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Investigation of grazing on plant diversity using rank-abundance model (Case study: Arid and semi-arid Kalimany rangelands in north Khorasan province)

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Abstract

This research is preformed in arid and semi-arid in Kalimany rangelands in north Khorasan province in order to study the effect of grazing on plant diversity using an ordering abundance model. Selecting standard area in evolved 50 plots each 1 m^2, were established randomly in this site. In each plot, canopy cover and density percentage were measured. In this way, diversity indices in clouding log series, log normal, Geometric model and MacArthur's broken stick, with Biodap Software were evaluated. Results show that grazing region did not follow from broken stick and geometric model. But, plant diversity complied with the log series and log normal ($p<0.05$). Thus, it can be concluded plant diversity is declining due to grazing still not reach to critical stage and it is in a transitional period. Hence, level of plant diversity can be improved by applying systematic strategic such as controlling the number of permissible livestock and also utilization season.

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Introduction

Based on statistics offered by FAO, 24 percent of the land in the world is dedicated to permanent rangelands and 31 percent to forest and shrub lands (Holechek *et al.,* 2004). According to the latest reports by organization of forest, rangelands and watershed of Iran, rangeland area is 86.1 ha (Eskandari *et al.,* 2008). At present, these natural ecosystems and related biodiversity must be paid attention to for two reasons. First, they provide the human wide range of utility at local and global scale. Second, much of human activities leading to an unprecedented loss of biodiversity threaten ecosystem stability and their good and service provision(Makhdoom,2005).Therefore, participation of social groups is important in order to protect plant diversity and in this regard, comprehensive and exhaustive rules must be approved. This, any activity leading to the pollution and degradation of the environment is prohibited. In this context, numerous laws have been enacted and on the basis of article 3 of protection and utilization of forest and rangeland of Iran any exploitation of this resource must be in the form of plans or operation license. However, due to the social and economical problems of stockholders, such measures are not widely taken. As a result causes the destruction of ecosystem and the diversity of the plant as part of biodiversity. With this action, many valuable plant species and animals faded out of the nature or going in to extinction. With the loss of this ecosystems (to exploit the animals), level of biodiversity has also been dropped (Kooijman, 2001, Çakal *et al*., 2012). In the event that one of the goals of the management of natural resources is to protect plant diversity in natural ecosystems, because stands with more diversity will have more fertility and ecological stability against changes and are considered one stable and dynamic ecosystem(Smith,1996; Agele, 2011). Thus, plant diversity is one of the most important topics in ecology which acts in relation to the reduction and deterioration of a species, its benefit, production in ecosystem and maintenance of grasslands rich in native and alien species (Ejtehadi *et al.,* 2009; Sobh Zahedi, 2012). Hence, investigation of the plant diversity and the information derived therefore, as well as environment reactions to the changes resulted in it is especially important. In this research, the effect of grazing on plant diversity is studied using parametric method (a rank abundance model) with regard to the role of rangeland use and natural interactions to these effects and its positive and negative

feedbacks on environment. In this context, several attempts have been made so that Khadem Alhosseini 2011, Gholinejad and Ghorbani 2010, Mahdavi *et al*. 2012, El-hag 2012, Khalifezadeh and Mesdaghi 2009, conclude in their research that overgrazing decreases species diversity. But, Hartnett *et al.,* 1999, Noor Alhamad 2006 found that species richness and evenness showed significant increase against grazing. Moeinpour 2009 showed both grazing and enclosure region follow from log normal model because of species with average abundance. Karen *et al.*,2004 studied the effect of grazing management on plant diversity of long grasses in sever grazing treatment, controlled enclosure and deferred – rest system, suggested reduction of plant diversity in heavy grazing. By comforting plant species in both grazing area and enclosure of Nowshahr in north of Iran using parametric model, Salami *et al.,* 2008found that diversity profile in enclosure is always above grazing area in all indices that indicating more diversity in enclosure ground. Also numerous investigators studied in this relation including Wana Desalegn and Carl Beierkuhnlein 2010, Ricotta and Carlo 2009, Tothmeresz and Bala2009 and Austrheim *et al.,* 1999. Aim of this study was investigating impact of grazing on plant diversity using rank-abundance model. This study is first time that using rank-abundance model in this area.

Materials and methods

This study is performed in Kalimany area in Maneh and Samalghan cities in north Khorasan province in Iran at 4350 ha). These rangelands are situated in 60 km western north of province center (Bojnourd) and geographically are placed in longitude 47600 to

47800 and latitude 4184000 to 4192000 in megnatic system situation. Based on linear diagram of temperature variables in this region, avarege annual temperature is 16.2 ^{oc} and maximum and minimum temperature are 23.4 and 8.9 ^{oc} respectively. The average rainfall is 262 mm and region climate is semi arid based on Domarthen method and its average elevation is 837.1 m above sea level. Texture of soil in this region is silt and soil alkalinity and salinity and Ec 6.2 ds/m. Rank abundance models are used in order to measure diversity indices. These models include geometric series, log, log normal and MacArthur's broken stick, with its formulas in Table 1.

Table 1. Formula for rank abundance models.

Index name	Geometric series	Log series	Log normal series	Broken stick series
Formula	$n_i = NC_k K(1-K)^{i-1}$	$S = \alpha \ln(1+N/\alpha)$	$S(R) = S_O \exp(-a^2 R^2)$	$S(n) = \left[S(S-1)/N\right](1-n/N)^{S-2}$

In geometric series, n_i is number of individuals at 1-th species, N is total number in sample , c_k is a constant value, its value is obtained in $C_k = \left[1-(1-k)^s\right]^{-1}$ and ensures that $\sum n_i = N$. k is a constant value and is derived from N_{min}/M. In log series, S is total species in sample, N total number in sample, α diversity index and Ln logarithm at base 10. In log normal series, s(R) is total number of R-thoctaves(stage) in either side of symmetric curve, α= $a = (2\sigma^2)^{\frac{1}{2}}$ Inverse of curve distribution width and S_O is the number of species in mode octave 5. In MacArthur's broken stick series, S (n) is the number of species in frequency class with odd, S total number of species and N total number. 1 m^2 plots were used for measured plant vegetation parameters (density and canopy cover). Total canopy cover and all of species is measured separately in to each plot and the number of species base was counted. Data analysis was done using Bio-Dap software. Chi-sqare test was used in order to examine measured levels significance ($p<0.05$). Meanwhile, plot number was computed by the formula $N = \left(\frac{t_\alpha CV}{d}\right)^2$ in which N is minimum sample number, T_α student, T, CV variation coefficient and d correctness percentage (50 plots in total area) and plots were implemented randomly at area level.

Table 2. Canopy cover and relative density in region families under study.

Class	Family	Percentage canopy caver	Relative density	Class	Family	Percentage canopy caver	Relative density
1	*Apiaceae*	0.29	1.10	16	*Labiatae*	1.4	8.16
2	*Boraginaceae*	0.04	0.33	17	*Liliaceae*	0.08	1.43
3	*Brasicaceae*	0.02	0.22	18	*Malvaceae*	0.06	0.11
4	*Caryophyllaceae*	1.08	0.55	19	*Papaveraceae*	0.07	0.77
5	*Chenopodiaceae*	5.59	12.35	20	*Papilionaceae*	1.02	2.76
6	*Composite*	8.41	13.89	21	*Plumboginaceae*	0.00	0.11
7	*Convolvulaceae*	0.04	0.22	22	*Poaceae*	4.66	42.01
8	*Cruciferae*	0.26	6.59	23	*Podophyllaceae*	0.02	0.11
9	*Cucurbitaceae*	0.14	0.11	24	*Ranunculaceae*	0.00	0.00
10	*Cypraceae*	0.28	0.22	25	*Resedaceae*	0.26	0.22
11	*Dipsacaceae*	0.00	0.00	26	*Rosaceae*	1.37	2.21
12	*Ephedraceae*	0.00	0.00	27	*Rubiaceae*	0.02	0.44
13	*Euphorbiaceae*	0.69	3.75	28	*Scrohulariaceae*	0.00	0.00
14	*Geraniaceae*	0.03	0.44	29	*Solanaceae*	0.00	0.00
15	*Iridaceae*	0.05	11.21	30	*Zygophyllaceae*	0.92	0.33
16	*Labiatae*	1.40	8.16		Sum	27.16	100

Results and Discussion

Floristic examination in this region showed there is 71 species of 61 geniuses and 25 families (table2). Chi-square test was used in order to examine models fitness with common models. Base on the above results, there is significant difference between chi-values measured with expected chi- values corresponding to the geometric and MacArthur's broken stick models, thus, density distribution in grazing region do not follow from two above models (tables3, 4).

Table 3: Results of diversity measurement using broken stick model in grazed area.

Class	Upper limit	Observe density	Expected density	Chi-square
1	2.5	29	9.78	37.75
2	4.5	11	8.4	0.81
3	8.5	11	13.39	0.43
4	16.5	6	17.09	7.19
5	32.5	6	14.12	4.47
6	64.5	4	5.11	0.24
7	128.5	4	0.41	31.83
Sum		71	68.3	8219 ns

NS: There is no significant deference

But there is no significant difference in log series model at $p<0.05$ thus this region complies with this model (table 5). Results show there is no significant difference between density curve in grazing area using log normal ($p<0.05$), thus, this is management method complies with this model (table 6).

Results in this research show, the maximum canopy cover in grazing region related to the *compositae* family with *Artemisia sieberi* species. After that, the maximum canopy cover pertains to *chenopodiaceae* family with annual species like ceratocarpus *arenarius*, *Anabasis annua* and perennial ones like *Salsola sp*. This, grazing increases share of annual species like *Eremopyrum* by wide ecological riche and depend on every year seed production for survival. Herbivores and plants have evolved together and grazing is useful for plant vegetation and plant growth increases up to optimal limit by increasing the grazing intensity then decreases and ends in plant declining (Holechek *et al.,* 2004).Fitness in rank abundance model in region under study using current models and chi-squre test shows that species density in those region do not comply with geometric series. Thus, it can be concluded grazing species of plant is not in a very heavy grazing which cases drastic reduction of the sequence stages and dominating a bit of dominant species and a drastic reduction of diversity, because this model is usually seen in polluted societies or communities with poor species or in the early stage of succession (Ejtehadi *et al.,* 2010 and Porbabaee, 2005). The reason that species density does not comply with MacArthur's broken stick series is not smooth distribution because of the operation in the region under grazing as well as succession stages and resulting competition among plant species , but because larger share of resources and species resistant to grazing and environmental factors is obtained. In this context, Southwood 1978 believes that this model reflects a condition of minimum occupations with equally-distributed resources among species. Adherence to the grazing area of two log normal and log series can be justified as follows, this area was initially a uniform place and as a result of continuous grazing trends toward log model characteristic of an under pressure environment. So, this is not a balanced and moderate grazing and diversity is declining in this region. Akafi, Ejtehadi 2008 founded that the area under grazing has a steep slope curve and its functions shift from log normal state towards log model that indicates destruction and diversity reduction in this region. Over grazing reduces species diversity declines perennial species and replaces annual species like *Hyssopus, Glaucium corniculatum, Ceratocarpos arenarius, Androsace manima, Bromus danthoni, Eremopyrum distans, Angustifolius* and perennial and non- palatable ones like *Citrullus coloynthis, Iris acutiloba, Noeae mucronata, Dianthus crinitus*. Because this range is grazed continuously during the year (at least 10 months) and diversity reduction has not reached to a critical stage (geometric series). This result is not in accordance with theories offered by Hartnett *et al.* 1999, Harrison 1999 and in accordance with other authors like Karen *et al.,* 2004. Therefore, grazing reduces plant diversity in this area and in different conditions; species diversity is not in an early stage of succession. Hence species diversity profile can be driven to the higher stages using a systematic approach and grazing reduction. Thus it is recommended to control exactly utilization season and permissible rancher and livestock as well as optimally protect the rangelands. Meanwhile, in respect to the ecophysiological conditions of dominant plant species (Artemisia and salsola), change in grazing season from pediment to winter rangeland can also help in improving diversity conditions of rangelands.

Table 4. Values corresponding to geometric distribution in grazed area.

Class	Specie name	Observe density	Expected density	Chi-square	Class	Specie name	Observe density	Expected density	Chi-square
1	Eremopyrum distans	110	50.32	70.77	26	Iris acutiloba	7	12.42	2.36
2	Poa bulbosa	88	47.58	34.33	27	Noaea mucronata	5	11.74	3.87
3	Artemisia sieberi	83	44.99	32.11	28	Phlomis cancellata	5	11.1	3.35
4	Salsola keraneri	82	42.54	36.59	29	Dianthus crinitus	5	10.5	2.88
5	Androsace maxima	60	40.23	9.72	30	Stachys turcomani	5	9.93	2.44
6	Zataria multiflora	50	38.04	3.76	31	Taraxacum montanum	5	9.39	2.05
7	Hordium gluca	35	35.97	0.03	32	Cynodon dactylon	4	8.87	2.68
8	Stipa capensis	33	34.01	0.03	33	Astragalus gifanicus	4	8.39	2.3
9	Euphorbia falcata	30	32.16	0.14	34	Asperula iaxiflora	4	7.93	1.95
10	Aegilops crassa	29	30.41	0.07	35	Stipa barbata	4	7.5	1.63
11	Phragmites australis	27	28.75	0.11	36	Geranium persicum	4	7.09	1.35
12	Bromus tecterum	23	27.19	0.64	37	Ixiolirion tataricum	4	6.71	1.09
13	Ceratocarpus arenarius	20	25.71	1.27	38	Euphorbia cheiradenia	4	6.34	0.87
14	Rosa persica	18	24.31	1.64	39	Astragalus pinetorum	3	6	1.5
15	Tragopogon buphthalmoides	16	22.98	2.12	40	Centaurea kotschyi	3	5.67	1.26
16	Bromus sterilis	14	21.73	2.75	41	Onosma microcarpum	3	5.36	1.04
17	Nepeta pungens	11	20.55	4.44	42	Zygophyllum atriplicoides	3	5.07	0.85
18	Alium synthamantum	10	19.43	4.58	43	Heracleum lasiopet *al*um	2	4.79	1.63
19	Achillea tenuifolia	9	18.37	4.78	44	Lactuca glaucifolia	2	4.53	1.42
20	Astragalus brivedens	9	17.37	4.03	45	Setaria glauca	2	4.29	1.22
21	Bromus danthoniae	8	16.43	4.32	46	Alhagi camelorum	2	4.05	1.04
22	Bunium persicum	7	15.53	4.69	47	Kochia prostrata	2	3.83	0.88
23	Glaucium corniculatum	7	14.69	4.02	48	Malcolmia strigosa	2	3.62	0.73
24	Cousinia diezii	7	13.89	3.42	49	Carex stenophylla	2	3.43	0.59
25	Astragalus siliqusus	7	13.13	2.86	50	Gagea raticulata	2	3.24	0.47
51	Convolvulus pilosellaefolius	2	3.06	0.37	62	Hyssopus angustifolius	1	1.65	026
52	Reseda luteola	2	2..9	0.28	63	Salvia viridis	1	1.56	0.2
53	Alyssum linifolium	2	2.74	0.2	64	Hordeum bulbosum	1	1.48	0.16
54	Bromus tomentelus	2	2.59	0.13	65	Malva sylvestris	1	1.4	0.11
55	Anabasis annua	2	2.45	0.08	66	Peroveskia abrostanoides	1	1.32	0.08
56	Citrullus colocynthis	1	2.32	0.75	67	Salsola richteri	1	1.25	0.05

57	Prunus divaricata	1	2.19	0.65	68	Crambe kotschyana	1	1.18	0.03
58	Sanguisorba minor	1	2.07	0.55	69	Atraphaxis spinosa	1	1.12	0.01
59	Bongardia chysogonum	1	1.96	0.47	70	Psyliostachys spicata	1	1.06	0
60	Phalaris minor	1	1.85	0.39	71	Eryngium bungei	1	1	0
61	Tulipa micheliana	1	1.75	0.32		Total sum	907	907	279.75 ns

NS: There is no significant deference

Table 5. Diversity measurement results using log series in grazed area

Class	Upper limit	Observe density	Expected density	Chi- square
1	2.5	29	26.35	0.27
2	4.5	11	9.83	0.14
3	8.5	11	10.11	0.08
4	16.5	6	9.43	1.25
5	32.5	6	7.71	0.38
6	64.5	4	5.01	0.2
7	128.5	4	2.55	0.83
Sum		71	71	3.14 *

*: There is significant deference ($p<0.05$)

Table 6. Diversity measurement results using log normal model in grazing area

Class	Upper limit	Log 10 upper limit	Standard form of log 10 upper limit	Observed density	Cumulative expected density	Expected density	Chi- square
Ultra of Vill line	0.5	-0.3	-1.13	0	10.45	10.45	0
1	2.5	0.4	-0.15	29	36.03	25.57	0.46
2	4.5	0.65	0.22	11	47.69	11.67	0.04
3	8.5	0.93	0.61	11	59.3	11.61	0.03
4	16.5	1.22	1.01	6	68.82	9.51	1.3
5	32.5	1.51	1.43	6	75.25	6.43	0.03
6	64.5	1.81	1.85	4	78.85	3.6	0.04
7	128.5	2.11	2.28	4	81.45	2.6	0.75
Sum				71		81.5	2.65 *

*: There is significant deference ($p<0.05$)

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