The Journal of Animal & Plant Sciences, 23(4): 2013, Page: 1034-1040
ISSN: 1018-7081

COMPOSITION AND ANIMAL PREFERENCE FOR PLANTS USED FOR GOAT FEEDING IN SEMIARID NORTHEASTERN MEXICO

R. Foroughbakhch, J. L. Hernández-Piñero, A. Carrillo-Parra* and A. Rocha-Estrada

Universidad Autónoma de Nuevo León, Fac.de C. Biológicas, Dpto. de Botánica, AP. F-2, C.P. 66451 San Nicolás de los Garza, N.L., México,
*Universidad Autónoma de Nuevo León, Facultad de C. Forestales, Carr. Nac. Km. 145, A. P. 41, 67700 Linares, N.L., Mexico.
Corresponding author E-mail: rahimforo@hotmail.com, rahim.foroughbakhchpr@uanl.edu.mx

ABSTRACT

Arid and semiarid zones of Northeastern Mexico are characterized as regions with high variation in their climatic conditions but rich in drought-tolerant botanical species which are potentially useful for grazing and pastoral activities. Feeding habits and voluntary intake from a total of 100 grazing goats were determined through identification of the plants that make up their diet, their availability in the rangeland, preference index, browsing height and their chemical composition during a 10-month growing period. Four heights of browsing were determined in the different vegetative strata. Climatic factors were determinant in the height of grazing and the availability of forage. Shrub species constituted 78% of the animal diet during the growing season followed by herbs (12-18%) and grasses (6-10%). The species with higher index of preference offered high availability in the rangeland with proper content of crude protein (10.7-24%), crude fiber (12.2-24.5%), cellulose (5.9-20.6%) and nitrogen free extract (30.2-50.6%). These results indicate that in seasons of high feed availability the intake of most preferred shrubs is taking place most of the time at a browsing height between 80 and 120 cm with species rich enough in nutrients to satisfy their minimum daily protein and fiber requirements. [¿Y que ónda con aquello de que cuando hay muchas hierbas abajo prefieren comer esas hierbas?]Thus, the pasture conditions, climate and the availability of the vegetation in a given season are crucial factors for suitable livestock management.

Key words: Feed habits, feed intake, shrubs, fodder, chemical composition.

INTRODUCTION

Trees and shrubs in northeastern Mexico are mainly distinguished by its diversity, their nutritional importance and preference by the grazing ruminants. The value of these forages in animal feeding is associated with their availability during the vegetative period as well as their floristic diversity for the diet of ruminants as a supply of nitrogen, energy, vitamins and minerals (Ramírez, 2003).

The differences between animal nutrition under grazing conditions and traditional nutrition under confinement of animals have been widely discussed by various authors (Holechek *et al.* 1989) indicating the need to determine the quality of the diet of grazing cattle under the conditions prevailing in each region and the corresponding type of vegetation. These studies were conducted due to the complexity of the relationships between the floristic composition of grasslands and its dependence on climatic conditions or certain factors inherent to the animal nature, such as the species in question, nutrient requirements and feed selectivity in addition to management practices (Foroughbakhch *et al.* 2007).

Browse plants constitute a major source of feed for goats in arid and semiarid regions of the world (Momcal, 1984~~,~~: Pfister and Malechek, 1986:~~,~~ Schacht and Malechek, 1989). It has been assumed that browse generally contains adequate protein for the growing of goats based on comparisons between protein quality of both grasses and legume species with their proper availability (Gutteridge and Shelton 1994). However, since cattle cannot be practiced in semiarid areas of low productivity, goats deserve special attention as important contributors to the food supply to local inhabitants due to their ability to use the existing forage resources in these areas. This is supported by reports that show that goats digest forage in a more efficient manner than cattle. Moreover, this advantage can also be due to their smaller size compared to the low availability of forage and their ability to select feed (Van Soest 1987).

The feeding of goats in Mexico is based primarily on the use of native vegetation. Young leaves, stalks, seeds and floral parts of the vegetation components have a high nutritional value. However, the occurrence of high nutritional quality plant species in the rangeland is not enough to meet their nutrient demands (Fierro *et al*. 1989). Due to their high nutritional content, the use of fodder from shrubs and trees as supplements may be a strategic alternative in the feeding of goats in

arid and semiarid regions of Mexico.The way to determine what an animal consumes in rangeland conditions is not an easy task. Most of the rangeland in northeastern Mexico and southern Texas, USA, offers great potential for the production of goats for meat and play an important role in the economy of the region. Thus, despite the number of shrubs and trees with forage potential in extensive systems of arid and semiarid regions of Mexico is enormous, only a few species have been incorporated into feeding systems of grazing ruminants. In this work we attempt to overview the occurring situation on the feed availability for goats in the rangeland in different growing seasons of the year so we could further be able to estimate the stocking rate with this type of vegetation at a specific season. This information implies data on the botanical species consumed, availability of the preferred species and their proximal analysis for nutritional values.

MATERIALS AND METHODS

Study Area: This study was conducted over a 250 ha of a semiarid zone allotted to grazing goats with 100 animals. It is geographically located between 24°54'and 24°58' North latitude and between 99°28'and 99°32' West longitude at an altitude of 300-420m. The climate of that region is defined as semi-hot, with two rainy seasons (March to July and September to October) and a dry season between November and April. Average annual rainfall is 710 mm. The annual temperature is 23°C with extreme temperatures beyond 40°C in summer and frost events during the winter.

The soils of the area correspond to a typical Vertisol of alluvial-colluvial origin, deep and dark. They are characterized by a high clay content and relatively low organic matter (Foroughbakhch et al. 2009). The pH is slightly alkaline (7.2-8.2) and the concentration of main nutrients shows limitations especially in phosphorus and nitrogen.

Shrubby vegetation in this area is dominated by species such as *Acacia rigidula* (blackbush), *Acacia berlandieri, Cordia boissieri, Pithecellobium pallens, Celtis pallid* (Hackberry*), Porlieria angustifolia* (soapbrush)and *Cercidium macrum.* Dominant herbs in the study area are *Dyssodia spp., Cynanchum spp.*and *Zephyrantes spp.* Important dominant grasses are *Cenchrus ciliaris* (buffelgrass), *Hilaria berlandieri* (curly mesquite), *Setaria macrosrachya* (plains bristlegrass) and *Panicum hallii* (Hall's panicum).

Plant selection by goats: Goats started grazing in the bush at 9.00 a.m. taking a short break of about an hour during the day to reach a nearby water hole. To evaluate the plant selectivity by goats, daily observations were carried out throughout six to seven hours of grazing and data was obtained using the multi-minute method (Altmann 1974) consisting of recording one consumption event every five minutes by annotating the species and the organ that was being consumed at the time of the event. Thus, the name of the plant species, its most palatable part and the time of consumption was recorded. Field observations were carried out during 10 months from March to December 2005. Every month 10 different goats divided in two groups: 5 male (30-33 kg) and 5 female (38-40 kg of weight), Spanish criollo breed 4 years old, were selected and observed by people sitting at the pasture in each period of observation.

Determination of the grazing height: In order to determine the grazing height, direct observations were made to grazing goats measuring the browsing height at which the plants were eaten by goats in the different vegetative layers of the semi-arid region plants. Thus, we could determine the minimum and maximum browsing height and its average value. These data are important to know the approximate range of grazing taking into account that the total forage production in a given area is not defined as the total feed offered but as the feed that is located within the volume range of grazing.

Degree of preference and relative preference index: The degree of preference or percentage of preference of the plant species consumed by goats were obtained by selecting one goat and watch for its activity every five minutes all its way during three consecutive days (10 goats per month) to see what it is consuming at those times. According to Rosiere *et al*. (1975), the degree of preference (DP) of a given species is calculated using the following equation:

$$DP = \frac{\text{Number of consumption events on a specific species}}{\text{Total number of events (of all species consumed)}} \text{ X } 100$$

A systematic sampling of vegetation in 3 X 3 m quadrants was conducted along 20 transects routes (100 m long each) registering the plant species consumed in each quadrant. Likewise, data on the number of plants consumed as well as their crown projections were also recorded in order to determine the importance value (IV) or availability of the species. Finally, the relative preference index was calculated as DP/IV for each species.

Proximal analysis: Leaves and young stalks of shrub species were removed manually from branches and grounded in a Wiley mill (2 mm screen). Dry matter (DM), Crude Protein (CP), Ether Extract (EE), Crude Fiber (CF), and Nitrogen Free Extract (NFE) was determined (AOAC, 1995). Leaves and stems were also analyzed for condensed tannins using the vanillin-HCL procedure (Burns 1971) modified by Price et al. (1978).

Statistical analysis: To apply the analysis of variance, the data for the proximate analysis and the percentage of preference of the plants were subjected to the Arcsine transformation (Zar, 2010).

The mean values and standard errors were calculated for each species and for the proximate analysis values. The model were applied using the statistical package SPSS (v. 15.0). Least significant differences were calculated with a 5% probability level (L.S.D. 0.05).

RESULTS AND DISCUSSION

Roaming distance and forage production: Goats under study in the semiarid vegetation roamed throughout an average distance of 2.2 Km in one hour 45 minutes, giving a grazing rate of 1.2 Km per hour. By multiplying the front of the pasture (10 to 15 m for 100 animals) by the distance traveled we obtained a grazing area of 2.2 to 3.3 ha after 1h 45 min which is equivalent to 1.6 ha per hour on average. Assuming an effective time grazing per day from 4 to 6 hours, the grazed area would be between 5 ha per day (during favorable weather conditions in autumn) and 11 ha per day (under the drought conditions of summer) with an average of 8 ha per day. Considering this result the energy cost for feed search is high in summer since goats stay longer time grazing in the pasture with its consequent decrease in milk and meat. According to Lailhacar *et al*. (1981), the average forage production of Mediterranean-type shrubs is 0.7 to 1.2 ton of dry matter (DM) $ha^{-1}year^{-1}$ thus extrapolating these data, the area grazed per day would give a yield of 7,600 kg DM per year. Based on animals (which corresponds to 38.4 UAA consuming 270.4 kg DM per day), the forage produced in this area would be consumed in 15 days, i.e. 15 rotations in the same area but not consecutive.

Degree of utilization of plants: The most preferred parts of plants by goats are sprouts (young shoots), leaves and fruits in the fruiting season of woody species especially in the early summer and autumn. The goats have a very strong preference in the consumption of fruits of *Cordia boissieri* , *Pithecellobium pallens*, *Acacia rigidula*, *Forestiera angustifolia*, *Acacia farnesiana* and *Celtis pallida*. The fruits, leaves and young steams of the families Mimosaceae, Ebenaceae, Oleaceae, Borraginaceae, Rutaceae and Caesalpinaceae consumed by goats constitute around 78% of the animal diet during the growing season.

Herbs in this type of vegetation are relatively abundant and placed second in importance when selected by goats (12-18%) during the summer. The main herbs consumed by goats in grazing conditions were: *Clematis drummondii* , *Malva parviflora* , and *Euphorbia maculate*.

Grasses contributed from 6 % up to10% of the plants eaten by goats. *Cenchrus ciliaris*, *Setaria macrostachya* and *Panicum hallii* were consumed in greater quantity compared to *Bouteloua trifida*, *Eleusin eindica* and *Chloris* sp. in the spring and fall. These results are comparable with observations from Sidhamed (1981) in California, USA, who reported a botanic composition in the diet of 80 % shrubs, 10% grasses and 10% herbs.

Height of browsing: There may be noticed in Fig. 1 the presence of 4 separate ranges of grazing heoghts according to the changes in the frecuency. It is observed that in the lower layer (0-19.5 cm) there is a high frequency (77%) for grazing grasses (*Cenchrus ciliaris*, *Setaria macrostachya* and *Panicum hallii*) and herbs (*Ruelia corzoi, Polianthes maculosa, Coldenio greggii, Physalis cordata)* as well as fallen fruits of *Cordia boissieri*, *Acacia farnesiana*, *Celtis pallid* and *Diospyr*os *texana*. In the range of 20-59.5 cm grazing is less frequent (25-34%) probably due to the presence of less foliage and more shrubby stalks from *Pithecellobium pallens*, *Acacia rigidula*, *Cordia boissieri* and *Acacia farnesiana* in accordance to the architectural structure of the shrubs and trees in this stratum occurring during the low precipitation months of March and April. Browsing frequencies are higher (62-88%) in the shrub stratum in the range between 60 and 119.5 cm and corresponds to the normal browsing heights for goats. Finally, for the range 120-179.5 cm, maximum heights of browsing and occurs only when animals eat the fruits found at higher altitudes or when foliage and shoots at the normal height have been already consumed.

It was importantly noticed that simultaneously with the shrub growth during the rainy season an abundant array of native grasses along with a variety of herbs become also available as a biomass rich in nutrients which affect the browsing heights meaningless that typically over 75% of the diet of goats consists of browsed leaves and stems from shrubs so it can be said that goats are browsers of shrubs and trees by nature as it was also found by Kiribia (1994) and Wilson (1977).

On the other hand, the least preferred plants in favorable periods for grazing (rainy season) and even those undesired species such as *Croton* spp., *Opuntia* spp., *Parthenium lozanianum, Amyris texana, Helietta parvifolia* and *Salvia* spp., become part of the goat diet during the most critical times of the year when a critical shortage of fodder occurs in the rangeland.

Relative preference index of the species consumed by goats: The results on the degree of preference of goats show that 15 to 20 species of shrubs and trees (78%) are present in the composition of their diet depending on the season. A marked difference is observed in the number of species consumed in the diet with respect to the sampling dates. The number of shrubs consumed by goats was higher during the rainy season, in the months of March, April, May , October and November (88%) while the least consumption (66%) occurred in the dry season (June-August).This is due to the phenological stage of the plants in that time, increasing the preference for fruiting species in most of the cases. *Cordia boissieri (17.8%*

±1.55), Pithecellobium pallens (17.7%± 1.12), Acacia rigidula (13.7%±1.2), Forestiera angustifolia (8.5%±1.1), Acacia farnesiana (6.95%±0.96) and *Celtis pallida* (5.34%±0.85) were the most selected species in the ten sampling periods (Table 1).

Polianthes maculosa, Zephyranthesa renícola, Ruellia corzoi, Ruelli apedunculata, Coldemia greggii, Heliotropium angiospermum, Cynanchum barbigerum, Palafoxia texana and *Dyssodia spp* were the preferred non arbustive species during the year. Grasses presented the same pattern as herbs in the degree of preference by goats throughout the period of study.

The preference index for a particular species indicates whether the plant is preferred or rejected by the animal (Table 2). The rejection or preference of a species by an animal is closely related to the availability of the plant in the pasture. It is possible that a plant was rejected under certain conditions but preferred under other circumstances. According to Kreuger (1972) and Devendra (1994), an index of relative preference equal to1.0 indicates that the percentage of a particular species in the diet is equal to the percentage of the same species available in the pasture. Values above 1.0 indicate selectivity while values below 1.0 indicate avoidance of the species by the animal.

The results indicate that *C. pallida* (3.17), *A. farnesiana* (2.21), *C. boissieri* (2.04), and *P. pallens* (1.92) were the only species to be selected with a high rate of preference (preferential species are marked with the letter "A" and "B" in Table 2) compared with *F. angustifolia* (1.34), *A. rigidula* (1.09), which showed the same availability in the diet and the pasture land (letter "C"**).** *Mimosa biuncifera* (0.95) and *Zanthoxylum fagara* (0.70) showed the same availability than the previous species but with a lower degree of preference (letter "D") in the favorable season of the year. The rest of the bush species were considered avoided species ("E", "F").

Chemical composition: The importance of a species considered as forage depends largely on its chemical composition and individual growth in the plant community (Blair 1990, Hoffman 1987, Le Houérou 1980). The results of ANOVA indicate highly significant differences ($p<0.01$) for the chemical components between species and the feeding periods. In the case of semi-arid shrub it is important to note that there is a great variability in the chemical composition between different components and sections of the branches. Table 3 lists some parameters of the chemical composition of the main species consumed by goats. The protein content, moisture and the nitrogen free extract of trees and shrubs vary accordingly to the season and period of observation, being early summer(June 18.7%) and autumn (September – October 19.5%) the periods of higher content of crude protein and cellulose (20.1 %) .The lowest mean percentages of CP were recorded in late winter in March

Table 1.Monthly mean values of the degree of preference for the selected plant species by goats in northeastern Mexico.

Species	Sampling period										Mean	Sig[a]
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Pithecellobiumpallens	12.3^{f}	14.0^{de}	15.6^{d}	16.0^{d}	20.7^{c}	13.5^{f}	28.6^{a}	18.6^{cd}	23.8^{b}	14.3^{de}	17.72	**
Acacia rigidula	8.7^{f}	9.4^{f}	11.5^{e}	7.9	17.2^{c}	13.5^{d}	8.6^{f}	16.9^{c}	19.1^{b}	23.8^{a}	13.66	**
Cordia boissieri	0.0	0.0	6.5^{e}	8.1^{cd}	---	28.9^{b}	28.6^{b}	36.8^{a}	9.5^{c}	____	17.8	**
Forestiera angustifolia	2.1^{h}	6.8^{e}	6.1^{e}	9.4^{d}	17.6^{a}	13.5^{b}	11.4^{c}	3.0^{g}	4.8^{f}	9.5^{d}	8.42	*
Acacia farnesiana	0.0	4.6^{e}	4.0^{e}	6.2^{d}	3.5^{f}	1.9^{g}	11.4^{b}	9.7^{c}	____	14.3^{a}	6.95	*
Mimosa biuncifera	+	+	+	7.4^{b}	6.2^{c}	____	5.0^{d}	____	19.1^{a}	19.1^{a}	5.68	**
Celtis pallida	0.0	4.7^{d}	6.3^{bc}	7.7^{b}	10.3^{a}	5.7^{bc}	2.9	6.2^{bc}	4.8^{d}	4.8^{d}	5.34	*
Eysenhardtia polystachya	0.0	0.0	0.0	2.5^{b}	1.7^{c}	____	____	2.8^{b}	4.8^{a}	4.8^{a}	1.66	*
Cercidium macrum	0.0	1.8^{c}	1.5^{cd}	2.1^{b}	____	____	2.9a	1.6^{c}	_____	____	1.201	NS
Prosopis laevigata	0.0	0.0	____	2.6	1.8	____	____	____	____	4.8	1.10	NS
Condalia hookeri	0.0	0.0	0.0	0.0	____	____	____	3.6	4.8	____	0.84	NS
Lantana macropoda	+	+	1.3	1.0	____	____	____	____	____	4.8	0.90	NS
Zanthoxylum fagara	0.0	1.3	1.6	0.0	0.0	____	____	____	4.8	0.0	0.90	NS
Porlieria angustifolia	0.0	0.0	0.0	0.0	0.9	1.1	____	____	4.8	____	0.80	NS
Herbs	+	+	+	0.0	10.3^{a}	5.4^{c}	6.7^{b}	3.0^{d}	3.6^{d}	+	3.5	**
Grasses	+	+	+	+	10.3^{a}	7.7^{b}	5.7^{c}	4.6^{d}	4.3^{d}	+	4.3	**
Mean	2.8	5.2	6.6	8.6	13.5	11.1	13.6	13.0	13.2	12.2		

Values in rows with different superscripts differ ($p< 0.05$);

Sig. = significance level; ** = $p < 0.01$; * = $P < 0.05$; N.S = not significance ($p \geq 0.05$).

Note: Zero indicates that the species was identified in the transects but was not present in the diet (poor foliage). + indicates that the species was not present in the diet in some months; ____indicates that the species was present but not consumed or rarely consumed.

Table 2. Botanical composition of the most consumed species by grazing goats, their preference percentage (DP), importance value (IV), and index of preference (IP) in the study area.

Species	DP	IV	IP
Cordia boissieri	17.83	8.10	2.04 B
Pithecellobium pallens	17.17	8.94	1.92 B
Acacia rigidula	13.66	12.52	1.09 C
Forestiera angustifolia	8.42	6.27	1.34 C
Acacia farnesiana	6.95	3.15	2.21 B
Celtis pallida	5.34	1.66	3.17 A
Mimosa biuncifera	5.68	5.98	0.95 D
Eysenhardtia polystachya	1.67	3.47	0.48 E
Condalia hookeri	0.49	1.00	0.49 E
Lantana macropoda	0.92	6.13	0.15 E
Porlieria angustifolia	0.82	1.48	0.55 E
Prosopis laevigata	1.10	2.84	0.38 E
Zanthoxylum fagara	0.91	1.30	0.70 D
Acacia wrightii	---	1.39	0.00 F

Table 3. Proximal chemical analysis of leaves and young green stems (based on% of DM) of the most preferred shrubs in the diet of goats.

Species	CP	CF	EE	NFE	Lignin	Cellulose
Acacia berlandieri	21.9ab	17.3^{c}	3.6^{ef}	46.5^{ab}	17.7^{ab}	12.4^{efg}
Acacia farnesiana	19.1^{c}	22.2^{a}	7.5^{ab}	36.5^{de}	12.9^{d}	11.1^{fg}
Acacia rigidula	16.5^{d}	22.9^{a}	2.6^{g}	38.0^{cd}	19.1^{a}	18.2^{bc}
Acaciawrightii	20.2^{b}	21.7^{b}	3.6^{ef}	35.1^{ef}	11.6^{de}	23.1^{ab}
Bernardia myricaefolia	11.6^{f}	16.0^{cd}	3.7^{ef}	36.0^{ef}	7.3^{fg}	15.8^{cd}
Celtis pallida	20.6^{b}	13.8^{e}	3.6^{ef}	38.3^{cd}	4.2^{i}	12.1^{efg}
Cercidium macrum	12.2^{f}	15.6^{d}	5.0^{c}	36.3^{de}	10.1^{e}	5.9^{i}
Condalia hookeri	14.2^{e}	18.8^{c}	2.3^{gh}	40.5^{bc}	10.8^{e}	16.4^{cd}
Cordia boissieri	18.1^{c}	14.2^{de}	6.7^{b}	39.8^{cd}	7.1^{fgh}	22.5^{ab}
Diospyros texana	10.7^{fg}	14.0^{de}	5.3^{c}	39.2^{cd}	18.7^{a}	12.5^{efg}
Eysenhardtia polystachya	18.0^{c}	24.4^{a}	3.1^{fg}	42.5^{bc}	7.6^{fg}	12.4^{efg}
Forestiera angustifolia	12.8^{f}	20.9^{b}	6.4^{b}	32.8^{fg}	12.7^{d}	10.1^{gh}
Lantana macropoda	13.9^{e}	12.2^{ef}	5.1^{c}	30.7^{h}	9.2^{ef}	13.2^{de}
Leucaena leucocephala	19.8^{c}	15.1^{d}	4.1^{de}	41.6^{bc}	8.9^{efg}	24.6^{a}
Mimosa biuncifera	14.3^{e}	15.0^{d}	3.9^{e}	34.3^{ef}	7.5^{fgh}	19.2^{bc}
Pithecellobium pallens	24.0^{a}	14.5^{de}	4.1^{de}	50.6^{a}	8.1^{fg}	16.4^{cd}
Porlieria angustifolia	15.1^{de}	24.5^{a}	1.8^{h}	30.2^{h}	15.2^{c}	15.6^{cd}
Prosopis laevigata	20.0^{b}	15.2^{d}	8.5^{a}	37.4^{cd}	13.2^{d}	13.7^{de}
Zanthoxylum fagara	13.3^{e}	13.40^{e}	4.5^{d}	44.3^{bc}	10.3^{e}	12.8^{efg}
Mean ± S.E	16.6	17.4	4.5	38.9	11.1	15.1
Sig. level	*	**	**	***	**	**

*S.E. = Standard Error; Sig. level * P < 0.05; ** p < 0.01; *** p< 0.001; Values in columns with different superscripts differ (p < 0.05); DM = dry matter; CP = crude protein; CF = crude fiber; EE = ether extract; NFE = nitrogen free extract.

(12.8%) and early spring in April (12.5%), especially in *Diopyros texana* (10.70%), *Bernardia myricaefolia* (11.60%), *Forestiera angustifolia* (12.80%) and *Cercidium macrum* (12.20%). On the contrary, mean values of CP were high in *Pithecellobium pallens (*24.0%*), Acacia berlandieri* (21.9%), *Celtis pallida* (20.6%), *Prosopis laevigata* (20.0%) and *Acacia wrightii* (20.2%). These values are as high as values of CP of the legume *Medicago sativa* (19.0%).

The content of CP was consistently high enough throughout the year to fill the theoretical minimum requirements of 12% for goats in gestation and 14% for lactating goats. The lowest levels of CP in the diet occurred during the months of lowest rainfall in March (12.8%), April (12.5%), July (14.9%) and August (13.6%).

High levels of protein content in the diet are evidence of the selection mechanisms that these small ruminants have developed, which are governed largely by their low reticule-rumen capacity that does not enable them to survive on voluminous low quality forage, although such a highly selective behavior means more walking time looking for fodder (Blair, 1990). However, CP values can be a poor indicator of true nutritional values of diets based on shrubs as it is the case for goats (Ivory, 1990) since the presence of secondary metabolites

such as phenolic compounds interfere with nitrogen assimilation (Sidahmed 1981, Malechek and Provenza 1983, Núñez 1989).

According to Haresing and Cole (1988), the amount of cellulose digested in the rumen depends largely on the degree of lignification of the plant since lignin is resistant to bacterial attack and hinders the breakdown of cellulose. The results on the quantification of lignin (Table 3) show that the species *Acacia rigidula* (19.13%) *Diopyros texana* (18.75%), *Acacia berlandieri* (17.71%) and *Porlieria angustifolia* (15.25%) were very high in lignin content compared to *Celtis pallida* (4.22%), *Bernardia myricaefolia* (7.33%), *Eysenhardtia polystachya* (7.67%) and *Mimosa biuncifera* (7.52%). Species with higher content of cellulose such as *L. leucocephala* (24.62%), *C. boissieri* (22.5%), and *A. wrightii* (23.15%) showed least lignin amount (7 -11%).

In summary, research to date on the selectivity of plants in the diet of goats indicates the existing difficulties occurring when generalizing about the selectivity and degree of preference by the animal. These studies have focused on different conditions from the point of view of the availability of plants, weather, season of grazing, etc. However, despite these limitations the results of such studies, when applied to their places of origin, could be very useful for rangeland operators and managers who are interested in a management system suitable for livestock production.

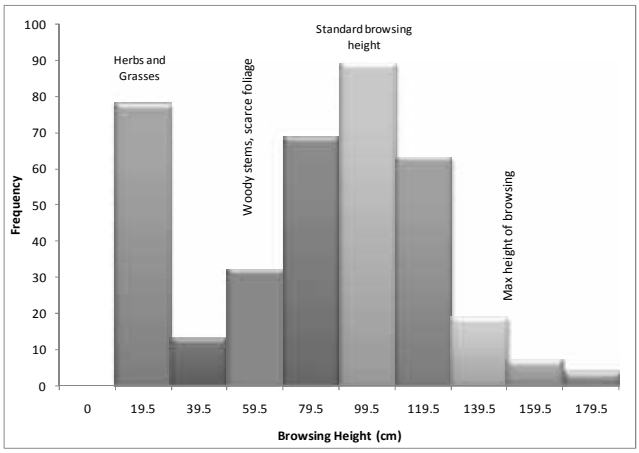

Figure 1.Determination of the height of browse by goats in different vegetative strata in semiarid areas of northeastern Mexico.

Conclusions: The floristic composition in the diet of goats contained 78% of trees and shrubs followed by 12-18% herbs and 6-10% grasses throughout the year.A high preference was observed on the consumption of shrubs such as *Acacia rigidula, A. farnesiana, Cordia boissieri, Celtis pallid, Condalia hookeri, Forestiera angustifolia* and *Eysenhardtia polystachya* over herbs(*Z. Arenicola, R. corzoi* y *P. maculosa*) and grass (*Aristida* spp, *Panicum hallii*, and *Cenchrus ciliaris*), which served as complimentary feed of grazing goats . However, although leaves, branch debris and fruits of these shrubs were consumed during all periods of observation consumption patterns such as the height of browsing varied according to the season and fodder availability. Thus, determining the chemical composition of fodder trees may be useful for the inclusion of specific shrubs indifferent feeding systems of small ruminants in arid and semiarid zones anywhere. In this sense, high protein and cellulose content of shrubs when compared to grasses from semiarid zones suggest their potential use as a supplement for these small ruminant diets. The majority of the shrub species showed a protein content equivalent or superior to *Medicago sativa* (Leguminosae) as a reference feed. This protein content is considered sufficient to cover the minimum requirements for goats.

In summary goats can choose their feed from groups or types of plants in a broader way than other ruminants allowing them to have a wide ecological distribution in extreme conditions, particularly in arid and semiarid areas of the world. However, it is reasonable to consider that the ideal diet of goats is not only limited to browsing on scrub or shrub components but it also varies according to the pasture conditions and the availability of the existing vegetation.

REFERENCES

AOAC (1995). Official Methods of Analysis (16th ed.)Association of Official Analytical Chemists, Washington, DC. USA.

Altmann, J. (1974). Observational study of behavior: Sampling methods. Behaviour 49,227-267.

Blair, G.J. (1990). The diversity and potential value of shrubs and tree fodder. In:C. Devendra (Editor). Shrubs and Tree Fodders for Farm Animals. Proceedings of a Workshop in Denpasar, Indonesia. International Development Research Center (IDRC-276e), Ottawa, Ontario, pp. 2-11.

Burns, R.E. (1971). Method for estimation of tannins in sorghum. Agron. J. 63, 511-515.

Devendra, C. (1994). Browse as a sustainable feed resource for small ruminants. Proceedings of VII World Conference on Animal Production. Edmonton, Alberta, Canada, pp. 119-136.

Fierro, L.C., R. Foroughbakhch, and J. Landa (1989).Consumo voluntario de forraje de caprinos en un sitio de matorral alto subinerme espinoso. Fac. de Ciencias Forestales, UANL, Linares, Mexico. Reporte Científico 13,18-26.

Foroughbakhch, R., J.L. Hernández, R. Ramírez, and M.A. Alvarado (2007). Nutrients, mineral and volatile fatty acids content in four *Leucaena* species. J. Anim. Vet. Adv. 6, 1083-1087.

Foroughbakhch, R., J.L. Hernández, M.A. Alvarado, E. Céspedes, A. Rocha, and M.L. Cárdenas (2009). Leaf biomass determination on woody shrub species in semiarid zones. Agroforestry Sys. 77, 181-192.

Gutteridge, R.C. and M.H. Shelton (1994). The role of forage tree legumes in cropping and grazing systems. In forage tree legumes in tropical agriculture, CAB International, Wallingford, U.K.: 3-11.

Haresign, W. and D.J.A. Cole (1988). Recent Developments in ruminant nutrition. Butterworth-Heinemann, London.367 pp.

Hoffman R.R. (1987). Role of shrubs and trees as a feed for animals. In: Dobson A. (Editor).Aspects of Digestive Physiology in Ruminants. Cornell University Press, New York, pp. 1-26.

Holechek, J.L., R.E. Estell, M.L. Galyean and W. Richards (1989). Chemical composition, *in vitro* digestibility and *in vitro* VTA concentrations of New Mexico native forages. Grass Forage Sci. 44,101-105.

Ivory, D.A. (1990). Major characteristics and nutritional value of shrubs and tree fodders. In: C. Devendra (Editor). Shrubs and Tree Fodders for Farm Animals. Proceedings of a Workshop in Denpasar, Indonesia. International Development Research Center (IDRC-276e), Ottawa, Ontario, pp. 22-38.

Kiribia, S.S. (1994). Tree leaves as alternative feed resources for Black Bengal goats under stall feed conditions. Small Ruminant Res. 13, 217-222.

Kreuger, W.C. (1972). Evaluating animal forage preference. J. Range Manage. 25, 471-486.

Lailhacar, S., A. Manterota, A. Olivares, and D. Contreras (1981). Species diversity and stratification to improve grazing in Mediterranean Chilean range. Facultad de Ciencias Agrarias, Veterinarias y Forestales, Universidad de Chile, Santiago, pp. 612-614.

Le Houérou, H. N. (1980). Chemical composition and nutritive value of browse in tropical West Africa. In: H.N. Le Houérou (Editor). Browse in Africa: The Current State of Knowledge. Int. Livest. Centre for Africa, Addis Ababa, Ethiopia, pp. 30-40.

Malechek, J.C., and F.D. Provenza (1983). Feeding behavior and nutrition of goats on rangelands. World Animal Review, 47, 38-50.

Momcal, D.G. (1984). Performance and diet quality of goats grazing creosote bush dominated rangelands and their effects on the plant community. Ph. D. dissertation. New Mexico State University, Las Cruces, USA.

Núñez-Hernández, G. (1989). Influence of native shrubs on nutritional status of goats: nitrogen retention. J. of Range Manage. 42, 228-232.

Pfister, J.A., and J.C. Malechek (1986).The voluntary forage intake and nutrition of goats and sheeps in the semiarid tropics of Northeastern Brazil. J. Anim. Sci. 63,:1078-1086.

Price, M.L., S. Van Scoyoc, and L.G. Butler (1978). A critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. J. Agric. Food Chem. 26, 1214-1220.

Ramírez, R.G. (2003). Nutrición de rumiantes: sistemas extensivos. 1st Ed. Trillas, Mexico, 314 p.

Rosiere, R.E., R.F. Beck, and J.D. Wallace (1975).Cattle diets on semidesert grassland: botanical composition. J. Range Manage. 5, 314-318.

Schacht, W. H., and J.C. Malechek (1989). Nutrition of goats as influenced by thinning and clearing of deciduous woodland in northeastern Brazil. J. Anim. Sci. 67, 2487-2498.

Sidahmed, A.D. (1981). Contribution of mixtures of tree chaparral shrubs to the protein and energy requirements of Spanish goats. J. Animal Sci. 53, 1391-1400.

Van Soest, P.J. (1987). Interactions of feeding behavior and forage composition.Proc. IV International Conf. Goats, Brasilia, Brazil. EMBRAPA-DDT, pp. 971-987.

Wilson, A.D. (1977). The digestibility and voluntary intake of the leaves of trees and shrubs by sheep and goats. Aust. J. Agric. Res.28, 501.

Zar, J. H. (2010). Biostatistical analysis.5th edition, Prentice-Hall, Upper Saddle River, New Jersey, USA, 662 p.