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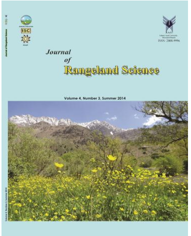

Full Length Article:

Plant Species and Functional Types' Diversity in Relation to Grazing in Arid and Semi-arid Rangelands, Khabr National Park, Iran

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Abstract. In arid and semi-arid rangelands, grazing as one of the natural or human induced processes has direct and indirect effects on structure and dynamics of plant community and ecosystems. A study was done to analyze the effects of grazing on plant species diversity and Plant Functional Types' (PFTs) diversity of arid and semi-arid rangelands. We analyzed plant richness and diversity data from 75 sampling plots located in five bioclimatic zones of Khabr National Park containing a total of 73 plant species. Ward's hierarchical clustering was then used to cluster all plant species into eight PFTs according to the chosen traits. For each site, grazing intensity was estimated in three classes (low grazing, medium and high grazing intensities). We found that as grazing intensity increased, total species richness and diversity were decreased. Considering PFTs as total showed the same pattern for species; however, each PFT diversity and richness didn't display a significant different response to grazing. Looking at each PFT relative cover change in different grazing intensities showed that PFT1 and PFT8 were grazing sensitivities while PFT6 and PFT7 benefited from grazing and their relative cover increased consistently in response to the increased grazing intensity. PFT3 and PFT4 had the highest relative cover rates in moderately grazed areas. PFT2 and PFT5 had a complicated response to grazing and their relative cover was the minimum at moderately grazed sits. This finding may imply that grazing has completely negative impacts on the community structure and it seems that it reduces plant species and functional types' diversity and richness. It can be also concluded that the analyses on PFTs level possibly give more insight into the grazing response of plant community in arid and semi-arid rangelands than those on species level but there is a need for further studies.

Key words: Grazing, Plant functional types, Diversity, Arid and semi-arid rangelands, Khabr national park

Introduction

Ecologists have always been faced to the problem of high degree of diversity among plant species that limits the scale of the studies to local ones (Anderson and Hoffman, 2011). To resolve that problem, numerous approaches have been developed by ecologists to simplify this diversity through categorizing plants on the basis of physiological and morphological affinities (Rutherford *et al.,* 1995). Plant Functional Types (PFTs) place a species in a group, the members of which have similar combinations of functional attributes (Solbrig, 1993) and respond similarly or are similarly sensitive to environmental disturbances (Gitay and Noble, 1997; Lavorel *et al.,* 1997). Reducing the diversity of species to a diversity of structures and functions and hence simplifying the complexity of nature to better describe and predict environmental effects on ecosystem functioning was the central goal of this paper (Smith *et al.,* 1997).

Functional classifications provide a framework for describing vegetation changes in natural ecosystems in terms of functional traits as a response to disturbances (Grime *et al.,* 1997) and specially grazing (Diaz *et al.,* 2001). Additionally, they provide predictive models of vegetation dynamics and vegetation changes (Lavorel *et al.,* 1997; McIntyre *et al.,* 1999; Diaz *et al.,* 2002) and reduce the complexity of species diversity to a few key plant types which help to predict the composition and functioning of ecosystems in a changing environment (Woodward and Cramer, 1996). PFTs are used to evaluate ecosystem dynamics (Noble and Gitay, 1996) and can provide information on ecological adaptations and survival mechanisms in extreme environments (Weiher *et al.,* 1999; Jauffret and Lavorel, 2003). Ecologists lead to the conclusion that vegetation changes such as vegetation regression can be explained by the attributes and interactions between different species (Navarro *et al.,* 2006). Thus, study of the attributes of individual species is of primary importance in understanding vegetation changes and the response to disturbances such as fire and grazing.

Grazing is the most important factor affecting vegetation in all rangelands of the world (Perevolotsky and Seligman, 1998). Grazing has critical impacts on the ecosystems' biodiversity (Bergmeier and Dimopoulos, 2003; Davari *et al.,* 2011), structure (Walker and Noy-Meir, 1982; Noy-Meir, 1993), function (Hobbs and Huenneke, 1992; Forouzeh and Sharafatmandrad, 2012), nutrient cycling (Frank *et al.,* 1998; Ritchie and Tilman, 1995) and hydrological processes (Sharafatmandrad *et al.,* 2010). However, plant grazing predictive response is difficult due to the large number of species and complexity of the plants' response mechanisms. Hence, plant functional type concept led to develop alternative methods instead of analyzing them at the species level (Gitay and Nobel, 1997). In addition, plant functional types can be used as the indicators of vegetation changes in relation to environmental and managerial factors as well as sustainability indicators of rangelands and other semi-natural ecosystems (Gondard *et al.,* 2003). Therefore, to minimize the reduction of species diversity and potential reduction of ecosystem resilience, it is necessary to understand and predict the behavior of various plant functional types (Mitchell *et al.,* 1999, 2000). Actually, plant functional types provide valuable information related to the response of vegetation to grazing. So, plant functional types can be a useful tool to evaluate long-term changes in these managerial systems.

Rangeland species diversity and richness may be strongly influenced by grazing but grazing impacts are totally variable and likely to be complicated by range management practices, individual species responses and abiotic factors such as soil characteristics and light availability (Safford and Harrison, 2001). However, the results of rangelands species diversity and richness studies are controversial and more research is necessary in order to understand how plant species and communities are affected by grazing and the potential variations of its intensity (Papanikolaou *et al.*, 2011). So, grouping species into plant functional types may help to understand the composition and functioning of ecosystems in response to grazing. So, current study was done to consider the plant functional types and single species at the same time. In this study, plant species and functional types' diversities were assessed in relation to grazing and its different intensities in arid and semi-arid rangelands. Our study was focused on species richness and diversity, Plant Functional Types (PFTs) richness and diversity and plant functional types' relative cover changes with grazing gradients in the Khabr National Park, Iran.

Materials and Methods

Study area

The field research is Khabr National Park and Ruchun Wildlife Refuge located in Kerman Province in South-East of Iran (between 28° 59'–28° 25' N and 56° 02'–46° 39' E). Khabr National Park and Ruchun Wildlife Refuge cover an area about 170000 hectares. Ranked as the most eleventh National Park of Iran, Khabr alone covers an area about 120000 ha. The area has a rich flora. In view of phytogeography, the area is situated between Irano-Turanian and Sahara-Sindian regions which include several communities and various vegetations (Irannejad Parizi *et al.,* 2001). The area includes five bioclimatic zones: (a) cool plain with a Mean Annual Precipitation (MAP) of 340.8 mm, Mean Annual Temperature (MAT) of 17.6°C and elevation between 2000-2200 m a.s.l; (b) cool mountains with a MAP of 384 mm, a MAT of 14.1°C and elevation between 2000-2200 m a.s.l; (c) temperate plain with a MAP of 294.5 mm, a MAT of 18.6°C and elevation between 1800-2200 m a.s.l; (d) semi-hot mountains with a MAP of 174 mm a MAT of 19.7°C and elevation between 1100-2510 m a.s.l; (e) hot plain with a MAP of 95 mm, a MAT of 23.4°C and elevation between 1000-1800 m a.s.l (Irannejad Parizi, 2000).

Data collection

Vegetation investigations were conducted in the spring of 2013. A total number of 75 sampling plots might be located in different bioclimatic zones (cool plains, cool mountains, temperate plains, semi-hot mountains, and hot plains) to show the variability of plant species compositions. Fifteen 10×10 m sampling plots were located in each bioclimatic zone in both grazed (10 plots outside the park) and non-grazed (5 plots within the park) areas. In each plot, three 10-m transects were laid out in two sides and in the middle of the plots to estimate the cover of the species using the line intercept technique.

For all species encountered during sampling, functional traits were recorded from field measures (Table 1). Trait selection was based on the literature (Weiher *et al.*, 1999; Diaz *et al.*, 2007; Wesuls *et al.,* 2012; Anderson and Hoffman, 2011) and primarily, those traits that have been mentioned relevant to grazing were recorded. Trait definition and measurement were based on Cornelissen *et al.* (2003).

Table 1. Traits used for clustering plant species into different plant functional types and their subgroups

Traits	Subgroups
Growth form	Short basal, Long basal, Semi basal, Erect leafy, Cushions, Grass/grass-like, Dwarf shrub, Shrub, Tree, Leafless shrub/tree
Life form	Phanerophytes, Chamaephytes, Hemicryptophytes, Geophytes, Therophytes
Clonality	Non-clonal, Clonal above-ground, Clonal below-ground
Hairiness	None, Sparse, Intermediate, Dense
Spinescence	None, Sparse soft spine, Dense soft spine, Sparse hard spine, Dense hard spine
Waxes	Yes, No
Specific leaf area	Small, Medium, Large, Very large
Ratio leaf length/width	Small, Medium, Large
Leaf dry matter content	Small, Medium, Large, Very large
Leaf longevity	Deciduous, Evergreen
Leaf type	Entire, Compound
Dispersal mode	Autochorous, Anemochorous, Endozoochorous, Exozoochorous
Leaf size	Small, Medium, Large, Very large
Height	Small, Medium, Large
Life cycle	Annual, Weak perennial, Perennial

Since accurate determination of grazing intensity was impossible because of the absence of stocking-rate data for each specific site, herds leading by ranchers and severe grazing pressure, subjective grazing scores were assigned based on Holechek and Galt (2000) and a visual assessment of grazing. So, grazing intensity was scored into three levels ranging from a value of 1 for five plots with no grazing or light wildlife grazing (located within the park) to a value of 3 for five highly grazed ones (plots outside the park that are grazed by region nomadic livestock). A value of 2 was assigned to the five plots with medium grazing intensity.

Data analysis

For each plots, total species richness (number of species encountered per plot) and Shannon species diversity index $H' = -\sum_{i=1}^{s} p_i \ln p_i$ (Magurran, 1988) were determined by calculating the relative cover of each plant species (pi= relative cover of species i in each plot).

To assess the changes in PFTs composition, all plant species were classified using a posteriori approach which would require a multivariate technique (Gitay and Noble, 1997). First, optimum number of clusters was determined by plotting the within groups' sum of squares vs. the number of clusters extracted. Ward's hierarchical clustering was next performed. The resulted clusters were considered as plant functional types. These plant functional types were then examined to see which traits were associated with each group.

For each PFT, we calculated the relative plant cover of each PFT and the number of species within each PFT. Total number of PFTs and the H' diversity index of PFTs were also calculated for each plot from the cover estimations. H' diversity index (Magurran, 1988) was calculated for PFTs as (Equation 1):

$$H' = -\sum_{i=1}^{s} p_i \ln p_i \quad \text{(Equation 1)}$$

Where

p_i is the sum of the relative plant cover values for species belonging to PFT i.

Our first step in data analysis was to assess statistical differences in the grazed versus non-grazed areas. Initially, we conducted independent t-tests (Mesdaghi, 2011) to assess plant community differences between the grazed and non-grazed plots.

Further analyses addressed variations among the different grazing intensities. One-Way ANOVA (Mesdaghi, 2011) was used to assess statistical differences in species richness and species diversity between the grazing intensities. ANOVA was followed by a Tukey HSD for the determination of plant community response differences between the grazing intensities. The same statistical analyses were performed for PFTs. All statistical analyses were performed using Minitab16 (Minitab Inc., State College, Pennsylvania).

Results

Plant species diversity

There were several significant patterns between the grazed and non-grazed plots. Grazed plots showed significantly higher values for both species richness and species diversity than those for the non-grazed plots (P<0.00). Subsequent analyses assessed differences in community responses among the various grazing intensities.

The results of ANOVA showed significant differences for plant species richness and diversity of the grazing intensity treatments (Table 2).

Plant species richness was significantly higher in the low and moderate grazing intensities treatments than the severe grazing intensity (P<0.00) with no significance between the moderate and low grazing intensities. However, plant species diversity was significantly higher in the low stocking density as compared to the severe grazing intensities treatments (P<0.00) although differences between moderate and low grazing intensities and moderate and severe grazing intensities were not significant.

Table 2. Differences in species richness and Shannon diversity index between grazed and non-grazed plots and along the grazing gradient

Diversity Indices	Non-Grazed	Grazed	P	Grazing Intensity			P
				Low	Intermediate	Severe	
Species Richness	8.28	6.36	<0.00	8.440 a	7.20 ab	5.36 c	<0.00
Shannon Diversity	1.68	1.39	<0.00	1.697 a	1.50 ab	1.25 b	<0.00

The means of three grazing intensity in each rows with the same letters has no significant differences

Classification of PFTs and trait assessments

Different plant species were classified using cluster analysis and based on the within groups' sum of squares vs. the number of extracted clusters, eight emergent groups were separated which were considered as eight plant functional types (Fig. 1). Growth form, spinescence, life form and dispersal mode were the most influencing traits on the desired classification. PFT1 includes grasses and grass-like ones. PFT2 comprises some dwarf shrub species with water dispersal mode. PFT3 includes species with a shrub growth form. PFT4 comprises both leafless shrubs and trees. PFT5 and PFT7 are with plant functional type 5 comprising shrubs and trees with the highest degree of spinescence with some clonality while plant functional type 7 comprises shrubs with somewhat erect branches and some unpalatable forbs. PFT6 comprises cushions which are not palatable at all but sensitive to grazing. Plant functional type 8 is palatable annual forbs.

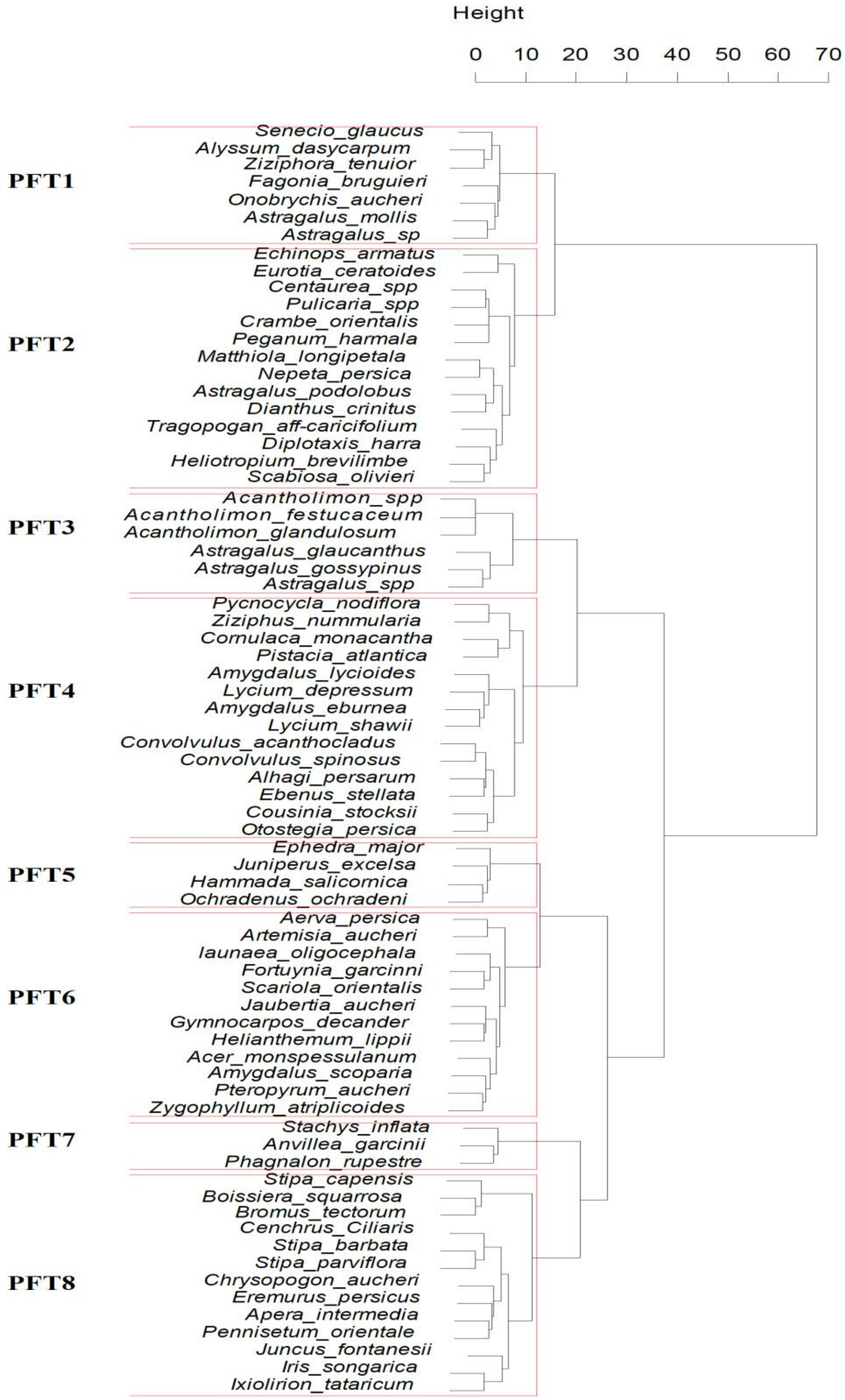


Fig. 1. Classification of 73 plant species into 8 plant functional types using Ward's Hierarchical clustering

PFTs diversity

PFTs also showed several significant patterns between the grazed and non-grazed plots. Grazed plots showed significantly higher ($P<0.05$) PFTs richness than the non-grazed ones. The grazed plots also had significantly higher PFTs diversity than the non-grazed ones ($P<0.01$, Table 3). However, PFTs richness was significantly higher in the low grazing intensity as compared to the severe grazing intensity treatment (P<0.01) although there were no differences between moderate and low grazing intensities and moderate and severe grazing intensities (Table 3). For PFTs diversity (Shannon H' index), there were no significant differences between 3 grazing intensities (Table 3).

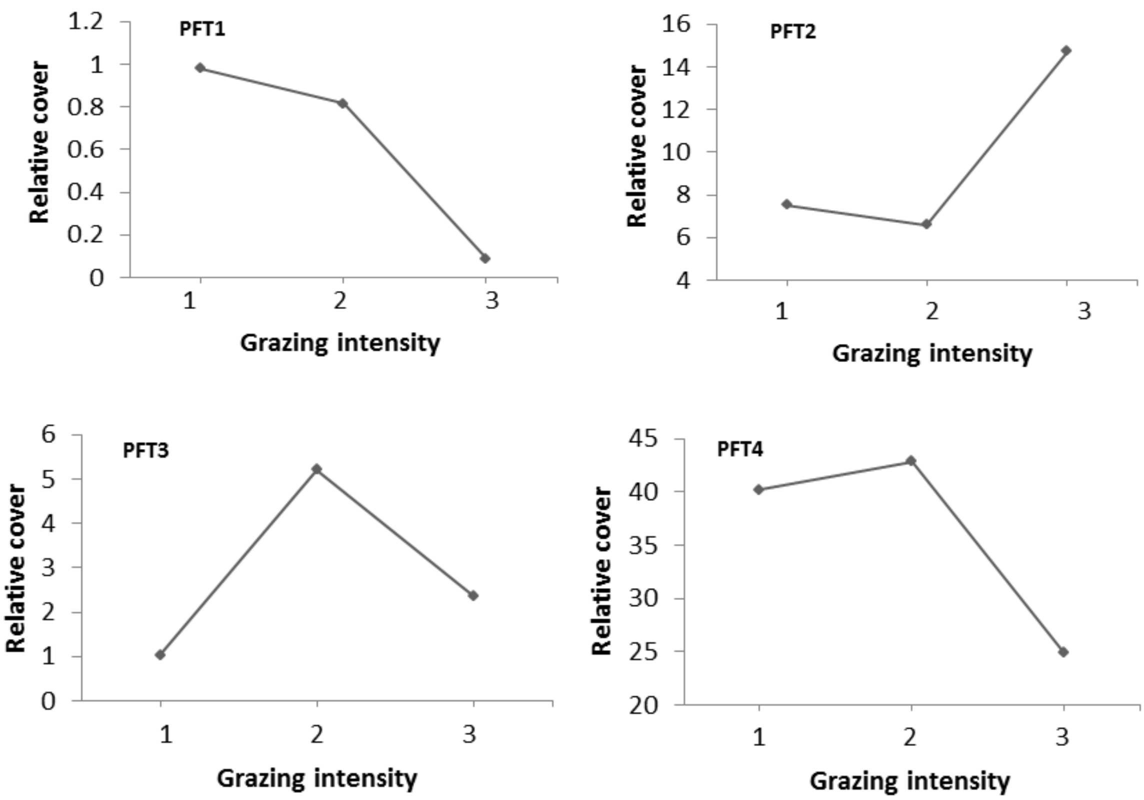
Table 3. Differences in PFTs richness and Shannon diversity index between the grazed and non-grazed plots and along the grazing gradient

PFT Diversity Indices	Ungrazed	Grazed	P	Grazing Intensity			P
				Low	Intermediate	Severe	
PFTs Richness	4.36	3.72	<0.05	4.36 a	4.04 ab	3.40 b	<0.01
PFTs Diversity	1.10	0.87	<0.01	1.08 a	0.90 a	0.86 a	<0.07

The means of three grazing intensity in each rows with the same letters has no significant differences

A subsequent analysis was done to assess differences in different PFTs diversities and abundance in response to grazing. As an examination of diversity within plant functional types didn't provide any additional insights, we assessed different PFTs frequency changes in response to grazing intensity treatments (Fig. 2).

There were no significant differences between three grazing intensities with respect to each PFT's relative cover although different PFTs' relative cover revealed interesting patterns between different grazing intensities. PFT1 and PFT8 had a decreasing trend in response to grazing. PFT6 and PFT7 increased in response to grazing. PFT3 and PFT4 showed an increasing trend with grazing intensity but their frequency was decreased in severe grazing intensities. PFT2 and PFT5 had a complicated response to grazing so that their frequency was decreased in the moderate grazing intensity but increased in the severe grazing intensity.



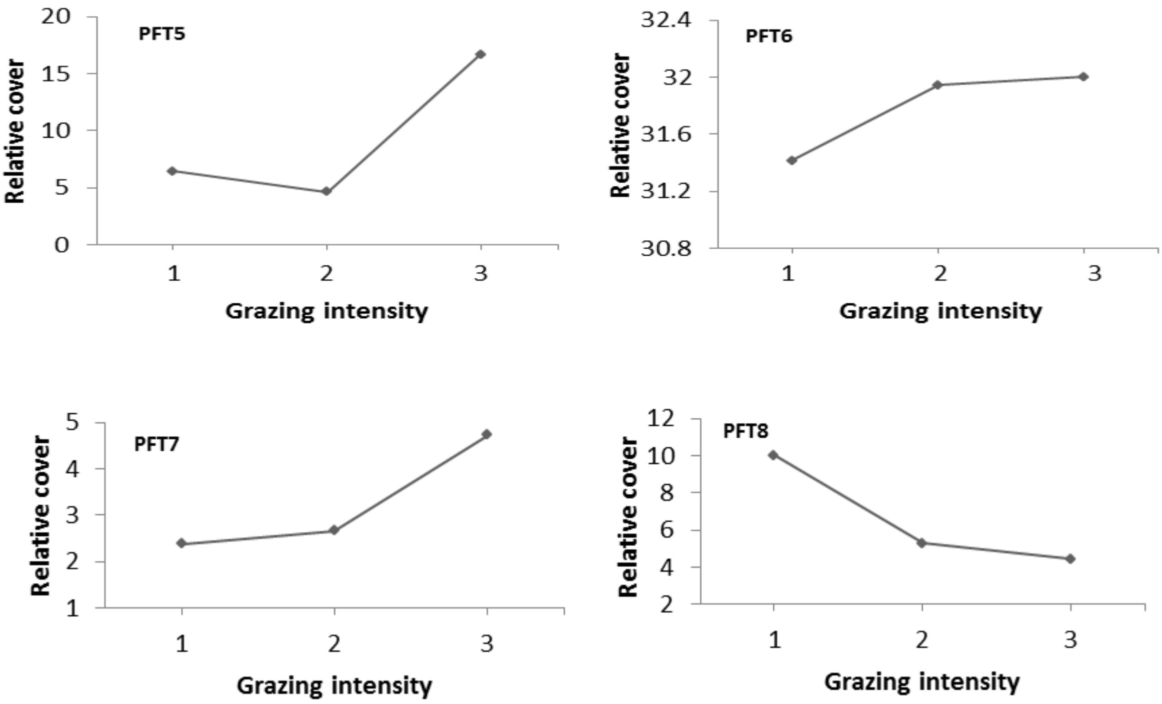


Fig. 2. Changes in relative cover of the different PFTs in response to the grazing gradient

Discussion and Conclusion

One of the important factors affecting the rangelands plant communities is grazing intensity that influences the overall herbivory and physical impacts (Hickman *et al.,* 2004). The results of the study showed that grazing generally had significant effects on arid and semi-arid rangelands' vegetation. There were significant differences between plant species composition and diversity of the grazed and non-grazed areas. Grazing intensity had also significant effects on the analyzed diversity indices. These results clearly reflect the role of herbivory in the arid and semi-arid rangelands' vegetation. Some of the species are limited to the non-grazed plots. Omission of grazing and possibility of growth from seed banks in the soil or vegetative organs can be accounted for the presence of this species in the ungrazed plots (Valone *et al.,* 2002). Some species involving *Peganum harmala* were limited to the grazed plots. These species are unpalatable or poisonous like *Peganum harmala* which is indicator of an area with a severe grazing intensity. Most of the grazing resistant species could be observed in both the grazed and non-grazed plots but their frequency was generally reduced.

Animal density is generally the most important grazing management variable affecting plant community structure in rangeland ecosystems (Heitschmidt *et al.,* 1987). The results of the study showed that grazing generally had significant effects on arid and semi-arid rangelands' vegetation. There were significant differences between plant species composition and diversity of the grazed and non-grazed areas. Grazing intensity had also significant effects on diversity indices.

Based on these results, there were no significant differences between richness and diversity of the low and moderate grazing intensity treatments although the indices of low grazing intensity were significantly higher than the severe grazing intensity.

Although there was no significant difference between the low and moderate grazing intensity treatments, based on the larger values of diversity indices in the plots with low grazing intensity relative to the plots with moderate grazing intensity, the Intermediate Disturbance Hypothesis (IDH) where species richness reaches maximum values at intermediate levels of disturbance (Mwendera *et al.,* 1997), it can be rejected for this area. It appears that this hypothesis is true for the grazing disturbances often associated with the more humid rangelands like grasslands. In the harsh conditions in the most part of the study area that vegetation may be struggling for survival, grazing obviously will have negative effects on plant diversity. The other reason for the lack of support to the IDH may refer to long-standing history of the rangelands' exploitation i.e. grazing (Papanikolaou *et al.,* 2011).

Looking at the PFTs in total showed that non-grazed plots showed significantly higher richness and diversity than the grazed ones. PFTs' response to grazing intensity revealed that the PFTs richness and diversity patterns are the same as the species i.e. moderately grazed plots had intermediate indices. So, the results about PFTs also didn't support the intermediate disturbance hypothesis. It was impossible to assess trends among different PFTs in response to grazing intensities at plot level due to high number of plots without any PFT. So, further analyses were done at the stand level. The overall effects of grazing intensities on the diversity of each PFT were not significant. It was possible to identify some trends among different PFTs' relative cover rates in response to grazing intensities at this level (Fig. 2) although the variability of the relative plant cover of the different PFTs was not significant.

The changes in PFTs' relative cover rates in response to grazing intensities were not consistent with classical theory of grazing response (Dyksterhuis, 1958). The relative cover rates of PFT1 and PFT8 in the community decrease consistently in response to the increased grazing intensity (decreasers) while that of PFT3 and PFT4 increases partly with grazing intensity but their frequency decreases in severe grazing intensity (increasers) while PFT6 and PFT7 increase consistently and only appear above a certain threshold of grazing intensity (invaders); but PFTs' responses to different levels of grazing intensity were more diverse than those could be expressed in a simple increaser-decreaser continuum as mooted by the 'classical' theory. PFT2 and PFT5 did not respond consistently to grazing intensity so that their frequency was decreased in the moderate grazing intensity but increased in the severe grazing one.

PFT1 and PFT8 are grass/grass-like and annual forbs, respectively. As the general structure of Khabr National Park vegetation is shrub land, it is somewhat expectable that their relative cover rate decreases in response to grazing intensity due to high palatability of grasses and forbs in comparison to shrubs. PFT3 and PFT4 are non-spiny shrub and leafless tree/shrubs. These functional types are competitors that their abundance increases with reduction of more palatable ones. PFT6 and PFT7 are cushions and some specific unpalatable annual and perennial forbs and shrubs. For example, poisonous species including *Peganum harmala* belong to PFT7 which is an invader species and indicator of an area with severe grazing intensity. PFT2 and PFT5 are some shrubs with rare dispersal modes and spiny shrubs/tree.

Conversation of plant species diversity is one of the goals of ecosystems' management. Plant species diversity is used in vegetation studies and environmental assessments as one of the important and rapid indices of determining ecosystem status. Rangelands are ecosystems that encompass a vast resource of diversity of plant species and genetic resources. This biodiversity ensures the sustainability of rangelands against environmental and biological disturbances. Grazing is one of the controversial disturbances that have significant effects on rangelands' plant diversity. Some studies indicated a monotonic increase in diversity with greatest diversity at the highest grazing intensity (Hickman *et al.,* 2004) while some others were in support of the intermediate disturbance hypothesis and reported the highest diversity in moderately grazed rangelands (Hayes and Holl, 2003) while some others indicated a decrease in diversity with the greatest diversity in non-grazed areas (Jouri *et al.,* 2011). However, our results are in the support of the third one i.e. decreasing diversity with grazing intensity. This can be due to high stocking rate over long-standing history. Lack of the precipitation is another reason in this respect and drought and grazing act in the same direction. Although looking at the PFTs as total showed significant differences between richness and diversity of various grazing intensities, considering each PFT lonely showed no significant responses to different grazing intensities. Short-term studies may be unable to reveal significant effects of herbivory because the rate of vegetation changes in arid regions is slow and high spatial-temporal variations in vegetation presence and abundance limit the effects of herbivory (Ward, 2006).

Understanding the role of grazing in the rangelands' vegetation is essential to make rational decisions about proper range management practices, particularly in the case of arid and semi-arid rangelands where rainfall is the most important limiting environmental factor and short-term effects of herbivory are insignificant, but its long-term ecological effects are different. So, conservative management programs are a priority in arid and semi-arid rangelands because it helps to sustain soil, plant and animal productivity. Therefore, the effective sustainable management of these rangelands requires more studies to understand the effects of grazing and abiotic environmental factors on grazing responses and functional traits.

Literature Cited

Anderson, P. M. L. and Hoffman, M. T., 2011. Grazing response in the vegetation communities of the Kamiesberg, South Africa: Adopting plant functional type approach. *Jour. Arid Environment*, 75: 255-264.

Bergmeier, E. and Dimopoulos, P., 2003. The vegetation of islets in the Aegean and the relation between the occurrence of islet specialists, island size, and grazing. *Phytocoenologia,* 33: 447–474.

Cornelissen, J. H. C., Lavorel, S., Garnier, E., Díaz, S., Buchmann, N., Gurvich, D. E., Reich, P. B., ter Steege, H., Morgan, H. D., van der Heijden, M. G. A., Pausas, J. G. and Poorter, H., 2003. A handbook of protocols for standardized and easy measurement of plant functional traits worldwide. *Australian Jour. Botany*, 51: 335-380.

Davari, N., Jouri, M. H., Ariapour, A., 2011. Comparison of measurement indices of diversity, richness, dominance, and evenness in rangeland ecosystem (Case study: Javaherdeh-Ramesar). *Jour. Rangeland Science*, 2(1): 389-398. (In Persian).

Diaz, S., Briske, D. and McIntyre, S., 2002. Range management and plant functional types. In: Hodkingson, K., Grice, A. C., Global rangelands: progress and prospects, CAB International, Wallingford, UK, 81-100.

Diaz, S., Lavorel, S., McIntyre, S., Falczuk, V., Casanoves, F., Milchunas, D.G., Skarpe, C., Rusch, G., Sternberg, M., Noy-meir, I., Landsberg, J., Zhang, W., Clark, H. and Campbell, B. D., 2007. Plant trait responses to grazing – a global synthesis. *Global Change Biology,* 13: 313–341.

Diaz, S., Noy-Meir, I. and Cabido, M., 2001. Can grazing response of herbaceous plants be predicted from simple vegetative traits? *Jour. Applied Ecology,* 38: 497–508.

Dyksterhuis, E. J., 1958. Ecological principles in range evaluation. *Bot. Rev.,* 24: 253-272.

Forouzeh, M. R. and Sharafatmandrad, M., 2012. The effect of water spreading system on the functionality of rangeland ecosystems. *Jour. Arid Land,* 4(3): 292-299. (In Persian).

Frank, D. A., McNaughton, S. J. and Tracy, B. F., 1998. The ecology of the earth's grazing ecosystems. *Bioscience,* 48(7): 513–521.

Gitay, H. and Noble, I. R., 1997. What are functional types and how should we seek them? In: Smith, T. M., Shugart, H. H., Woodward, F. I., (ed). Plant functional types: Their relevance to ecosystem properties and global change. Cambridge University Press, London, 3–19. UK.

Gondard, H., Sandrine, J., Aronson, J. and Lavorel, S., 2003. Plant functional types: a promising tool for management and restoration of degraded lands. *Applied Vegetation Science,* 6: 223-234.

Grime, J. P., Hodgson, J. G., Hunt, R., Thompson, K., Hendry, G. A. F., Campbell, B. D., Jalili, A., Hillier, S. H., Diaz, S. and Burke, M. J. M., 1997. Functional types: testing the concept in Northern England? In: Smith, T. M., Shugart, H. H., Woodward, F. I. (ed), Plant functional types: Their relevance to ecosystem properties and global change. Cambridge University Press, London, 122–152.

Hayes, G. F. and Holl, K. D., 2003. Cattle grazing impacts on annual forbs and vegetation composition of me sic grasslands in California. *Conservation Biology,* 17: 1694–1702.

Heitschmidt, R. K., Dowhower, S. L. and Walker, J. W., 1987. Some effects of rotational grazing treatment on quantity and quality of available forage and amount of ground litter. *Jour. Range Management,* 40: 318–321.

Hickman, K. R., Hartnett, D. C., Cochran, R. C. and Owensby, E. C., 2004. Grazing management effects on plant species diversity in tall grass prairie. *Jour. Range Management*, 57: 58–65.

Hobbs, R. J. and Huenneke, L. F., 1992. Disturbance, diversity and invasion: implications for conservation. *Conservation Biology*, 6: 324–337.

Holechek, J. I. and Galt, D., 2000. Grazing intensity guidelines. *Rangelands,* 22(3): 11-14.

Irannejad Parizi, M. H., 2000. Assessing structure and diversity of vegetation with emphasis on arid and semi-arid woodland habitats of Khabr National Park. Ph.D thesis in Forestry, University of Tehran, Iran. (In Persian).

Irannejad Parizi, M. H., Sanei Shariat Panahi, M., Zobeiri, M. and Marvi Mohajer, M. R., 2001. A floristic and phytogeographycal investigation of Khabr National Park and Rouchun Wildlife Refuge. *Iranian Jour. Natural Resources,* 54(2): 111-129. (In Persian).

Jauffret, S. and Lavorel, S., 2003. Are plant functional types relevant to describe degradation in arid, southern Tunisian steppes? *Jour. Vegetation Science,* 14: 399–408.

Jouri, M. H., Patil, D., Gavali, R. S., Safaian, N. and Askarizadeh, D., 2011. Assessment of health conditions of mountain rangeland ecosystem using species diversity and richness indices, (Case study: Central Alborz, Iran). *Jour. Rangeland Science,* 2(1): 341-353.

Lavorel, S., McIntyre, S., Landsberg, J. and Forbes, T. D. A., 1997. Plant functional classifications: from general groups to specific groups based on response to disturbance. *Trends in Ecology and Evolution,* 12: 474–478.

Magurran, A. E., 1988. Ecological diversity and its measurement. Princeton Univ. Press, Princeton, New Jersey, USA.

McIntyre, S., Lavorel, S., Landsberg, J. and Forbes, T. D. A., 1999. Disturbance response in vegetation towards a global perspective on functional traits. *Jour. Vegetation Science,* 10: 621–630.

Mesdaghi, M., 2011. Statistical and regression methods "An applied approach to plant and animal sciences". Imam Reza University Press, Mashhad, Iran. (In Persian).

Mitchell, R. J., Auld, M. H. D., Le Duc, M. G. and Robert, M. H., 2000. Ecosystem stability and resilience: a review of their relevance for the conservation management of lowland heaths. Prospect. *Plant Ecol. Evolve. Syst.*, 3: 142-160.

Mitchell, R. J., Marrs, R. H., Le Duc, M. G. and Auld, M. H. D., 1999. A study of the restoration of heathland on successional sites in Dorset, Southern England: changes in vegetation and soil chemical properties. *Jour. Applied Ecology,* 36: 770-783.

Mwendera, E. J., Saleem, M. A. M. and Woldu, Z., 1997. Vegetation response to cattle grazing in the Ethiopian Highlands. *Agric Ecosys Environ,* 64: 43–51.

Navarro, T., Alados, B. and Cabezudo, B., 2006. Changes in plant functional types in response to goat and sheep grazing in two semi-arid shrub lands of SE Spain. *Jour. Arid Environment,* 64: 298-322.

Noble, I. R. and Gitay, H., 1996. A functional classification for predicting the dynamics of landscapes. *Jour. Vegetation Science, 7*: 329-336.

Noy-Meir, I., 1993. Compensating growth of grazed plants and its relevance to the use of rangelands. *Ecological Applications,* 3(1): 32–34.

Papanikolaou, A. D., Fyllas, A. D., Dimitrakopoulos, P. G., Kallimanis, A. S. and Pantis, J. D., 2011. Grazing effects on plant functional group diversity in Mediterranean shrublands. *Biodiversity and Conservation,* 20(12): 2831-2843.

Perevolotsky, A. and Seligman, N. G., 1998. Role of grazing in Mediterranean rangeland ecosystems. *Bioscience,* 48: 1007–1017.

Ritchie, M. E. and Tilman, D., 1995. Responses of legumes to herbivores and nutrients during succession on a nitrogen-poor soil. *Ecology,* 76(8): 2648–2655.

Rutherford, M. C., O'Callaghan, M. O., Hurford, J. L. and Mack, F., 1995. Realized niche spaces and functional types: a framework for prediction of compositional change. *Jour. Biogeography,* 22: 523-531.

Safford, H. D. and Harrison, S. P., 2001. Grazing and substrate interact to affect native vs. exotic diversity in roadside grasslands. *Ecological Applications,* 11:1112–1122.

Sharafatmandrad, M., Mesdaghi, M., Bahremand, A. and Barani, H., 2010. The role of litter in rainfall interception and maintenance of superficial soil water content in an arid rangeland in Khabr National Park in South-Eastern Iran. *Arid Land Research and Management,* 24(3): 213-222. (In Persian).

Smith, T. M., Shugart, H. H. and Woodward, F. I. E., 1997. Plant functional types. Cambridge University Press, Cambridge, UK.

Solbrig, O. T., 1993. Plant traits and adaptive strategies: their role in ecosystem function. In: Schulze, E.D. and Mooney, H.A. (ed.). Biodiversity and ecosystem function. *Ecological Studies,* 99: 97–116.

Valone, T. J., Meyer, M., Brown, J. H. and Chew, R. M., 2002. Timescale of perennial grass recovery in decertified arid grasslands following livestock removal. *Conservation Biology,* 16: 995–1002.

Walker, B. H. and Noy-Meir, I., 1982. Aspects of the stability and resilience of savanna ecosystems. In: Huntley, B. J., Walker, B. H., Ecology of Tropical Savannas, Springer, Berlin, 556–590.

Ward, D., 2006. Long-term effects of herbivory on plant diversity and functional types in arid ecosystems. In: Danell, K., Bergström, R., Duncan, P., Pastor, J., Large herbivore ecology, ecosystem dynamics and conservation. Cambridge University Press, 142-169. UK.

Weiher, E., van der Werf, A., Thompson, K., Roderick, M., Garnier, E. and Eriksson, O., 1999. Challenging Theophrastus: a common core list of plant traits for functional ecology. *Jour. Vegetation Science,* 10: 609–620.

Wesuls, D., Oldeland, J. and Dray, S., 2012. Disentangling plant trait responses to livestock grazing from spatio-temporal variation the partial RLQ approach. *Jour. Vegetation Science,* 23: 98–113.

Woodward, F. I. and Cramer, W., 1996. Plant functional types and climatic changes: Introduction. *Jour. Vegetation Science,* 7: 306–308.

تنوع گونه‌ای و گروه‌های کارکردی گیاهان در ارتباط با چرای دام در مراتع خشک و نیمه‌خشک، پارک ملی خبر

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چکیده. در مراتع خشک و نیمه‌خشک، چرا یکی از فرایندهای طبیعی یا انسانی است که تاثیرات مستقیم و غیر مستقیمی بر ساختار و پویایی جوامع گیاهی و اکوسیستم‌ها دارد. این تحقیق به منظور تحلیل تاثیر چرای دام بر تنوع گونه‌ها و گروه‌های کارکردی گیاهان مراتع خشک و نیمه‌خشک صورت گرفت. بنابراین داده‌های غنا و تنوع هفتاد و پنج پلات در پنج زون بیوکلیماتیک پارک ملی خبر حاوی هفتاد و سه گونه گیاهی ارزیابی گردید. آنالیز خوشه‌بندی وارد برای طبقه‌بندی گونه‌های گیاهی به هشت نوع کارکردی براساس صفات منتخب استفاده گردید. شدت چرای هر پلات در سه طبقه (قرق یا چرای سبک، چرای متوسط و چرای شدید) برآورد شد. نتایج نشان داد با افزایش شدت چرایی، غنا و تنوع گونه‌ای کاهش می‌یابد. گروه‌های کارکردی گیاهان نیز الگویی مشابه به گونه‌ها داشتند. با این حال در نظر گرفتن جداگانه هر گروه کارکردی، رابطه معنی‌داری با چرای دام نشان نداد. چگونگی تغییر پوشش نسبی هر گروه کارکردی در گرادیان چرایی نشان داد که گروه‌های کارکردی ۱ و ۸ نسبت به چرای دام حساس اما گروه‌های کارکردی ۶ و ۷ نسبت به چرا مقاوم بوده و پوشش نسبی آنها افزایش یافته است. گروه‌های کارکردی ۳ و ۴ دارای بیشترین پوشش نسبی در نواحی با چرای متوسط بودند. انواع کارکردی ۲ و ۵ پاسخ پیچیده‌ای به چرا داشته و پوشش نسبی آنها در پلات‌های با چرای متوسط حداقل بود. با توجه به نتایج می‌توان بیان کرد که چرای دام تاثیری منفی بر ساختار جوامع گیاهی داشته و تنوع گونه‌ای و گروه‌های کارکردی گیاهان را کاهش می‌دهد. همچنین می‌توان این نتیجه‌گیری را کرد که تحلیل در سطح گروه‌های کارکردی گیاهان در مقایسه با تحلیل در سطح گونه می‌تواند درک از پاسخ جوامع گیاهی به چرای دام در مناطق خشک و نیمه‌خشک را بهبود بخشد اما در این رابطه به تحقیقات بیشتری نیاز است.

کلمات کلیدی: چرا، انواع کارکردی گیاهان، تنوع، مراتع خشک و نیمه‌خشک، پارک ملی خبر