,12ab	43,05	43,31	

LSD: Species = 2.49**; Altitude = 1.03*; Aspect = No significance; Species x Altitude = 4.30**; Species x Aspect= 3.51**; Altitude x Aspect = 1.93**; Species x Altitude x Aspect = 6.09**.
Values followed by small and capital letter in a column show significantly different at levels of P: 0.05 and P: 0.01, respectively.
* and **: significant at 5% and 1% levels, respectively.

Table 4. The ADF ratios of shrub species in different altitudes and aspects (%).

Species	0-400 m		Mean	400-800 m		Mean	800 m above		Mean	South	North	Species
	South	North		South	North		South	North		Mean	Mean	Mean
Pistacia terebinthus	36,16	37,06	36,61	35,37	43,68	39,52	29,49	37,41	33,45	33,67	39,38	36,53A
Cistus creticus	27,96	29,49	28,72	30,32	29,43	29,87	30,18	32,59	31,39	29,49	30,50	29,99E
Arbutus andrachne	34,23	33,13	33,68	29,56	38,05	33,80	31,18	34,32	32,75	31,65	35,16	33,41BC
Quercus coccifera	36,90	39,16	38,03	40,38	42,33	41,36	32,87	31,63	32,25	36,72	37,70	37,21A
Q.infectoria sp.*boissieri*	29,79	30,41	30,10	33,00	31,61	32,31	29,08	31,99	30,53	30,62	31,34	30,98DE
Phlomis armeniaca	33,10	27,92	30,51	27,89	29,63	28,76	37,57	35,21	36,39	32,85	30,92	31,89CD
Smilax aspera	32,88	30,30	31,59	34,64	36,85	35,74	27,19	34,02	30,61	31,57	33,72	32,65C
Phillyrea latifolia	32,40	30,99	31,69	32,63	36,54	34,59	34,44	39,96	37,20	33,16	35,83	34,49B
Paliurus spina christi	12,90	14,40	13,65	10,69	10,72	10,71	12,26	11,50	11,88	11,95	12,21	12,08F
Gonocytisus angulatus .	14,12	11,57	12,84	13,90	14,24	14,07	12,16	12,39	12,28	13,39	12,73	13,06F
Mean	29,04	28,44	28,74B	28,84	31,31	30,07A	27,64	30,10	28,87B	28,51B	29,95A	

LSD: Species = 1.58**; Altitude = 0.87**; Aspect = 0.71*; Species x Altitude =2.74**; Species x Aspect = 2.24**; Altitude x Aspect = 1.23**; Species x Altitude x Aspect = 3.88**.
Values followed by capital letter in a column show significantly different at level of P: 0.01. * and **: significant at 5% and 1% levels, respectively.

measured in *Quercus coccifera* L. (52.62%), and the lowest NDF ratios have been deduced from *Gonocytisus angulatus* (L) *Spach.* (27.38%). Overall NDF composition of plants ranged from 27.38% to 52.62% with a mean of 43.18%. NDF rates, which are estimation of cell wall materials in plants were significant

differences due to altitude ($P < 0.01$). The highest NDF rate (43.98%) was determined at the 400-800 m, the lowest one at the 0-400 m elevation. The differences at the NDF rate of slope aspects were no statistically significant.

The ADF ratios of the plants are given in Table 4. There was a huge variation in ADF ratios of shrub species. The highest ADF content was measured in *Quercus coccifera* L. (37.21%) and *Pistacia terebinthus* L. (36.53%), the lowest one in *Paliurus spina-christi* Mill. (12.08%) and *Gonocytisus angulatus* (L) *Spach.* (13.06%). ADF content of all plants ranged from 12.08% to 37.21% with a mean of 29.23%. The highest ADF ratio (30.07%) among altitudes was found on 400-800 m. ADF ratios measured 0-400 m and over 800 m altitudes were not significantly different. However, ADF values of those two altitudes were significantly differed from the ADF values of 400-800 altitude level. The differences in ADF rate between slope aspects were found to be very significant. The ADF (29.95%) ratios in the northern slopes remained higher than in the southern ones.

The three way interaction of species x altitude x aspect was also found to be very significant for CP, NDF, and ADF ratios (Table 2, Table 3 and Table 4).

DISCUSSION

A wide variation among species in CP, NDF and ADF contents was observed and similar studies reported extensively in the literature. Ben Salem *et al*. (2000) reported that the CP, NDF and ADF ratios of six fodder shrubs and trees in Mediterranean Region varied with 7.7% to 13.8%, 44.7% to 60.8% and 24.5% to 44.8%, respectively. NDF and ADF contents of two shrubs and four trees in the southern of Turkey reported to range from 34.0% to 50.6% and 25.8% to 38.7%, respectively (Karabulut *et al*. 2006). Crude protein content of *Quercus coccifera* L. estimated as 9.2% by Karabulut *et al*. (2006), 10.1% by Koukoura (1984), 7.8% by Nastis (1982) and 8.7% by Le Houerou (1980a). Also, CP contents of *Arbutus andrachne* L. is reported to be 10.5% (Karabulut *et al*. 2006) and of *Smilax aspera* L. was reported as 8.9% (Le Houerou 1980a). The NDF ratios of *Arbutus andrachne* L. and *Quercus coccifera* L. were 49.2% and 50.6%, and as 37.0% and 38.7% for ADF, respectively (Karabulut *et al*. 2006). Variation in cell wall composition and CP content among species can be partly due to the genetic factors that control accumulation of foliage nutrients in the leaves of plants along with the habitats of species (Corleto *et al*. 1994).

Because of the fact that *Gonocytisus angulatus* (L.) Spach was a legume, the CP content of this plant was higher than the other species studied here. Due to symbiotic relationship between legumes and Rhizobium, legumes access nitrogen readily and thus have higher CP content (Thomas *et al*. 1990; Bakoğlu *et al*. 1999). And same phenomenon observed in legume shrub and trees (Silva-Pando *et al*. 1999).

In this study, samplings were collected in parallel to developmental period of plants. Difference in CP content of the species was evident in varying of altitudes and slope aspect. These differences could have risen due to different growing periods and as well as different climate and soil characteristics in their diverse growing habitat. Therefore, chemical compositions of plants are not the same in each region (Stephens and Krebs 1986). The effect of altitude mainly due to rainfall and temperature on forage quality of plants has been extensively documented (Burke *et al*. 1997; Adams and Rieske 2003; Kraus *et al*. 2004b).

ADF and NDF ratios of shrub species were found to be significant among altitudes. There is an incremental decline in the NDF ratios of plants in parallel to the decline in altitude. One of the possible explanations for the change in NDF ratio is the maturation time is different in different altitudes because of heat exposure.- In addition, difference in habitat could have an effect NDF values. The effect of regional differences on chemical compositions of plants was underlined previously (Stephens and Krebs 1986).

We did not detect any difference in NDF values of between both slope aspects; however, ADF rates of southern slope aspects were found to be lower. The high volume of light received at the southern slope could have lead to early maturation and therefore higher ADF value. Since mature plants have higher stem-leaf ratio, they are expected to have more fiber and thus more ADF (Andrea 2003).

In this study, we found that that kermes oak growing at 0-400 m and in the South-facing slope had higher crude protein content (9.01%) than any other altitude-aspects combinations (Table 2). We observed that kermes oak growing in this environment is surrounded by trees such as such as *Ceratonia siliqua* L. and *Olea europea var. oleaster* L. Similar to our study, Koukoura (1984) found that crude protein content of kermes oaks (10.1%) growing in an area of 80% covered with tree cover was 8.5% higher than those growing unsurrounded.

In the present study, the amount and production of material browsed in scrublands were put forward to affect by applied management systems with biotic and abiotic factors. We found that the average CP, NDF and ADF contents of species were 11.84%, 43.18% and 29.23%, respectively. The highest CP (21.58%) content was obtained from *Gonocytisus angulatus* L., the highest NDF (52.62%) and ADF (37.21%) ratios were found *Quercus coccifera* L. The highest CP content among altitudes was found on Altitude 0-400 meters, on 400-800 m for NDF and ADF. While the CP and ADF contents of shrub species were higher in the northern slopes, we could not detect any difference in NDF contents of

different exposures. As a result, *Gonocytisus angulatus* L. and *Paliurus spina-christi* Mill. between both species and altitudes and slopes were noted as the species with the lowest NDF and ADF ratios, but the highest crude protein rate. These species were also in important plants in terms of feed value.

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