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Research and Full Length Article:

Determination and Comparison of Preference Value for Five Halophyte Species in Marginal Rangeland of Salt Lake in Aran and Bidgol Region, Kshan, Iran

Reza Dehghani Bidgoli[A*]
[A] Assistant Professor, Department of Watershed &Rangeland Management University of Kashan, Iran
*(Corresponding Author), Email: dehghanir@kashanu.ac.ir

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Abstract. Since the halophytes species have an important role in such ecosystem balance and they have been grazed by livestock as supplementary forage, the awareness of livestock's desire to grazing and their preference values of these species is of high priority. Regardless of the importance of halophyte species in the livestock feeding in Iran, there is less published research on the livestock grazing from these species. In present study, the preference value of the five halophyte species (*Seidlitzia rosmarinus*, *Salsola crassa*, *Aeluropus littoralis*, *Suada fruticosa and Anabasis setifera*) was determined using preference index and timing methods in the marginal rangelands of Aran and Bidgol salt lake, Kashan, Iran in 2013-2016 during the grazing season. The preference values of these halophytes spices were assessed using Whittaker and Niering method. In the timing method, the animal grazing for 20 minutes was filmed for 1 to 2 hours after the flock arrival to the rangeland, and the grazing time of each species was recorded. According to the results of the analysis of variance, the species effect was significant for both grazing time and preference index ($p<0.01$). The results of the mean comparison showed that the *Aeluropus littoralis* with average values of 0.636 and 10.1 had a higher preference index and grazing time by livestock than that for other halophyte species, respectively. Also, in terms of livestock behavior for both factors, the highest grazing time was observed in October followed by November. The results of the species by grazing season interaction effect showed that the *Salsola crassa* and *Aeluropus littoralis* had higher preference indices for grazing whereas *Seidlitzia rosmarinus* and *Aeluropus littoralis* had longer times of grazing. According to the results of this research, the timing method was introduced as an appropriate method to determine the preference values of halophyte species in the studied area.

Key words: Grazing season, Playa, Halophyte, Livestock, Palatability

Introduction

The preference value of the range species is variable during the grazing season. In the meantime, the type of livestock that feeds from the rangelands is one of the important factors to determine the grazing capacity (Allison, 1985; Askarizadeh and Arzani., 2018). Some of the researchers consider that the preference value and palatability are sometimes used instead of each other mistakenly; palatability is a term used by range experts to select a plant (Provenza and Balph, 2011; Ngwa *et al*., 2000) while the other livestock experts call this mode as preference value (Malechek, 2013; Whittaker and Niering, 2009).

Supplementary feeding with sufficient energy from the small ruminants such as halophytes during the dry seasons and prolonged drought period is recommended. (El-Shaer, 2018). Halophyte plant species vary considerably in their nutritive value and information on forage quality of halophytes in each phenological stage and awareness of preference value of these range species could help range managers to choose suitable plant species for cultivation and also determine the suitable grazing time to achieve higher animal performance in the saline rangelands (Stoddart *et al.*, 1975; Miftakhova *et al.*, 2018). Also, the knowledge of the preference value is useful for the determination of rangeland capacity and the appropriate timing for the entrance of animals in rangeland. In addition, definition of the preference value in different plant species can be helpful for range managers to select suitable grazing times and stocking rates to extract maximum performance without damaging the existing vegetation.

The palatability or amount of attractiveness and quality of the plant for livestock is typically related to the morphological and chemical characteristics of plant species, and also, the plant growth stage and environmental factors can be considered as effective agents. As, there are some factors that are beneficial to the palatability and cause the livestock to prefer some plants to other plants, but the preference value is to prefer the livestock to feed a plant than other plants although the livestock can freely choose the plant species for grazing (Heady, 1984; Rogosic *et al.*, 2006). The preference value is affected by livestock characteristics such as age, sex, type and physiological stages. Also, some factors are related to plant growth rate, flowering, phonology, morphology, chemical compounds, dominant type and availability (Arzani, 2009; Arzani *et al.*, 2006; Senft, 1989).

Many of the halophytic plant species and salt-tolerant species provide a valuable reserve feed for grazing animals particularly under salt stress or fill regular gaps in feed supply caused by seasonal conditions (Nedjimi, 2017a). The value of halophyte species has been recognized by their incorporation in pasture improvement programs in many salt-affected regions throughout the world. There have been recent advances in selecting species with high biomass and protein levels and the ability to survive a wide range of environmental conditions including salinity. For example, *Salsola crassa* has been field-tested for domestic livestock and found to produce good fodder with biomass varied from 0.5 to 5 kg DW/ha. This productivity is mainly related to the water availability and soil depth or *Seidlitzia rosmarinus* had higher protein content that could cover N requirements in the grazing period (Nedjimi, 2017b).

Aeluropus littoralis is palatable; the leaves of this species have 12-22% protein content and regenerate well after grazing. The aerial parts of *Suada fruticosa* contain 16.8% protein, 0.9% fat, 22.4% fiber, 15.8% ash and 44.2% ADF. Its leaves are used as a spinach substitute; they have a bland flavor

and are often mixed with stronger tasting leaves (Bown, 2016; Miftakhova *et al.,* 2018). Also, the seeds of this species, harvested when just ripe, are effective as a laxative (ACSAD, 1979).

In general, the preference value has a broader concept and to include the palatability. In other words, the palatability affecting the preference value and the preference value is the performances of all the factors that make the livestock prefer the plant to another plant. Currently based on available scientific resources, the methods of estimating the dietary composition and preference value of livestock in the rangelands were divided into five groups: 1) Studying forage consumption, 2) Using fistula, 3) Collection and analysis of feces, 4) Exploitation techniques and 5) Direct observation (Holechek, *et al.,* 1984; Malechek, 2013).

Aregheore *et al.* (2006) studied the composition of the herbal diet of sheep and found that it was consisted of 2 to 23% branches, 9 to 62% broad leaves, and 36 to 84% thin leaves. They emphasized the diversity of sheep's diet. One of determining method of utilization percent of rangeland species per month from the grazing season is paired cages method; in this method, only the percentage of species exploited by livestock is shown (Habibian *et al.,* 2010; Sanadgol, 2011). In the uniform pasture, the supply of forage is affected by the amount of forage consumed and its durability. This situation does not happen to uneven pastures and shrublands in these pastures, the livestock‘s preference is at different levels, and the livestock at the start of grazing selects an area and then goes to the next area (Phayaz *et al.,* 2011; Abdelsalam *et al.,* 2017).

One of the basic tools in rangeland management is the determination of the grazing capacity that leads to the optimum performance for livestock and it guarantees the health of the rangeland ecosystem. According to past studies, several factors affected determination of the rangeland’s capacity such as forage production, preference values and appropriate allowable use. The preference value means the livestock preferring to feed a plant to other plants; however, the livestock is able to select plants for grazing freely (Miller, 2015).

Rashtian *et al.* (2008) to determine the preference value of seven important rangeland species in a steppe rangeland of Yazd province, Iran reported that the sheep spend much of their grazing time to *Teragopegon sp., Artemisia sp.* and then, other annual plants with attention to the preference value of rangeland species in different months in the grazing season; one can achieve optimum performance of livestock, and could determine grazing capacity in the rangelands.

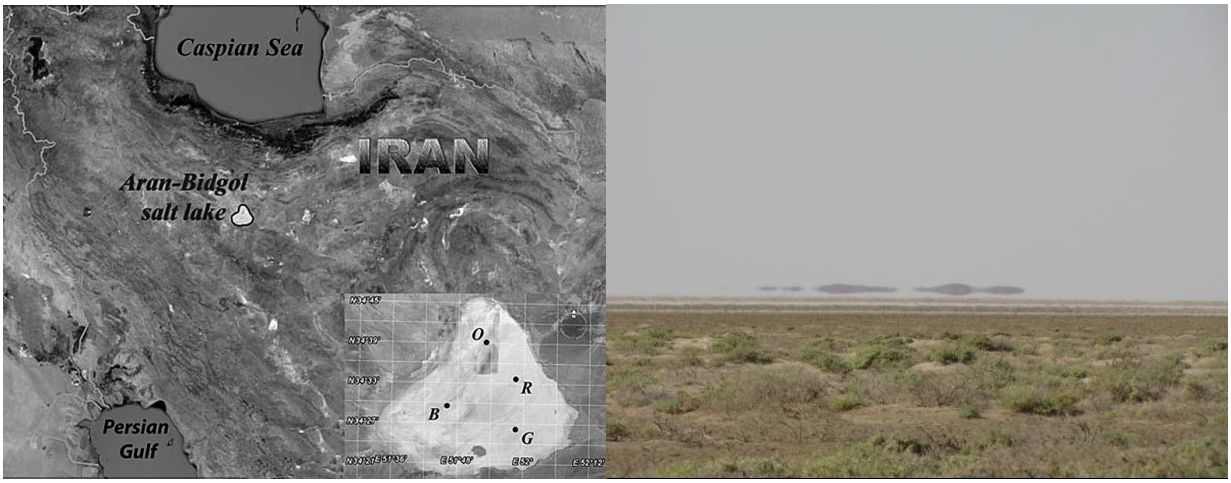
Regardless of the importance of halophyte species in the livestock feeding in arid and semi-arid regions, there is no documented research on the livestock grazing from these species. This issue becomes more important in autumn and winter seasons; this study aimed to determine the preference value of five halophyte species in the marginal rangeland of salt lake in Aran and Bidgol region, Kashan, Iran by preference index and the timing methods.

Materials and Methods

Study area

The study area is located in the northeast of Aran and Bidgol city in the geographical position of 59°29'45" eastern longitude and 34°14'20" northern latitude with the area of 3500 ha. The elevation of the area from the sea level is 890 m, the evapotranspiration rate is 2626 mm and the average annual precipitation is 90 mm (Isfahan Meteorological Organization, 2017). The

climate type of the study area is dry based on the modified Domaten method and the soil of this area is arid with low groundwater level and with approaches and the salt lake appears saline and alkaline (Rohban *et al.*, 2009). The presence of salt and gypsum in the soil is edaphic characteristics of habitat from this plant species. The location of the studied area on the map is shown in Fig. 1.



(A) (B)

Fig. 1. Location of the Aran-Bidgol lake (A), marginal rangeland (B)

The hyper-saline lake in the Aran-Bidgol region covers an area of 2,400 km^2 in the central part of Iran. This lake is located at an altitude of 800 m in an area with an arid to semiarid continental climate. It was formed by the deposition of halite sediments from an ancient sea in different geological periods (Pliocene). In the wet season, these sediments are dissolved by rainfall (mean annual rainfall of 50–200 mm) and later subjected to high evaporation (mean annual evaporation of 1,727 mm) resulting both in elevated temperatures (up to 50°C, yearly fluctuations between 10°C–50°C) and high salinity of the brine. During the dry season, the salinity of the lake increases up to saturation, allowing for commercial production of halite.

The study area has playa physiographic types and its vegetation physiognomy is shrub. According to the measurements, the dominant vegetation types of this area are *Seidlitzia rosmarinus* and *Anabasis setifera* and *Halocnemum strobilaceum*, *Salicornia fruticosa*, *Suaeda aegyptiaca* from the accompanying species and the most prominent annual species are *Bromus* L ., *Convolvulus arvensis* and *Suaeda dimorphestegi*. Grazing season date in this area starts from late April until November which is largely dependent on the annual precipitation changes (Habibian *et al.*, 2010).

In this area, some plant species have salt tolerance up to 12 ds/m. *Salsola crassa* and *Anabasis setifera* prefers loamy soils, and grow in very alkaline and saline soils, these two species propagates either from seeds or from roots and can stand considerable drought. Sometimes, they are the exclusive visible plant, especially around settlements. In addition, they are the indicator of overgrazing and vegetation degradation (Zandi Esfahan *et al.*, 2010).

Methodology

In the present study, the preference value indices of five halophytes species (*Seidlitzia rosmarinus, Salsola crassa, Aeluropus littoralis, Suada fruticosa and Anabasis*

setifera) (Fig. 2) were determined by timing method (Grazing minutes) in the grazing seasons during the 2013 to 2016 years. The preference values of these five halophytes species were measured by Whittaker and Niering method (2009). In this method, the consume percentage of these five halophytes species was measured in the grazing area at three phenological stages. In the timing method, after the flock arrival to rangeland, the animal grazing was filmed during 1 to 2 hours for 20 minutes, and the grazing time of each species was specified; then, plant species were arranged according to their grazing time in each month.

Seidlitzia rosmarinus

Aeluropus littoralis

Salsola crassa

Suada fruticosa

Anabasis setifera

Fig.2. Halophyte species in the marginal rangelands of Aran and Bidgol salt lake

Finally, the preference values of plants were calculated based on the selection index according to the equation 1 and palatability was measured based on the PI index in Table 1 (Baumont *et al*., 2000; Vallentine, 1990).

(1)

$$\text{Preference index (PI)} = \frac{\text{species rate in ration}}{\text{species rate in forage}}$$

The production ratio equals to the production of each plant species in the month and is divided to total production forage in the month multiplied by 100 and the ratio of the diet equals to the consumption of each species in the month divided by total consumed forage in the month and multiplied by 100.

Before the analysis, data were tested for normality with the Shapiro-Wilk statistic index. Finally, the data were analyzed by the SAS software version 15.1 and the means were compared by Duncan's multiple range test at $P<0.01$.

Table 1. Classification of palatability based of (PI) index

Preference Index	Class of palatability
PI>2.1	Highly Palatable
1.4- 2.0	Very Palatable
0.7- 1.3	Palatable
0.3- 0.6	Non Palatable

Results

The analysis of variance for grazing timing and preference value indices for five halophytes species during 4 years was shown in Table 2. As the results show, for grazing time, the effects of year, phenological stage, species and their interaction were significant. Similarly, for preference index, the effects of phenological stage and species and their interaction with year were significant (Table 3). The means comparison of five halophytes spices is shown in Table 3; according to the results, *Seidlitzia rosmarinus* had the highest value for two methods. For preference index method, *Salsola crassa*, *Aeluropus littoralis* and *Suada fruticosa* species had no significant difference. *Anabasis setifera* had the lowest preference value using both methods. In comparisons between moths, higher and lower preference values were observed in October and July, respectively. There was no significant difference between October and November for grazing timing method but for preference index method, there was a significant difference between October and November. Also, there was no

difference between the last two months in the grazing season according to both methods (Table 4). According to the results, there is a significant difference between years for grazing times but there was no difference between years for preference index method. In the timing method, the highest grazing time was observed in 2015 and there was no difference between 2014 and 2016 in terms of this factor (Table 4). All of the plant species had the highest preference value in October and November in timing and preference index methods, the lowest values were observed in June followed by July that showed significant differences in both methods (Figs. 3 and 4).

Table 2. Analysis of variance of five halophyte species based on timing and preference index method

Source	DF	MS	
		Grazing time	Preference index
Year	3	152.33**	0.056
Month	8	3.25	0.183
Stage	3	106.23**	4.66**
Year× stage	8	138.15**	0.285**
Stage× Month	22	3.28	0.113
Species	4	698.23**	0.328**
Stage × species	12	210.05**	0.302**
Year× species	11	589.30**	0.202**
Year× stage × species	29	198.56**	0.136**
Error	98	1.59	5.86

**= Significant at 1% probability level

Table 3. Mean comparison of the five halophyte species preference value based on timing and preference index

Species	Preference index	grazing time (min)
Seidlitzia rosmarinus	0.482 [a]	12.661[a]
Aeluropus littoralis	0.635 [a]	10.101[b]
Salsola crassa	0.608 [a]	5.665 [c]
Suada fruticosa	0.491 [ab]	3.234 [d]
Anabasis setifera	0.263 [b]	1.817 [e]

The means of column followed by similar letters are not significantly different based on DMRT P<0.05 method

Table 4. Means comparison of month and year average over five halophyte species for preference value and grazing time

Grazing Period	Months/years	Preference index	Grazing time (min)
Month	October	1.350 [a]	8.49 [a]
	November	0.802 [b]	9.06 [a]
	June	0.031[c]	6.11 [b]
	July	0.001[c]	5.47 [b]
Year	2013	0.39 [a]	4.83 [c]
	2014	0.68 [a]	6.65 [b]
	2015	0.45 [a]	8.35 [a]
	2016	0.52 [a]	7.03 [b]

The means of column followed by similar letters are not significantly different based on DMRT P<0.05 method

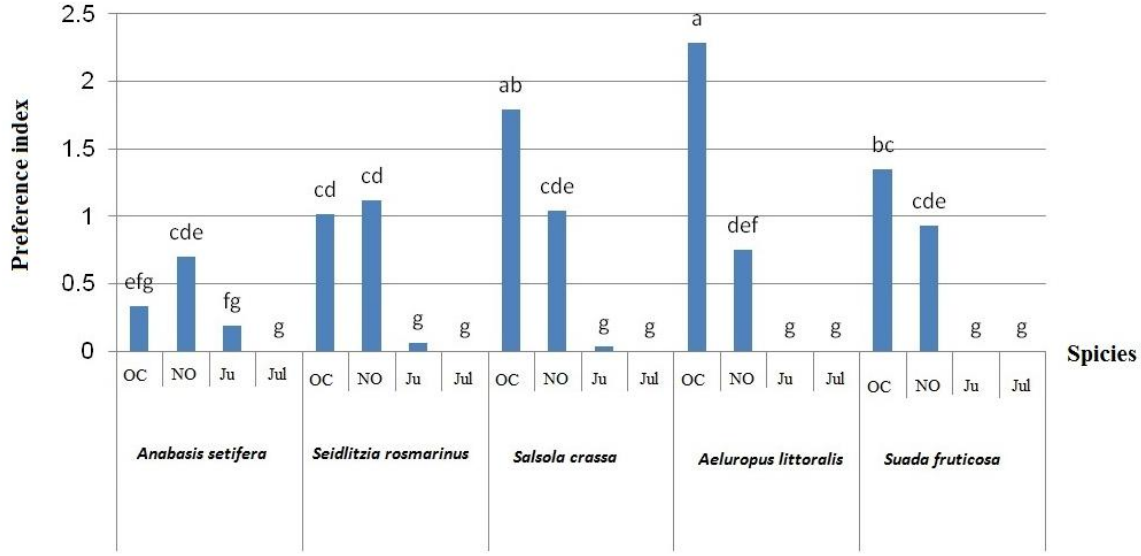


Fig.3. Means comparison of species by grazing season interaction for preference index
The means of column followed with letters are not significantly different based on DMRT P<0.05 method

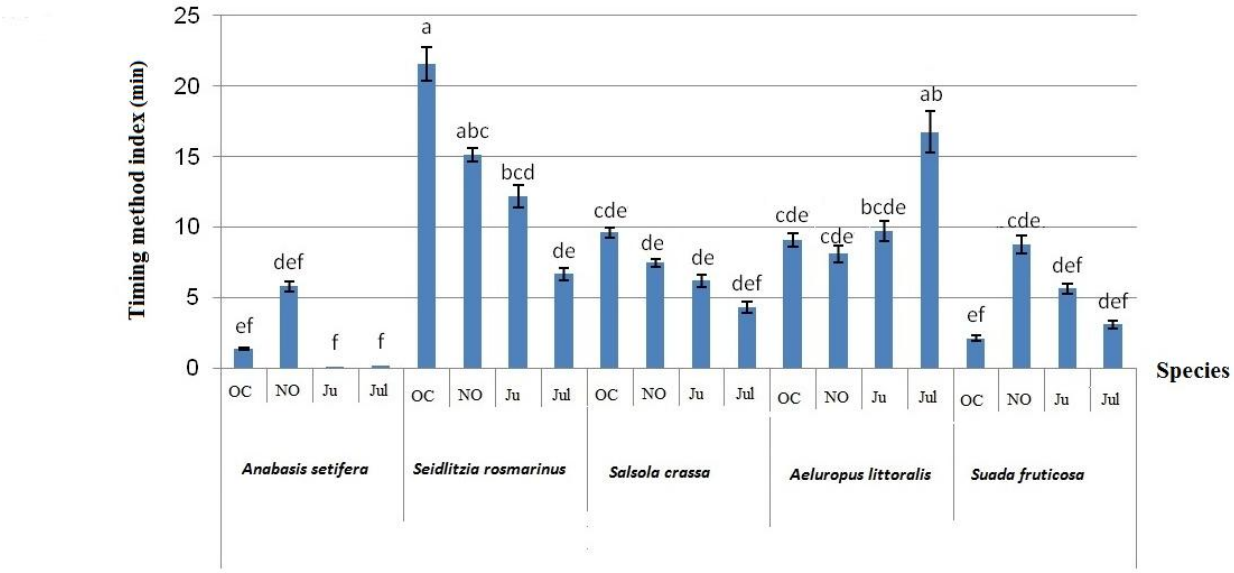


Fig.4. Means comparison of species by grazing season interaction for grazing timing method
The means of column with similar letters are not significantly different based on DMRT P<0.05 method

Discussion

The results of the preference value of five halophytes species showed that the *Seidlitzia rosmarinus* was the dominant type in the studied area and based on the timing method, this species had the highest preference value than other species and *Anabasis setifera* had the lowest preference value for grazing. Also, *Aeluropus littoralis* and *Salsola crassa* had the highest

preference index and *Anabasis setifera* had the lowest values by both methods. In the studied area, *Seidlitzia rosmarinus* was more abundant than other species; therefore, it seems that estimation of preference value of species using the timing method is more preferable than the preference index. This finding was validated by the findings of Abdullahi *et al.* (2009) who mentioned that small distribution of species is due to consumption rate of the plant (Springfield and Reynolds., 2016; Malechek, 2013; Miller, 2015). Ahmadi *et al.* (2009) confirmed a direct relationship between the plant availability and its selection as a feed by livestock. However, in the present study in both methods, *Anabasis setifera* was a plant species with low palatability and the livestock select this species after the loss of the other palatable species. In overall, the changes of the preference value of these plant species were significant in the timing method, these results are somewhat different from the finding of some studies (Hussain and Durrani., 2009; Miftakhova *et al.*, 2018) that indicated the preference value of *Salsola crassa* by both timing and preference index methods and reported that the *Suada fruticosa* has higher preference value than *Salsola crassa*. Also, they mentioned that *Suada fruticosa* had lower preference value than *Salsola crassa* although there was no significant difference between them for preference index. According to the results of present research in the grazing period (June to November), there was no significant difference between October and November in the timing method but the highest and lowest grazing values were obtained in October and July, respectively.

Mirdavoodi and Sanadgol (2008) reported that the preference value of the plant species is highly variable in different periods of the grazing season and between different plant species. The results of the species by grazing season interaction showed that *Aeluropus littoralis* had the highest value in October by preference index while *Seidlitzia rosmarinus* occupied a higher level in the study area. Also, *Aeluropus littoralis* had the maximum value in November for timing method. *Anabasis setifera* had been assigned to the lowest grazing value because of lower palatability in both methods but this minimum value was in July in the preference index method and in June in timing method although both months had shown no significant differences as compared with both methods as Ahmadi *et al.* (2009) indicated the interaction between of the animal age, species, months and preference index and grazing time.

According to the results of the preference value comparison of species in four years, it was found that the amount of forage consumption was reduced in 2014 and 2015 as compared to 2013 in both methods, so the grazing pressure reduced on the perennial grasses in these times. The results related to the timing method showed that the highest amount of grazing time was in 2015 and 2016, respectively. This result is consistent with the amount of rainfall in these years and indicates that fertility had a direct impact on the growth of these species. Also, the preference value of these halophyte species changes at different periods of the grazing season and between different species and in different years although this difference was not significant especially in years and species while the timing method was significant in all investigated species and the results of this method with the results of preference value by timing were not matched to the research conducted (Sanon *et al.*,2011) showing that there was no significant difference in preference value of species in sites, months and years. Such a difference can be attributed to the monopolistic characteristics of halophytes and their growth period. Ahmadi *et al. (*2008) in their study showed that the preference value of each grazed species during different months was variable that

was seen in our study too. As the results showed, the timing method provides more realistic results than the preference index method because of concrete and tangible results that are the same as the result of some studies (Okhovvat, 1999 and Nedjimi, 2017) that investigated the both bite count and timing methods in the semi-stepped rangeland in UAE country and stated that both methods had the same results. Rashtian *et al.* (2008) prefer morsel counting method to the timing method because of measuring with least means and equipment. They determined the preference value of seven important rangeland species in the steppe areas of Yazd province in Iran, which was done by timing and morsel counting methods.

Conclusion

As explained in the previous sections, halophytic and salt-tolerant plant species provide a valuable reserve feed for livestock, particularly under crisis conditions. So, there are some advances in the selection of plant species with high biomass and protein levels and the ability to survive a wide range of environmental conditions including salinity.

One of the important factors in determining the grazing capacity of rangelands is to determine the preference value of rangeland plants according to the type of livestock that using the pasture and its changes during the grazing season. On the other hand, one knows there are some factors that are beneficial to the palatability and cause the livestock to prefer some plants to others, but the preference value is to prefer livestock to feed a plant than other plants although the livestock can freely choose the plant species for grazing. Undoubtedly, raising the awareness in this area is an effective step in the proper management of livestock grazing. Considering the sum of factors and specific features of the studied area, the timing method is recommended because of its high accuracy, ease of implementation and repetition by computer operations that lead to longer time consuming and much cost than morsel counting. In summary, relying on the results of this study, the better measurement could be taken to planning the livestock grazing from the halophyte species.

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تعیین و مقایسه ارزش رجحانی پنج گونه شورپسند در مراتع حاشیه دریاچه نمک منطقه آران و بیدگل، کاشان، ایران

رضا دهقانی بیدگلی[الف*]

[الف] استادیار گروه مرتع و آبخیزداری دانشگاه کاشان * (نگارنده مسئول)، پست الکترونیک: dehghanir@kashanu.ac.ir

چکیده. باوجود اهمیت گونه‌های شورپسند در تغذیه دام در ایران، متاسفانه، تحقیقات زیادی در زمینه چرای دام از این گونه‌ها صورت نگرفته است. در این مطالعه ارزش رجحانی پنج گونه شورپسند شامل *Seidlitzia rosmarinus*، *Salsola crassa*، *Aeluropus littoralis*، *Suada fruticosa* و *Anabasis setifera* با استفاده از شاخص‌های اولویت و روش زمانی در مراتع حاشیه‌ای دریاچه نمک آران و بیدگل از در سال‌های ۱۳۹۲ الی ۱۳۹۵در طول فصل چرا مورد مطالعه قرار گرفت. در این راستا ۵ گونه هالوفیت در اواخر هر ماه از داخل و خارج محدوده چرای دام برداشت شدند و ارزش رجحانی آنها با استفاده از روش Whittaker و Niering اندازه گیری شد. در روش زمان بندی، چرای دام در مقاطع زمانی۲۰ دقیقه‌ای به مدت ۱ تا ۲ ساعت پس از ورود گله به مرتع فیلم‌برداری شد و به این ترتیب زمان اختصاص یافته به چرای هر گونه مشخص شد. با توجه به نتایج تجزیه واریانس، اثر گونه در هر دو روش معنی دار بود. نتایج مقایسه میانگین پنج گونه هالوفیت در روش شاخص رجحان و روش زمانی نشان داد که گونه *Aeluropus littoralis* با به ترتیب با میانگین ۰/۶۳ و ۱۰/۱ بیشتر از سایر گونه‌ها مورد توجه دام قرار گرفت. همچنین از نظر رفتار چرایی دام در دو روش شاخص رجحان و روش زمانی نتایج نشان داد که از نظر این دو شاخص بیشترین زمان چرای دام به ترتیب در دو ماه مهر و آبان انجام شده است. نتایج حاصل از اثر متقابل گونه در فصل چرا نشان داد که در روش شاخص رجحان دو گونه *Salsola crassa* و *Aeluropus littoralis* بیشتر از سایر گونه‌ها مورد چرای دام قرار گرفته اند در حالیکه در روش زمانی دام‌ها بیشتر از دو گونه *Seidlitzia rosmarinus* و *Aeluropus littoralis* چرا نموده‌اند. از آنجایی که گونه‌های شورپسند نقش مهمی در تعادل اکوسیستم ایفا می‌کنند و همچنین به عنوان علوفه اصلی و حتی علوفه مکمل توسط دام مورد استفاده قرار می‌گیرند، بنابراین آگاهی از تمایل دام‌ها به تغذیه از این گونه ها و تعیین ارزش رجحانی آنها بسیار مهم است. بر اساس نتایج این تحقیق، روش زمانی، روش مناسب‌تری برای تعیین ارزش رجحانی گونه‌های شورپسند در منطقه مورد مطالعه می‌باشد.

کلمات کلیدی: فصل چرا، پلایا، گونه‌های شورپسند، دام، خوشخوراکی