Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 3, No. 10, p. 42-51, 2013
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Preference value study of the species grazed by sheep in semi-steppe rangelands in west Azerbaijan of Iran using preference value index during the grazing season

Ahmad Ahmadi[1], Hassan Yeganeh[2], Hossein Piry sahragard[3], Ehsan Zandi Esfahan[4], Hasan Barati[5*], Elahe Ahmadi[6]

[1]*Agriculture and Natural Resources Research Center of West Azarbayjan, Iran*

[2]*Young Researchers Club, Ardestan Branch, Islamic Azad University, Ardestan, Iran*

[3]*Faculty of Natural Resources, Tehran University, Tehran, Iran*

[4]*Range Research Division, Research Institute of Forests and Rangelands, Tehran, Iran*

[5]*Faculty of Natural Resources, Tehran University, Tehran, Iran.*

[6]*Sari University of Agricultural Sciences and Natural Resources, Iran.*

Article published on October 5, 2013

Key words: Gharabagh Rangeland, Grazing Behavior, Preference Value, Palatability, Preference Index.

Abstract

Management of rangelands is dependent on optimal management of livestock grazing. Selecting an appropriate livestock type is one of the most important management decisions in grazing management of livestock. Considering preference value of plant species available is critical to ensure management's success in achieving the goals. The present study aimed to investigate and determine preference value of plant species. For this purpose, species selection index was used to determine preference value of range species. Results showed that the effects of month and year were significant at 1% level of probability, while the effect of species was significant at 5% level of probability. Furthermore, among interaction effects, the interaction effects of "year x species" and "year x month x species" were significant at 1% level of probability, also interaction effect of "month x species" was significant at 5% level of probability. Meanwhile, interaction effect of "year x month" was not significant. The maximum and minimum preference values were obtained for "Astragalus effuses" (1.42) and "Ziziphora clinopodioides" (0.49), respectively. The effect of month on preference value was significant at 1% level of probability. The highest and the lowest preference value were recorded for the months of June (1.23) and August (0.50), respectively.

***Corresponding Author:** Hasan Barati ✉ hasanbarati66@yahoo.com

Introduction

The diversity of rangeland vegetation is great. Management and use of valuable rangeland resources as well as their preservation, restoration, and sustainable development and utilization need the knowledge and understanding of vegetation characteristics. Preference value of different plant species is of key characteristics which greatly help management perform range management plans, determine range condition and range capacity, apply scientific range management, estimate available forage, preserve palatable species and sustainable utilization of rangelands. In general, livestock choose their food selectively; it means that particular species or different parts of the plant species are not consumed randomly and livestock do not graze the average of available forage, (Baghestani et al ., 2001). The preference degree indicates selective reaction of livestock to different plant species and is usually behavioral. Forage selection is resulted from a very complex interaction among three variables acting simultaneously; namely livestock grazing, plants browsed, and the environment. In general, palatability could be studied as a single factor considering the fact that it is not measurable alone since some other factors affect palatability and cause livestock to prefer particular plant species rather than the others. Livestock prefer some forage species to the others relatively. However, livestock are interested to a composition of plants they desire; otherwise, by consuming particular forage, they could not achieve necessary materials, and also they may suffer from health issues like fatigue. Under hard conditions and emergency situations, no preference value could be defined for a specific plant. Only if there are no restrictions for livestock and when they are under normal condition, then preference value finds meaning, (Moghaddam,1998).

It is possible to apply different methods for determining preference value of plant species, among which time study (Chronometry) and weighing (Cafeteria) have been used for a long time; However, time measurement (video surveillance) and direct observation of grazing by counting number of bites and utilization percentage are almost new techniques, and so they need be applied on plant species in different rangelands. Comparing such techniques and relevant findings are useful to realize rangeland carrying capacity and the amount of forage accessibility. In addition, from a scientific and practical perspective, this may guide local farmers, managers and planners in qualitative assessment of rangelands and pave the way for preservation, restoration, development and sustainable utilization of rangelands (Papachriston et al., 2005) .

Many studies have been conducted to compare different methods of determining diet composition and food preferences of livestock. Through an evaluation of the herbivore diet selection of goats in South African shrublands, (Heanley et al., 2001) compared three techniques, namely direct observation, faecal analysis and oesophageal fistulation and concluded that direct observation showed a relatively high level of precision with respect to the shrub class, but is not appropriate for grass class. (Papachristou, 2005) investigated grazing behavior of goats and sheep on Mediterranean shrublands by counting the number of bits and estimating food consumption rates. He found that when forage availability was high, 70% of the diet selected by sheep was made of wheatgrass and forbs, while shrubs were the main component of goat diet (51-90%). On his comparative study of the relationship between the palatability ranking of some important range species and grazing behavior of sheep and goats in Darbid rangeland in Yazd, (Delavaripour, 2005) showed that sheep concentrated more than 92.35% of the grazing time on key species and litter. This was followed by annual plants, and the third was dominant species of "*Artemisia sieberi"* and the companion species of "*Salsola rigida*".In addition to gustatory sense in sheep, production and presence of plants in diet composition, livestock distribution and access to

vegetation are of importance. It was found that the rates of consumption gave similar palatability rankings among different plant species for both sheep and goats; exceptionally species of and leaf litter were highly palatable for goats and sheep, respectively. However, no significant difference was observed in the morning and afternoon grazing periods. Using a time measurement method, (Ranjbari et al., 2005) studied preference values of rangeland species by goats and sheep in three phases of the grazing season on three different sites in Semirom. According to the results, there was a statistically significant difference between sheep and goats in terms of plant species selection. At the beginning of the grazing season, a strong correlation exists between the canopy cover percentage and livestock grazing preferences.

At the beginning of the grazing season livestock will have more selection power due to the presence of palatable and diverse species. After phonological stages and reduced amount of forage in rangelands, livestock selection power is reduced.

(Hunt and Hay, 1994) assessed the preference value of rangeland species for dairy cattle population in New Zealand. *Dactylis glomerata* was ranked highest in palatability, followed by the species of *Lplium hybridum*, *Phleum pratensis*, *Lolium prenne* and *Festuca arundinace*, repectively. Through a research on palatability of 16 species of "Atriplex", (Malan and Rethman, 2003) reported that the cause of difference in the palatability ranking of plants was affected by different factors, including crude protein, chemical composition, the amount of fiber, morphology, and vegetative period and growth stage. (Barcsak,1994) examined palatability of some rangeland species in Germany and concluded that in early May, livestock showed less preference value on "*Trifolium repens*", while increasing dry matter of the same forage resulted in increased palatability. Furthermore, "*Dactylis glomerata*" was one of the most palatable range species at this time but palatability was reduced significantly with increasing the fiber content, and in late May and early June the plant species showed one of the lowest palatability ratings. Studying the preference value in summer rangelands of Baluchestan (Pakistan), (Hussain and Durrani, 2009) concluded that sheep concentrated their grazing efforts on forbs, grasses, shrubs, and bush trees, respectively, by 54%, 23%, 22% and 1%. Similarly, this was obtained by 60%, 27%, 12%, and 1% for goats. (Rogosic et al., 2006) compared preference value between sheep and goats in the Mediterranean shrub lands and observed that goats exhibited a preference for browsing on shrubs and gained more weights compared to sheep, therefore it was better to keep the goats in this region. (Sanon et al., 2007) investigated grazing behavior of sheep, goat and cattle and their selection of shrub species in natural rangelands of Burkina Faso as a coastal zone. In this research, variations in grazing behavior of cattle, sheep, and goat populations were recorded every 15 min in three consecutive days for each month from May 2003 to April 2004. Results indicated a reduction in dietary efforts for all gazing livestock from the rainy season to the dry season, while rumination and resting were increased at the same time. A more reduction was recorded for cattle compared to the others (from 72% to 39%). Throughout the study, cattle spent only 4.5% of their overall time browsing. Sheep and goats respectively showed a peak of 28% and 52% for browsing behavior during the dry season. During the entire study period, 10 species were grazed by cattle, among which "*Guiera senegalensis*" ranked highest for the species selection in the rainy season, before the rain and dry season, respectively, by 59%, 54% and 84%.

Addressing the preference value of goats and sheep in n the semi-arid region of Brazil (Pfister and Malechek,1986) found that during the dry season (from May to October) preference value of goats and sheep were similar and included forbs and shrubs. In contrast, during the rainy season (from November to January grasses and forbs were

mainly grazed by sheep, while goats preferred to graze more shrubs. But in general, there was no priority between grazing of goats and sheep in these rangelands. (Baghestani, 2005) studied forage quality and grazing behavior of goats on steppe rangelands of Nodushan (Yazd) and concluded that at the beginning of the grazing season (spring and summer), livestock mainly fed on species of annual and perennial grasses rather than perennial shrubs; while at the end of the grazing season shrub species were more considered by livestock and fluctuations in rainfall affected forage yield especially annual species.

Considering the importance of preference value of range species in different months of the grazing season and its role in determining grazing capacity to achieve optimum performance of livestock, this study aimed to determine preference value of range species using the Preference Index.

Materials and methods

Study area

The study area is located between latitudes 38° to 38° 03' 23"N and longitudes 44° 58' 23" – 45 02' 29" E, 70 kilometers away from old road of Urmia – Gharabagh. It has an average elevation of 1752 meters above sea level, with an average annual rainfall of 390 mm. The area is affected by the Mediterranean climate, exerting direct impact on its thermal regime and rainfall level. According to Emberger classification, the region has a semi-arid cold climate, with a soil of sandy-clay-loam texture, and the type of animal and breed is mixed. The fenced area was half hectare. Vegetation type of the region was "*Festuca ovina-Thymus kotschyanus*". Grazing season was from May to October.

Ombrothermic curve of the study site used for the past 30 years showed that the humidity levels were high from November to May, as the wet and dry seasons lasted for 7 and 5 months, respectively (Fig.1.).

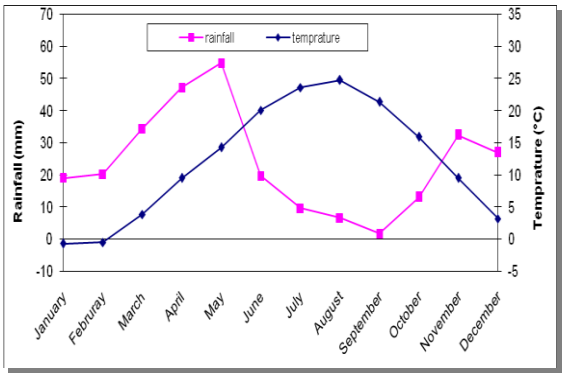

Fig. 1. Embrothermic curve of the study site.

Methodology

In this research, preference index was used to determine preference value of the species at different periods of the grazing season as follows:

In order to specify preference index, at the beginning of the grazing season, for each plant species five similar ones were selected and marked inside the exclosure and 1 to 5 similar species were identified and marked outside the exclosure. One month after livestock entering to the rangeland, the first 5 plant species for the first month were cut from inside and outside the exclosure. The forage harvested from each species was placed in separate paper bags and then weighed and recorded. Exactly one month later, the same procedure was repeated for the next months of the grazing season.

To calculate the preference index, first, data were estimated based upon production and non-cumulative consumption. For this, the production of inside the exclosure was subtracted from that of outside the exclosure, and cumulative consumption was calculated this way. Then, non-cumulative consumption was estimated by subtracting the consumption of each month from that of the previous month. Similarly, non-cumulative production was estimated by subtracting the amount of production of each month inside the exclosure from that of the related previous month. Then the ratio of species in the forage and also in diet was calculated.

The preference index was estimated by the following equation (Becker and Lohrmann, 1992); Van Dyne and Heady, 1965):
Preference Index = proportion of species in ration/ proportion of species in forage.

Finally, the obtained data (2007-2010) were analyzed using SAS statistical software based on a split-plot in a completely randomized design and mean comparisons were performed by Duncan's Multiple Range Test.

The preference value indices were determined based on the following classification:

Results and Discussion

Index > 1.2; indicates a complete preference and quite palatability of forage species,
Index 1.4- 2; indicates a relative preference and palatability of species,
Index 0. 7- 1.3; indicates an average preference and palatability of species,
Index 0.3- 0.6; indicates a relative avoidance and rarely palatable species,
Index < 0.2; indicates a complete avoidance and non-palatable species.

Table 1. Analysis of Variance of Preference Values among Different Months and Plant Species.

Source of Variation	DF	Mean Squares	F Value	Pr>F
Year	3	18.97	8.49	**< 0.0001
Error a	16	2.65		
Species	19	4.26	1.91	* 0.0109
Year x Species	57	5.64	2.53	**< 0.0001
Error b	304	2.17		
Month	3	30.31	13.56	**< 0.0001
Month x Species	57	3.24	1.45	* 0.0186
Month x Year	9	2.209	0.99	0.4 ns
Year x Month x Species	171	3.324	1.49	**< 0.0002
Error c	899	2.23		

*: $P \leq 0.05$, **: $P \leq 0.01$

Table 1. Represents the results of Multiple Analysis of Variance (MANOVA) for the preference values of various species in the study years. These results showed that the effects of year and month were significant at 1% level of probability while the effect of species was significant at 5% level of probability. Furthermore, among interaction effects, the effect of "year x species" and effects of "year x month x species" were significant at 1% and the interaction effect of "month x species" was significant at 5% level of probability. Meanwhile, the interaction effect of "year x month" was not significant. According to the results, the effect of year on preference value of the species was significant. It means that preference value of the species significantly differed among years. Furthermore, the effect of species on preference value and species selection by livestock was significant at 5% level of probability and different preference values were recorded for different species.

The maximum and minimum preference values were obtained for the species of "*Astragalus effuses*" (1.42) and "*Ziziphora clinopodioides*" (0.49), respectively. The effect of month on preference value was also significant at 1% level of probability. The highest and the lowest preference value were recorded for June (1.23) and the August

(0.50), respectively. The results of mean comparisons of preference value for plant species and the months being studied are represented in Fig.1. and Fig.2. In addition, the interaction effect of "year x species" and "year x month x species" on preference value were significant at 1% level of probability; and the interaction effect of "month x species" was significant at 5% level of probability. Fig.3. shows the results of mean comparisons of interaction effect of "month x species".

Table 2. Mean Comparisons of Preference Values of studied species.

Spceies	Preference Index
Astragalus effusus	1.43 [a]
Helychrysum plicatum	1.17 [ab]
Bromus tomentellus	1.13 [abc]
Dactylis glomerata	1.10 [abcd]
Festuca ovina	1.08 [abcd]
Koeleria cristata	1.07 [abcd]
Galium verum	1.05 [abcde]
Teucrium polium	1.03 [abcde]
Cephalaria microcephala	1.03 [abcde]
Poa bulbosa	1.01 [abcde]
Agropyron trichophorum	1.01 [abcde]
Crucianela gilanica	1.01 [abcde]
Fibigia macrocarpa	0.92 [abcde]
Agropyron intermedum	0.92 [abcde]
Jurinea leptoloba	0.87 [abcde]
Annual forb	0.80 [bcde]
Stipa barbata	0.72 [bcde]
Annual grass	0.58 [cde]
Thymus kotschyanus	0.55 [de]
Ziziphora clinopodioides	0.49 [e]

Fig. 3. represents the results of mean comparisons of interaction effect of "species x month". The highest preference value was recorded for *Dactylis glomerata* in June. However, the lowest preference value was obtained for "*Stipa barbata*" in August.

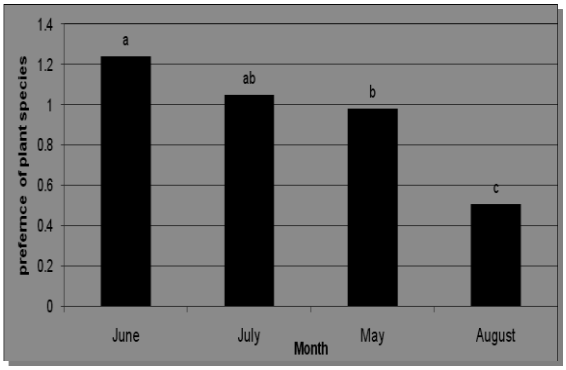

Fig. 2. Mean Comparison of Preference Value of Study Months.

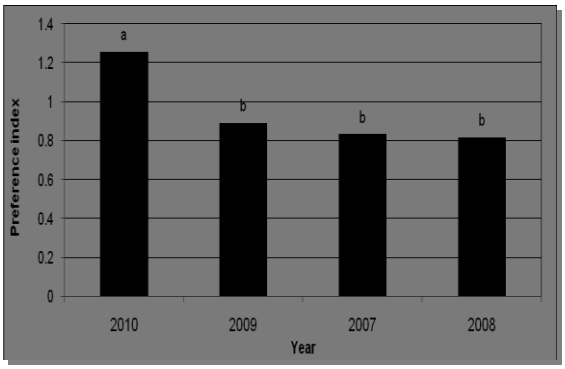

Fig. 3. Mean Comparisons of Preference Values of Study Years.

According to the research findings, the year had a significant effect on preference value of the plant species. It means that there is a statistically significant difference among preference value of the species in different years. Furthermore, the effect of species on preference value and species selection by livestock was significant at 5% level of probability. Since the forage quality indices such as dry matter digestibility, crude protein and metabolic energy lead to differences in forage quality and plant palatability, the species differ in terms of preference value for livestock. This result is compatible with findings of (Arzani et al., 2006, Baghestai et al., 2001), and (Norton et al., 2000).

Table 3. Mean Comparisons of Preference Values for Interaction effect of "Month x Species" in Study Months.

Species	Month	Preference Index	Species	Month	Preference Index
Astragalus effusus	May	0.73 bcdefghi	*Agropyron trichophorum*	May	0.78 bcdefghi
	June	0.80 a		June	1.18 bcdefghi
	July	1.13 bcdefghi		July	0.71 bcdefghi
	August	0.55 defghi		August	0.99 bcdefghi
Helychrysum plicatum	May	0.69 bcdefghi	*Crucianela gilanica*	May	0.97 bcdefghi
	June	0.50 defghi		June	0.84 bcdefghi
	July	0.93 bcdefghi		July	0.63 cdefghi
	August	0.12 ghi		August	0.39 fghi
Bromus tomentellus	May	0.73 bcdefghi	*Fibigia macrocarpa*	May	1.04 bcdefghi
	June	1.28 bcdefghi		June	1.59 abcdef
	July	0.17 ghi		July	0.75 bcdefghi
	August	0.04 i		August	0.69 bcdefghi
Dactylis glomerata	May	0.81 bcdefghi	*Agropyron intermedum*	May	0.81 bcdefghi
	June	1.98 ab		June	1.41 abcdefgh
	July	1.12 bcdefghi		July	0.94 bcdefghi
	August	0.21 ghi		August	0.88 bcdefghi
Festuca ovina	May	0.79 bcdefghi	*Jurinea leptoloba*	May	1.05 bcdefghi
	June	1.31 bcdefghi		June	1.26 bcdefghi
	July	1.06 bcdefghi		July	1.24 bcdefghi
	August	0.42 efghi		August	0.72 bcdefghi
Koeleria cristata	May	0.86 bcdefghi	*Annual forb*	May	1.14 bcdefghi
	June	0.78 bcdefghi		June	0.62 cdefghi
	July	0.10 hi		July	1.23 bcdefghi
	August	0.15 ghi		August	0.49 defghi
Galium verum	May	0.85 bcdefghi	*Stipa barbata*	May	1.06 bcdefghi
	June	1.45 abcdefg		June	2.57 a
	July	1.68 abcdef		July	0.73 bcdefghi
	August	0.15 ghi		August	0.02 i
Teucrium polium	May	1.07 bcdefghi	*Annual grass*	May	1.17 bcdefghi
	June	0.85 bcdefghi		June	0.77 bcdefghi
	July	1.34 bcdefghi		July	1.26 bcdefghi
	August	1.26 bcdefghi		August	0.80 bcdefghi
Cephalaria microcephala	May	0.99 bcdefghi	*Thymus kotschyanus*	May	1.07 bcdefghi
	June	0.63 cdefghi		June	1.74 abcde
	July	1.91 abc		July	1.12 bcdefghi
	August	0.94 bcdefghi		August	0.39 fghi
Poa bulbosa	May	0.96 bcdefghi	*Ziziphora clinopodioides*	May	1.99 ab
	June	1.32 bcdefghi		June	1.81 abcd
	July	0.92 bcdefghi		July	1.80 abcd
	August	0.76 bcdefghi		August	0.10 hi

The maximum and minimum preference values were obtained for the species of "*Astragalus effuses*" (1.42) and "*Ziziphora clinopodioides*" (0.49), respectively. *Astragalus effusus*" belonging to the family of Fabaceae (or Leguminosae) is a perennial and palatable species on steppe rangelands. Because of its very high nutritional value and palatability, it is generally preferred by grazing livestock, in particular sheep, and plays a great role in composition of livestock diet.

(Moghadam, 1998) Considered palatability ranking and frequency of the companion species, as well as vegetation composition as effective parameters for the species preference value, In addition, many factors including gustatory sense of livestock, yield and composition percentage of available plants, livestock distribution and access to plants have great effects on preference value, (Baghestani, 2005).

"*Ziziphora clinopodioides*" received the lowest importance rating among selected species in terms of consumption and diet. By a preference value of 20, 0.75 second was recorded as the time spent for grazing by livestock. This might be due to the presence of chemical compositions like essential oils, resulting to low desirability, (Barrton et al., 2007). Also, other studies indicated that among factors affecting the grazing behavior such as biomass, frequency of forage species and crude protein content the maximum correlation was found between plant selectivity and the crude protein content ,(Senft et al.,1985).

For the effect of month, since the vegetative growth stage in most studied species was from March to early June and the seeding stage occurred in mid-July to early August, it seems consequently that forage quality of plant species differ in various phonological stages; The most desirable quality was associated with the vegetative growth stage, while the lowest quality was obtained for the seeding period.

In other words, the growth stage was the most important factor affecting the quality and nutritional value of forage plants, (Arzani, 2006). In the current study, at the beginning of the growth stage plants showed more desirability and preference value for grazing livestock. It may be due to some plant characteristics including being watery and tender, high stem to leaf ratio and low indigestible material compared to final growth stages in which moisture content and plant vitality are reduced and woody parts of plants increase which consequently lead to low digestibility. This finding is compatible with results of (Arazani et al., 2004), and (Ghadaki et al., 1974). (Ahmadi and Peiravi, 2009) studied grazing behavior of Zandi sheep and similarly concluded that preference value of each species differed during the months. These findings emphasize that grazing time affect the proportion of plant species in livestock diet and preference value of a certain species and ultimately the species selection by livestock.

Conclusion

For studies on preference value, it is necessary to develop a palatability coding system for any particular livestock. Also, different age classes of livestock, growth stages and so on should be taken into account. It should be noted that preference value could not be determined as an absolute value, even for a given breed. Another important point is that results of preference value for a certain kind of livestock find meaning only with regard to the composition and percentage of the existing plants.

References

Ahmadi A, Peiravi M. 2009. Effects of animal age and different months of grazing season on grazing behavior and diet selection of Zandi ewes grazing in steppe rangelands (case study: Yekke bagh, Qom). Iranian Journal of Range and Desert Research **16**, 536-5560.

Arzani H, Ahmadi A, Azarnivand H, Jafari AA. 2006. Determination and comparison forage quality of five species in three phonological stages. Iranian Journal of Agricultural Science **37**, 303-311.

Arzani H, Zohdi M, Fish E, Zahedi A, Nikkhah GHA, Wester D. 2004. Phenolojical effects on forage quality of five grass species. Journal of Range Management **57**, 624-630.

Baghestani N, Arzani H, Zare T, Abdollahi J. 2001. Study of forage quality the important species of stepic rangeland of Poshtkhoeh Yazd. Iranian Journal of Range and Desert Research **11**,137-162.

Baghestani N. 2005. Harvesting time and rate in arid lands with regards to rainfall regime, the Management of Arid Regions Conference Proceedings. Technical Office of pasture, 84 pages.

Barcsak Z. 1994. Correlation between the palatability of grasses and their soluble sugar contents. Novenytemeles **48**, 221-228.

Barrton ChM, Barrton MD, Naseri M, Kamali Nrjad M, Bazargan M. 2007. Essential oil Composition and antibacterial effects of Ziziphora clinopodioides Lam. 17th European Congress of Clinical Microbiology and Infectious Diseases ICC, Munich, Germany, 31 Mar-04 Apr: Abstract .number: 1733-303.

Becker K, Lohrmann J. 1992. Feed selection by goats on tropical semi-humid rangeland. Small Rumin **8**, 285–98.

Delavaripour A. 2005. Comparison of palatability of some important range species in Darbid (Yazd) In relation to sheep and goat grazing, M.sc Thesis of range management, Islamic Azad University, Iran, branch of science and research.

Ghadaki MB, Van Soest PY, Mcdowell RE, Malekpour B. 1974. Composition and In-vitro digestibility of some arid zone forage from Iran. In: XII International Grassland Congress **III**, 542-549.

Heanley SR, Smith DJ, Raats JG. 2001. Evaluation 3 techniques for determining dietcomposition. Journal of Range Management **54**, 582-588.

Hunt WF, Hay RJM. 1990. A photographic technique for assessing the pasture species preference of grazing animals. Proccedings of the New Zealand Association **51**, 191-196.

Hussain F, Durrani MJ. 2009. Seasonal availability, palaitability and animal preferences of forage plant in Harboi Arid Rangeland, Kalat, Pakistan. Pak. J.Bot **41**, 539-554.

Malan PJ, Rethman NFG. 2003. Selection preference of sheep grazing different Atriplex species, 7 th international rangeland congress, Durban, Ireland.

Moghaddam MR. 1998. Pasture and Range Management, Tehran University Press, 470 pp.

Norton BW, Waterfall MH. 2000. The nutrient value of tipunatiou and calliandra calochrasus as supplements to low-quality straw for goats. Small Ruminant Research **38**, 175-182.

Papachriston TG, Dziba LE, Provenza FD. 2005. Botanical composition determination of range herbivore diets: a review. J. Small Ruminant Research **59**, 141-156.

Pfister JA, Malechek JC. 1986. Dietary selection by goats and sheep in a deciduous woodland of Northeastern Brazil. Journal of Range Management **39**, 24-28.

Rangbari AMR, Jowhari M. 2005. Studying of grazing behaviour of sheep and goat during grazing season in Semirom rangelands, proceedings of second seminar of sheep and goats of Iran.

Rogosic J, Pfister JA, Provenza FD, Grbesa D. 2006. Sheep and goat preference for and nutritional value of Mediterranean maquis shrubs. Small Ruminant Research **64**, 169–179.

Senft R, Rittenhouse L, Woodmanse RG. 1985. Factors Influencing Patterns of Cattle Grazing Behavior on Shortgrass Steppe. Journal of Range Management **38**, 82-87.

Sanon HO, Kabor´e-Zoungrana C, Ledin I. 2007. Behaviour of goats, sheep and cattle and their selection of browse species on natural pasture in a Sahelian area. Small Ruminant Research **67**, 64-74.

Van Dyne GM, Heady HF. 1965. Botanical composition of sheep and cattle diets on a mature annual range. Journal of Agriculture Science Hilgardia **36**, 465-468.