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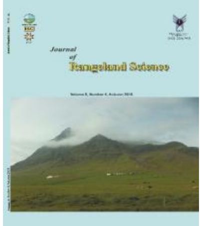

Research and Full Length Article:

Plant Species Diversity Response to Animal Grazing Intensity in Semi-Steppe Rangelands

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Abstract. Knowledge of the relationships between biotic components of rangeland ecosystem i.e. herbivores and plants is important for range managers. In order to study herbivorse grazing intensity on plant species diversity, an experiment was conductef using fuor grazing treatments in darrehshar rangelands, Ilam province in 2015. Plant species data were taken based on a randomized-systematic sampling method. Numerical values of diversity, richness and evenness indices were calculated using PAST as well as Ecological Methodology softwares. Significant differences were observed between grazing treatments for all diversity indices, except Camargo evenness index ($P \leq 0.05$).The highest values of Simpson and Shannon diversity indices as 0.916 and 3.96 respectively were obtained in the ungrazed site and the lowest values of those indices as 0.87 and 3.36 were obtained in the heavy grazing treatment. Ungrazed site had 6.4 %and 12.2 %higher diversity than the heavily grazed site. The highest values of Margalef and Menhinick richness as 4.66 and 0.91 were obtaned in the moderately grazed site. The lowest values of those indices as 2.71 and 0.598 were occurred in the heavy grazing site. Margalef and Menhinick indices values in the moderately grazed site were 36.8 %and 46% higher than those in the heavy grazing treatment, respectively. The highest modified and Smith & Wilson evenness indices with average values of 0.163 and 0.272 were obtained in the heavy grazing site and the lowest values with the average of 0.101 and 0.178 were in the ungrazed area. This study concludes that heavy grazing intensity can adversely affect plant species diversity in semi-steppe rangelands.

Key words: Diversity indices, Margalef, Biological community

Introduction

As the effects of different factors on maintaining, distributing and surveying plant species and the possibility of extinction of some species are important subject, identifying such species in different areas and planning to preserve them are required (Naghipour Borj *et al.*, 2010). Livestock and rangeland in natural ecosystems are constantly in balance and while the livestock population in ecosystem is harmonized with capacity of the rangeland, its valuable sources such as water, soil and plant will not be damaged (Heydariyan Aghakhani *et al.*, 2010). Managing the sustainable grazing in the rangeland ecosystems to understand the changes in combinations and species diversity of plant communities requires specific knowledge about vegetation and its answer to the climate factors and forage capacity (Moradi *et al.,* 2011). Livestock grazing is one of the main factors affecting the structure of plant community, species diversity and combination of rangeland environment that can cause changes in species diversity (Moradi *et al.*, 2011). Livestock grazing of each type (light grazing, heavy grazing, and medium grazing) with changes in the frequency of essential and key plants guarantees the stability of ecosystem (Zare Kia *et al.*, 2014). One of the first outcomes of intensive grazing in rangeland is to damage the ecology habitat of many plant and animal species which leads to change the species combination in a rangeland ecosystem (Pemer and Malt, 2003). Also, heavy grazing increases the vegetation defoliation and decreases the standing biomass of foliage cover and the plant species diversity. It often decreases the gross primary product and then decreases the photosynthesis as the heavy grazing changes vegetation combination by increasing annual species and decreasing the perennial ones (Naghipour Borj *et al.*, 2010).

Knowledge of intensity of optimal grazing to maintain and increase the diversity of plants species in rangeland is necessary for efficient and true management of rangeland ecosystems requiring enough knowledge about the effect of livestock grazing intensity on the species diversity. There is a relationship between the intensity of livestock grazing and normal human activities as well as the richness of diversity and species. Maintaining the human activities in balance can protect the richness and diversity in such ecosystems. Khani *et al.* (2011) in studying the effect of livestock grazing on plant species diversity and richness in southern warm-arid rangeland of Iran observed that there was no difference between the light and medium grazing areas for margalef richness index, but there was a significant difference between intense grazing area and medium and light areas. Rutherford and Powrie (2013) also studied the effects of heavy grazing on plant species richness in rangeland biomass of South Africa and showed that heavy grazing changed the plant species composition in all studied areas, and this change was accompanied with reducing the quality of grazing and the annual palatability plants. Fakhimi Abroghi *et al.* (2013) studied the effect of distance from watering on the diversity and plant coverage in the dry areas in rangeland of Nadooshan, Yazd, Iran and declared that different grazing intensities cannot always express changes made by the effect of grazing pressure because in the dry areas, plants stand the environmental stresses and livestock grazing in these regions cannot play an effective role in removing a species completely. Jahantab *et al.* (2010) studied and compared the plant diversities in two non-grazing and grazing parts in a mountain rangeland in Kohkiloieh and Boyerahmad province, and declared that numerical indicators in terms of richness, evenness, and diversity were higher in non-grazing pasture than grazing pastures. Yeylaghi *et al.* (2013) also compared species diversity in two grazed and non-grazed areas in Qushchi, Orumieh grassland. They stated that for all numerical indices of richness, evenness and species diversity values for the non-grazed rangeland had higher means than the grazed areas. This research aimed to study the effect of animal grazing intensity on plant species diversity in semi-steppe rangelands

Materials and Methods

Study area

This study was conducted in Darrehshahr town rangeland (year 2015) located in Southeast of Ilam province, Iran. The region is located on the geographic coordinates 33˚27′36″ to 37˚8′00″ latitude N and 46˚34′64″ to 50˚17′18″ E longitude. Maximum and minimum elevations of the region from sea level are 1150 and 301 m, respectively. Based on the ten year statistics (2003 to 2013) reported by Synoptic meteorology station of Darrehshahr, the climate of the region is semi-dry; the average of rainfall and the annual temperature are 404 mm and 22.5˚C, respectively.

Grazing treatments

Grazing treatments included heavy grazing, medium grazing, light grazing intensities and non-grazing in three replicates. Rangelands around the sheep cote and water troughs were considered as heavy grazing. According to the livestock grazing range during the day, the rangeland that was 2 -3 km far from the sheep cote and water troughs was considered as the medium grazing area. Finally, based on the field observations and consultations with local people, the rangelands located around the gardens and farmlands were recognized as the light grazing area. A preserved rangeland (5 years under protection) in the vicinity of other treatments was selected as the control treatment.

Sampling method

A regular-random method using transacts and quadrant was used to take samples of vegetation. According to the plant changes, five transacts with a length of 100 m and distances of 50 m were located in each repetition. The number of five plots with $1\times1m^2$ dimensions was located in each transact randomly. The number and the name of plant species, the total number of each species, growth form, palatability class, being invasive or non-invasive of each species were recorded in each plot. Then, canopy cover in any sampling was measured using sampling plot of 1×1 dimension. In addition, plant composition, frequency, richness, and other variables related to vegetation were measured. In total, in order to measure the vegetation variables in the whole study area, 60 transacts and 300 plots were measured.

Diversity, richness and evenness

List of plant species life form, and palatability class in the study area is presented in Table 1. First, the data related to plant species were analyzed. Ecological methodology software version 6.1.4 was used to calculate the mentioned indices value.

For species diversity, the Shannon-Wiener diversity index (Shanon and Wiener, 1949) (Equation1) and the Simpson diversity index (Simpson, 1949) (Equation2) were used.

$$H' = -\sum_{i=1}^{S}\left[\left(\frac{n_i}{N}\right)\ln\left(\frac{n_i}{N}\right)\right] \quad \text{(Equation 1)}$$

Where:

H'= Shannon diversity index

n_i =The number of species i

N =Total subject in the sample

$$SDI = 1 - D \quad \text{(Equation 2)}$$

$$D = \frac{\sum_{i=1}^{S} n_i(n_i-1)}{N(N-1)}$$

Where:

SID = Simpson diversity index,

S=Species number,
n_i =The number of the species basis, and
N =The number of total basis of all species

$$R = \frac{S-1}{\ln(N)} \text{ (Equation 3)}$$

Where:
R =Margalef richness index,
S=Total number of species and
N =Total number of all subjects in sample.

The species richness, Margalef index (Margalef, 1958) (Equation 3) and Menhinick index (Menhinick, 1964) (Equation 4) were calculated as follows.

$$R_2 = \frac{S}{\sqrt{N}} \text{ (Equation 4)}$$

Where:
R_2 =Menhinick richness index,
S =Total number of species and
N= Number of all species basis

The species evenness, Smit & Wilson evenness index (Smit & Wilson, 1996 (Equation 5) and Camargo evenness index (Camargo, 1974) (Equation 6) as well as Modifid evenness index (Alatalo, 1981) (Equation 7) were computed.

$$E' = \sum_{i=1}^{s} \sum_{j=i+1}^{s} \left[\frac{Pi-Pj}{R}\right] \text{ (Equation 5)}$$

Where:
E= Camargo evenness index
P_i= The share of I species
P_j= The share of j species
S= Number of all species basis.

$$E_{var} = 1 - \left[\frac{2}{\pi \arctan\left\{\sum_i^s (Log(ni))\,(Log(nj))^{2/s}\right\}}\right] \text{ (Eqution 6)}$$

Where:
E_{var} = Smit & Wilson evenness index
N_i = Number of species I in sample S
N_j= Number of species j in sample S
S= Number of species in sample complex

$$F = \frac{1/D-1}{e^{H'}-1} \text{(Equation 7)}$$

Where:
D= Density species
$e^{H'}$ = Hill diversity index

Data analysis

Data normality and variance homogeneity (Kolemograph-Smirnof) were considered by drawing the sum of data (box drawing chart). After accepting the hypotheses of statistical tests, in order to find whether there was a significant difference between grazing intensity treatments, the data were analyzed by one-way analysis of variance. The means comparisons were made using LSD method (P<0.01). Statistical analysis of data was done by SPSS software.

Table 1. List of plant species, life and growth form and, palatability class in the study area

Spices name	family	Life from	Class palatability	Growth form	Area
Achillea alppica	Asteraceae	Forb-B	II	He	H, L, M
Aegilops kotschyi Boiss	Poaceae	A-Grass	III	Th	N
Alcea kurdicaAlef	Umbelliferae	A-Forb	III	Th	N
Alhagi persarum	Papilionaceae	P-Forb	III	He	L
Allium akakagmelin	Lilaceae	P-Forb	II	Ge	M, N
Alopecurus apiatusovez	Poaceae	P-Grass	I	He	H, M, N
Alyssum canadensis	Cruciferae	P-Forb	II	Th	N
Amaranthus blitoides	Amaranthusseae	A-Forb	III	Th	L, M, N
Amaranthuss teteroflexus L.	Amaranthusseae	A-Forb	III	Th	L
Amigdalus sp.	Rosaceae	P-Tree	III	Ph	H, M
Anthemis hauss knechtii	Asteraceae	A-Forb	III	Th	H, L, N
Arrhenatherum kotschyi Boiss	Poaceae	P-Grass	I	He	H, N
Artemisia aucheri	Asteraceae	P-Forb	III	Ch	M
Arundo donax L.	Poaceae	P-Grass	I	He	N
Astragalus spp.	Papilionaceae	A-Shrub	III	Ch	H, M
Avena wiestiistend	Poaceae	A-Grass	II	Th	H, L, M, N
Boissiera squrrasa	Poaceae	A-Grass	II	Th	N
Brassica tournefortii	Cruciferae	A-Forb	II	Th	H, L, M, N
Brassica tournefortii	Cruciferae	A-Forb	III	Th	H
Bromus tectorum	Poaceae	A-Grass	I	Th	H, L, M, N
Bromus tomentellus	Poaceae	A-Grass	I	Th	H, L, M, N
Bromus tomentellus	Poaceae	P-Grass	I	Th	N
Caliconum intetextum	Polygonaceae	P-Shrub	III	Ch	L
Carduus arabicusjasq. Ex	Asteraceae	A-Forb	III	Th	N
Centaurea koeieanabornm	Asteraceae	P-Forb	III	He	H, L, M, N
Centaurea solstitialis	Asteraceae	A-Forb	III	He	H, L, M, N
Cerasus microcarpa	Rosaceae	P-Shrub	III	Ph	L
Chlorophytum comosum	Liliaceae	A-Forb	I	Th	L
Chrozophora tinctoria	Euphorbiaceae	A-Forb	III	Th	H, L, M, N
Cirsium congestum Fisch	copasitae	P-Forb	III	He	H, M, N
Cnicus benedictus	Compositae	P-Grass	III	He	N
Codonocephulum stenoculathiom	Asteraceae	P-Forb	II	He	N
Crepis kotschyana	Asteraceae	A-Forb	III	Th	N
Crupina crupinastrum	Asteraceae	A-Grass	III	Th	N
Cupsella barsapastors	Asteraceae	B-Forb	III	Th	M, N
Curtamus oxyaeantha	Asteraceae	A-Forb	III	Th	H, L, M, N
Cyperus fuscus	Cyperaceae	A-Forb	III	Th	N
Echinops quercetorum	Asteraceae	P-Forb	III	He	H, L, M, N
Echium italicum	Boranginaceae	A-Forb	II	Th	M, N
Eringium thyrsoideum	Umbelliferae	P-Forb	II	He	M, N
Eriobotry japonica	Rosaceae	P-Shrub	III	Ph	N
Eruca sativa Miller	Cruciferae	P-Forb	II	Ch	N
Euphorbia falcuta L.	Euphorbiaceae	A-Forb	III	Th	M
Galium aparine	Rubiaceae	P-Forb	III	Th	L, M
Hepnois rhajadioldoids	Asteraceae	A-Forb	II	Th	N
Hordeum bulbosum L.	Poaceae	P-Grass	II	Ch	M, N
Hordeum glaucum steud	Poaceae	A-Grass	III	Th	H, M, N
Hordeum murinum	Poaceae	A-Grass	II	Th	H, L, M, N
Hypericum hirtellum	Hyppericaceae	P-Forb	II	He	M
Inula britanica	Asteraceae	B-Forb	II	He	L,N
Ixiolirion tataricum	Amaryllidaceae	P-Forb	I	Ge	N
Lactuca serriola L	Asteraceae	B-Forb	III	Ch	L, M
Lathyrus inconspicuum	Papilionaceae	A-Forb	I	Th	L, M, N
Loliom rigidum	Poaceae	A-Grass	III	Th	H, L, M, N
Lophochloa phleoides	Poaceae	A-Grass	III	Th	H, M, N
Malabaila sekakul	Apiaceae	A-Forb	III	Th	N
Malva parviflora	Malvaceae	A-Forb	II	Th	M, N
Nigella arvensis	Ranunculaceae	A-Forb	I	Th	M, N
Onobrycheis cornuta	Papilionaceae	P-Forb	II	Ch	L, M, N
Onosma hebebulum	Boraginaceae	P- Shrab	III	He	L,N
Onosma microcarpum	Boraginaceae	P-Forb	II	He	M
Parietaria jadaica L.	Poaceae	P-Grass	I	He	N
Phlomis olivieri Benth	Labiaceae	P-Forb	II	He	N
Pilulare trifolium Boiss	Papilionaceae	A-Forb	I	Th	H, L, M, N
Pimpinella tragium Vil.l	Apiaceae	P- Shrab	II	Th	N
Poa Bulbosa	Poaceae	A-Grass	II	Ch	N
Quercus brantiilindl var. Belangeri	Fagaceae	P-Tree	II	Ph	H, L, N
Reseda aucheri Boiss	Poaceae	P-Grass	II	He	N
Salvia indica L.	Labiaceae	P-Forb	II	He	L
Silene microsperma	Caryophyllaceae	A-Forb	II	Th	N
Silybum marianum	Asteraceae	B-Forb	III	He	H, L, M, N
Sinapis arrensis L.	Cruciferae	A-Forb	II	Th	N
Sisymbrium septulatum	Asteraceae	A-Forb	III	Th	N

Tanacetum polycephalum	Asteraceae	P-Forb	II	He	N
Taraxacum montanum	Asteraceae	P-Forb	II	He	N
Thymbra spicata L.	Labiaceae	P-Shrub	III	Ch	N
Thymus daenensis	Labiaceae	P-Shrub	II	Ch	N
Trifolium purpureum Loisel	Papilionaceae	A-Forb	I	Th	H, L, M, N
Trifuliom repens	Papilionaceae	P-Forb	I	He	L, M
Vulpia myurus	Poaceae	A-Grass	III	Th	M, N
Vulpia myurus	Poaceae	A-Grass	III	Th	M
Zoegea ieptaurea	Asteraceae	A-Forb	II	Th	N

N: Non grazed, M: Medium grazed, L: Light grazed, H: Heavy grazed A: Annual plant, B: Biennial plant, P: Perennial plant
Ph=phanerophytes ،Th=Therophytes ،He=Hemicryptophytes ،Ge=Geophytes ،Ch=Chamephytes

Results

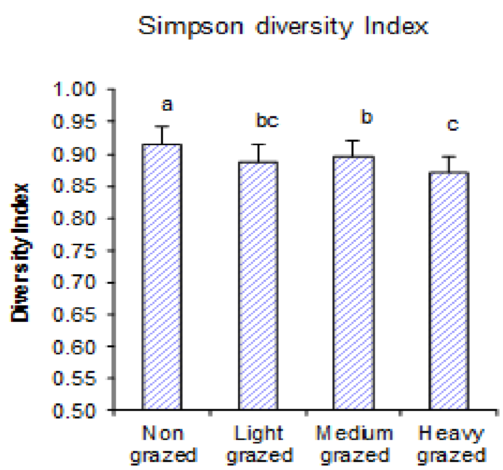
Analysis of variance of four grazing intensities on plant diversity indices is presented in Table 2. Results showed significant differences among grazing treatments for all diversity indices except Camargo index (P≤0.05).

Table 2. Analysis of variance of four grazing intensity on plant study diversity indices in semi-steppe rangeland of Darrehshahr, Iran

Source of variation	df	MS Simpson diversity	Shannon-Wiener Diversity index	Margalef index	Menhinick index	Camargo index	Modified index	Smith and Wilson
Treatment	3	10.71**	20.00**	2.552*	9.391*	1.267ns	0.260**	0.557*
Replication	2	0.948	2.045	1.616	3.642	0.757	0.046	0.362
Error	6	0.920	2.523	0.647	1.428	0.375	0.034	0.145
CV%		1.07	4.32	20.78	18.54	19.51	15.30	16.76

**,* = MS of treatments are Significant at 1% and 5% level of probability, respectively

Results of means comparison between indices are presented in Figs. 1 to 3. The value for Simpson diversity and Shannon-Wiener diversity indices in different grazing treatments was different. Both indices had the same trends. The highest Simpson and Shannon-Wiener diversity indices with average values of 0.916 and 3.96 were obtained in Un-grazed area and the lowest indices with average values of 0.871 and 3.36 were obtained in the heavy grazing treatment, respectively indicating that un-grazed area had 6.4 ٪ and 12.2 ٪higher diversity than that for heavy grazing, respectively (Fig. 1). But there was no significant difference between the light and medium grazing area intensities. Finally, the effect of heavy grazing intensity on diversity was higher than medium and light grazing intensities (P ≤ 0.05) (Fig. 1).



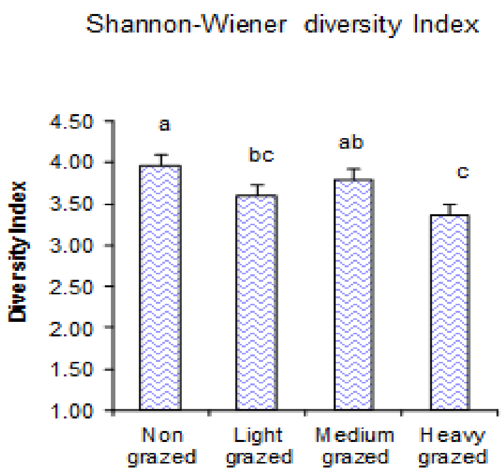


Fig. 1. Means comparison of Simpson diversity and Shannon-Wiener diversity indices in different livestock grazing treatments in semi-steppe rangelands of Darrehshahr, Iran

The highest and lowest Margalef richness indices with average values of 4.67 and 2.71 were obtained in the medium and heavy grazed areas. The highest and lowest Menhinick richness indices with average values of 0.906 and 0.521 were obtained in the medium and light grazing areas, respectively indicating that in the medium grazed area, the Margalef and Menhinick indices were 36.8 ٪and 46 ٪ higher than those for the heavy grazing area, respectively (Fig. 2). There was no significant difference between un-grazed areas, light and medium grazing areas for Margalef richness index and there was no significant difference between the ungrazed areas and light and heavy grazing areas for Menhinick richness indices (Fig. 2).

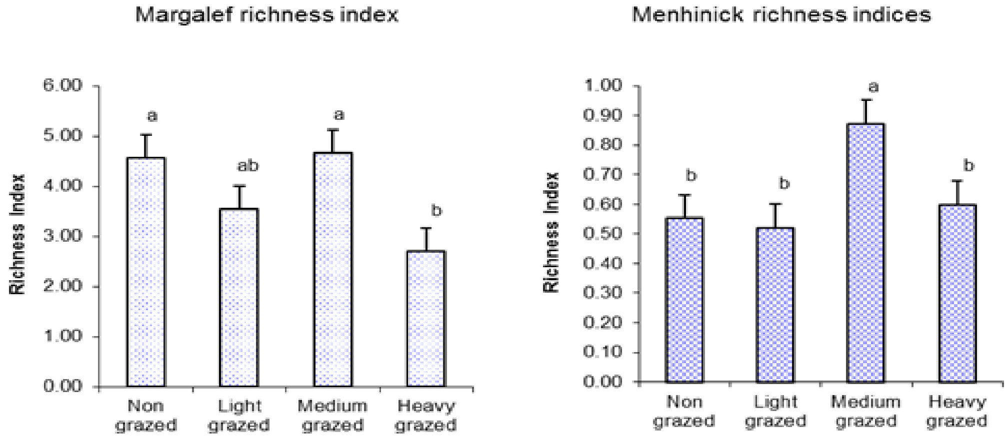


Fig. 2. Means comparison of Margalef and Menhinick indices in different livestock grazing treatments in semi-steppe rangelands of Darrehshahr, Iran

For Modified and Smith and Wilson evenness indices, the highest values of 0.163 and 0.272 were obtained in the heavy grazing area and the lowest indices with average values of 0.101 and 0.178 in the ungrazed area, respectively (Fig. 3). For Modified evenness index, there was no significant difference between non-grazed, light and medium grazing. But according to Smith's and Wilson's evenness index, there was only a difference between non-grazed region and heavy grazing ($P \leq 05.0$) and there was no difference between other regions (Fig. 3). The result obtained from Camargo index showed that there was a significant difference between medium and heavy grazing regions ($P\leq 05.0$), but there was no difference between other regions (Fig. 3).

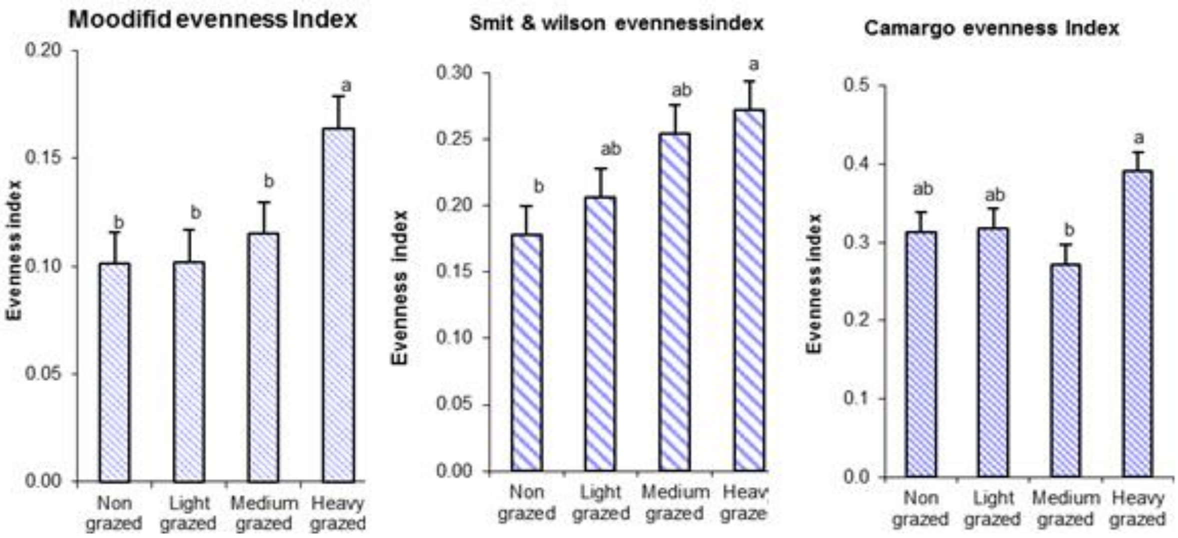


Fig. 3. Means comparison of Camargo, Modified and Smith &Wilson evenness indices in different livestock grazing treatments in semi-steppe rangelands of Darrehshahr, Iran

Discussion

The maximum and minimum values of Simpson diversity index were observed in non-grazing and heavy grazed area. Based on observations, increasing in livestock grazing intensity on this index was less. Based on Simpson diversity index, the probability that two randomly items selected from same area belonged to same species. So whatever this indicator is closer to the zero, the species diversity is lower. In the case of Shannon-Wiener's index, it can be said that numerical value of this index is changed between 0 and about 4.5 and the closer this number is to 4.5, the higher the species diversity is. The numeric value of Shannon-Wiener's diversity index in non-grazed region had the maximum value and in the grazed one, it was the lowest value. This shows that grazing had affected the species diversity of Darrehshahr rangelands. The decrease in the grazed areas can be caused by improper environmental conditions and existing or increasing of environmental stresses is derived from the pressure of grazing and removing the sensitive, rare species in the region. These results are consistent with the results of Hickman *et al.* (2004); Hendrick *et al.* (2005); Miligo (2006); Ejtehadi *et al.* (2002); Salami *et al.* 92005);Yeyneshet *et al*. (2007); Khadem Alhoseyni (2010); Nikan *et al.* (2010).These researchers found out that with the increase in the intensity of grazing, the variety of index species decreases. The results of Margalef species richness in the region showed that the highest value of this index was in the medium grazing area and the lowest value was in the heavy grazing area, but there was no significant difference between non-grazed areas and grazing regions. Moreover, Menhinick index value was the highest in medium grazing area and the lowest value in heavy grazing area. There was a significant difference for Species richness in the study region and its maximum value was in grazing region. These results are consistent with Mohebi & Mirzaii (2011) study. But, other researchers (Hendricks *et al.*, 2005; Angassa and Oba, 2010; Rutherford and Powrie, 2013; Jahantab *et al.*, 2010; Yeylaghi *et al.*, 2013; Ebrahimi *et al*., 2015; Ebrahimi *et al*., 2016; Akhzari *et al*., 2015) reported that livestock grazing decreases the species richness that is not consistent with the present study results. Since the studied indices are sensitive for rare species, and the removal of rare species decreases the indices of species richness, it is possible that the grazing pressure and type of livestock using it have no effect on removing these species, and providing the conditions for growing these species, and it also can be a reason for increasing the value of species richness in a grazing region. Since it is not possible to count all species during the sampling, species richness index doesn’t show an accurate measurement. So, there is no suitable criterion to evaluate the species diversity in the region. In this regard, Salami *et al.* (2005) and Mahmodi *et al.* (2011) stated that since there is no possibility to count all species types in an area, the role of species plant evenness in increasing species calculating is much more than species richness. Camargo, Smith Wilson and Modified’s evenness indicators imply that the most species evenness was observed in the livestock areas that is consistent with the results of some researchers (Ruiz- gaen and Aide, 2005; Mohebi &Mirzaii, 2011; Nikan *et al.*, 2012; Nazari *et al*., 2016; Golami and fakhimi Abarghohi, 2019). Because of grazing and animal utilization of palatability plant species in the rangeland, only the non-palatable or less palatable species in the region will remain and (invaders species) will be distributed in Rangeland surface constantly. Therefore, as the pressure of grazing is increased on the Rangeland, only the non- palatable or less palatable species in the region will remain and they will be distributed in Rangeland surface constantly. Because of existing rare species in the preference region, and invasive species in the critical zone, evenness in critical area is higher than the non-grazed area, and livestock grazing increases the species evenness. In general, the results showed that the increase in grazing intensity related livestock diversity has decreased and has been added to monotonous type leading to natural resources destruction. Based on the obtained results, the medium livestock rate in natural resources of present area can be conducted in administering natural resources.

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پاسخ تنوع گونه‌های گیاهی به شدت چرای دام در مراتع نیمه استپی

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چکیده. شناخت روابط بین اجزای زنده اکوسیستم مرتع یعنی علفخواران و گیاهان برای مدیران مرتع ضرورت دارد. به منظور بررسی شدت چرای دام بر تنوع گونه های گیاهی آزمایشی در قالب چهار تیمار با سه تکرار در مراتع نیمه استپی شهرستان دره شهر استان ایلام در سال ۱۳۹۳ به اجرا درآمد. داده‌های گونه‌های گیاهی به روش تصادفی-منظم برداشت شدند. مقادیر عددی شاخص‌های تنوع، غنا و یکنواختی با استفاده از نرم‌افزارهای PAST و Ecological Methodology محاسبه شدند. بین تیمارهای شدت‌های مختلف چرا، به جز شاخص یکنواختی کامارگو، تفاوت معنی‌دار وجود داشت ($P\leq0.05$). بیشترین مقدار شاخص تنوع سیمپسون و شانون به ترتیب ۰/۹۱۶ و ۳/۹۶ در تیمار عدم چرا مشاهده شد. کمترین مقادیر این شاخص‌ها به ترتیب ۰/۸۷ و ۳/۳۶ در شدت چرای سنگین بود. براساس دو شاخص سیمپسون و شانون، تنوع در منطقه چرا نشده به ترتیب ۶/۴ و ۱۲/۲ درصد بیش از تیمار چرای سنگین بود. بیشترین مقدار شاخص‌های غنای مارگالف و منهنیک به ترتیب ۴/۶۶۷ و ۰/۹۰۶ در تیمار چرای متوسط یافت شد. کمترین مقدار این شاخص‌های به ترتیب ۲/۷۱ و ۰/۵۹۸ در تیمار چرای سنگین مشاهده شد. مقادیر شاخص‌های مارگالف و منهنیک در تیمار چرای متوسط به ترتیب ۳۶/۸ و ۴۶ درصد بیش از تیمار چرای سنگین بود. بیشترین مقادیر شاخص‌های تنوع اصلاح شده و اسمت و ویلسون به ترتیب ۰/۱۶۳ و ۰/۲۷۲ در تیمار چرای سنگین و کمترین مقادیر آنها به ترتیب ۰/۱۰۱ و ۰/۱۷۸ در تیمار عدم چرا رخ داد. نتیجه این مطالعه نشان می‌دهد که شدت چرای سنگین توسط دام می‌تواند اثر معکوس بر تنوع گونه‌های گیاهی در مراتع نیمه استپی بگذارد.

کلمات کلیدی: شاخص تنوع، مارگالف، جامعه زیستی