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CASE STUDY

Biodiversity and integration of ecological characteristics of species in spatial pattern analysis

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ABSTRACT

BACKGROUND AND OBJECTIVES: Assessment of biodiversity is a key factor in understanding of function and ecosystem management. Nevertheless, an operating procedure for assessing biodiversity and spatial pattern has not been established yet. Therefore, this empirical study was conducted to explore the role of diversity of species in the spatial patterning of tow shrub herbaceous communities.

METHODS: First, the biodiversity analysis was performed by Past3 software to compare the relationship between the two communities. Secondly, the distance and quadrat indices were employed to explore the spatial relationship of dominant species with diversity. In this regard, 64 and 84 plant species recorded in two vegetation types were investigated. Distribution patterns were extracted by distance and quadrat indices and Ecological Methodology software.

FINDINGS: The results showed that vegetation type 2 had more diversity and richness compared to vegetation type 1. Besides, the spatial distributions of dominant species (*Astragalus gossipinus* and *Bromus tomentellus*) in the two vegetation types were clumped and random with tendency to be clumped. The Scrophulariaceae, Malvaceae, Papaveraceae, and Euphorbiaceae families were not found in vegetation Type 1, and vegetation Type 2 had no species of the Boraginaceae, Rosaceae, Thumeliaceae, Capparidaceae, Oleaceae, Sistaceae, and Dispaceae families. The results showed significant differences in the number of Gaminae and Legominosea families between the two vegetation types.

CONCLUSION: It was concluded that in communities with a dominant cover of shrub, the distribution pattern was clumped, and quadrat indices were less efficient than distance indices. While, in high-diversity communities with a predominant cover of gross, spatial distribution was random and distance and quadrat indices were more convergent.

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INTRODUCTION

Spatial pattern analysis methods provide insights into where things occur, how the distribution of incidents is or how the arrangement of data aligns with other features in the landscape, and what these patterns may reveal about potential connections and correlations (Scott 2015). In general, plant's distribution pattern could be classified into three vegetation types as random, uniform and clumped (Krebs 1999; Carvalho, 1992; Buschini, 1999; Askari *et al*., 2013 ; Lohe *et al.,* 2015). In the random distribution pattern, each member is independent from the other members (Pielou 1977; Whistle Wood, 1978; Petrere, 1985). Correspondingly, this pattern is based on the environmental similarities and non-selective behavior forms. In uniform distribution pattern, the members are positioned with regular intervals. Therefore, this pattern shows the negative impacts of competition on food or niche (Elliott, 1979; Matuky and Kulma, 1982). The clumped distribution pattern occurs when all or the majority of the population prefer to concentrate mostly on the specific parts of the environment (Odum, 1986; Krebs, 1999; Carvalho, 1992; Buschini, 1999). Apparently, the occurrence of this pattern is attributed to asexual reproduction and abundance of seed production. Therefore, these patterns are affected by the environmental factors, species behaviour, and individual characteristics of the plant species. Using Pielou and Hopkins indices, the distribution pattern of plain *Artemisia* was studied in three sites located in a step zone (Jamali *et al*., 2020). Results showed that the distribution pattern of *Artemisia* in the first habitat was uniform; this distribution was clumped in the second habitat and uniform in the third habitat. Additionally, the distribution pattern of *Anadenanthera peragrina* species was determined using the proportion of variance to the mean, Morisita, standard Morista, negative binomial distribution, green indices and various measuring plots. Among the calculated indices, the standard morista index was found to be the best one, despite the plot size (Malhado and Petter, 2004). The distribution patterns of three species of *Festuca ovina*, *Prangos ferulacea,* and *Bromus tomentelus* in a pasture were investigated. Accordingly, it was proved that the distribution of *F*. *ovina* was as clumped vegetation type, and the distributions of *P*. *ferulacea* and *B. tomentellus* were random (Zare Chahooki *et al*., 2010). Furthermore, the spatial pattern of *Crategus sp*. in the Central Zagros was evaluated. All the applied indicators showed a clumped pattern for *Crataegus sp.* forests. The obtained results also demonstrated that distance distribution indices had the same pattern for one species in most of the cases, and were more accurate than quadrat indices (Askari *et al.,* 2013). Biodiversity is defined as the kinds and numbers of organisms and their patterns of distribution (Schuler, 2006). Generally, it can be said that biodiversity measurement typically focuses on the species level, and species diversity is one of the most important indices used for the evaluation and sustainable management of ecosystems. The diversity distribution can be evaluated using different spatial indices and scales such as species ecological traits, phytogeographic history, species richness, evenness and diversity (Crist *et al*., 2003; Sühs *et al*., 2019). Species diversity studied in grazed and non-grazed areas showed that herbaceous layer had the highest richness, evenness and diversity. The differences between biodiversity indices in the two areas were statistically significant in the tree, shrub and herbaceous layers (Haidari *et al.*, 2013). Erfanzadeh *et al*. (2015) studied the variation of plant diversity components in arid and semi-arid regions in different scales, and reported that diversity had the highest contribution to the total diversity for all the species as well as rare species in both regions. The results of a study conducted by Luiza *et al*. (2020) on three dimensions of plant diversity change across ecological and biogeographic scales showed that two Neotropical inselbergs were taxonomically different (beta diversity); however, they had convergence in their function and diversities. The plant floristics in different parts of Kermanshah province have been studied by some scientists. For instance, Sadeghirad *et al.* (2014) showed that among 29 plant genera in Kermanshah, Poaceae (25 species), Papilionaceae (17 species) and Lamiaceae (11 species) had the highest frequencies. No study has tested the relationship between spatial pattern and assessment of diversity so far. Notably, the main objectives of this study were: i) to analyse the distribution of the different vegetation types of the existing plant species at two different altitudes in order to better understand the relationship among floristic composition, richness, and diversity to species spatial pattern; and ii) to select proper indices which can illustrate the distribution pattern of different species more accurately. This would consequently facilitate the selection of sampling methods. This study was carried out in Kermanshah, Iran in 2020.

MATERIALS AND METHODS

Study area

The study area, with an area of 11009.62 hectares, is located on Sepol and Dodgoosh mountains, at a distance of 13 km from Kermanshah city. In addition, 5725.49 hectares of the study area are covered with rangelands occupied with Poaceae and legominacea families. This area is located between latitude of 34° 10′ to 34° 19′ N and longitude of 47° 16′ to 47° 24′ E. The elevation range of the study area is 1248-1804 m above the sea level and its mean slope is in the range of 12-20%. Also, the annual rainfall is 400-450 mm. Soil in this area has a medium texture with a high percentage of gravels, and in some parts, out crops are observable. Based on the previous studies performed in this region, the area has four main vegetation types. In the present study, has only focused on two vegetation types at minimum and maximum two altitudes as follows: the first vegetation type (Type 1), with an area of 1,600 hectares, covers about 28% of the whole area and exists at an altitude of 1,248 m above the sea level on the southern hills leading to Gamasiab and Gharesoo rivers (Karimi, 2017) (Fig. 1). Accordingly, this pasture is mainly used for grazing during the growing season. The most important species of the first vegetation type are *Astragalus gossypinus* (dominant species), *Astragalus brachystachis, Bromus tomentellus*, and *Gundelia turnefortii*. The second vegetation type (Type 2), with an area of 487 hectares, has the smallest share among the vegetation types, covers 5.8% of the natural habitats, and exists at an altitude of 1,804 m. This vegetation type has a high potential for producing rangeland vegetation. Although the accumulation and density of the rangeland vegetation have been decreased due to drought, this vegetation type, due to having higher moisture, high altitude and less grazing, has the highest forage production and percentage of cover among the other vegetation types. The dominant family of the second vegetation type is Poaceae with the dominant species of *Bromus tomentellus* and other species such as *Hordeum bulbosum* and *Gundelia turnefortii* (belonging to the compositae family).

Data collection

The two vegetation types (Type 1 and Type 2) were selected for sampling. For random placement

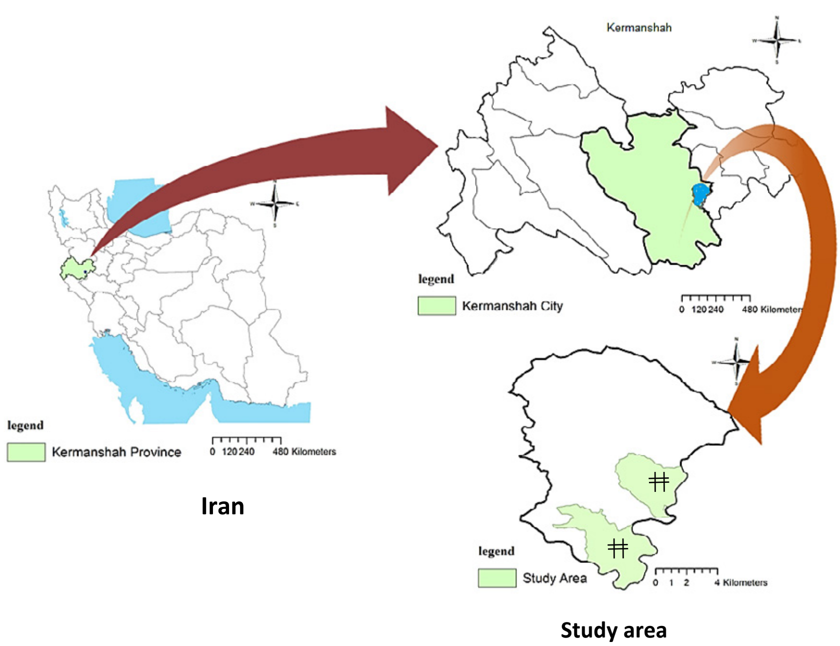

Fig. 1: Geographic location of the study area in the Northern Zagros region, Kermanshah, Iran

of transects, 10 points with a distance of 50 m were selected, so that the first 4 points were randomly selected and then transects were extended from these points. Considering the expansion of the area and the species distribution, four 300-m transects with spacing of 100 m were randomly allotted to each vegetation type. Along each transect, 25 points with intervals of 4 m were selected and 15 of them were measured. A total of 100 quadrats, with a 2-m^2 surface, were established in each vegetation type to count and identify the species. The plant species were assessed by the authors and experts in the plant phenology.

Data analysis

Information on cover, frequency, and number of species in each plot were recorded. Past3 software was then utilized to calculate the species richness and diversity indices. Menhinic and Margalef indices, presented by Eqs. 1 and 2 respectively, were utilized for calculating the species richness. Moreover, Simpson, Shannon and Brillouin indices were introduced to calculate the species diversity indices (Eqs. 3, 4 and 5, respectively).

$$R = \frac{S}{\sqrt{N}} \qquad (1)$$

$$R = \frac{S-1}{Ln(N)} \qquad (2)$$

$$H' = 1 - \sum_{i=1}^{s} Pi^2 \qquad (3)$$

$$H' = \sum_{i=1}^{s} (\mathrm{Pi})(\log 2\mathrm{Pi}) \qquad (4)$$

$$HB = \frac{\mathrm{Ln}N! - \sum_{i=1}^{n} Lnn_i!}{N} \qquad (5)$$

Where, S is the number of plant species included in the sample; N is the total frequency of all the studied plant species; and Pi is the frequency ratio of i^{th} group to the all the studied species (Magurran, 1988; Schowalter, 2012). Compared to complete sampling methods, distance and quadrat indices required less time and costs and had higher accuracy at the same time. Therefore, these indices were selected to measure the distribution of species. For each random point, the distance to the nearest plant, the distance of the mentioned plant to the nearest neighbor, and the distance of random point from the second near plant were measured. Finally, distance and quadrat indices of the distribution were described based on the obtained information. Johnson and Zimer (1985) and Ludwig and Reynolds (1988) proposed following index for measuring the spatial pattern of distance in which if E(I) > 2 the pattern is clumped and the spatial pattern is random when E(1) = 2 (Eq. 6).

$$I = (N+1)\frac{\sum_{i=1}^{N}(d_i^{\,2})^2}{\left[\sum_{i=1}^{N}(d_i^{\,2})\right]^2} \qquad (6)$$

Where, N is random points (with x and y co-ordinates), d_i is Distance from the i^{th} point to the nearest neighbor and E(I) is the expected value of I.

Eberhart's index is suggested as the following equation (Krebs, 1989) where IE > 1.27 indicates clumped spatial pattern, IE < 1.27 represents the uniform pattern and IE = 1.27 indicates the random pattern using Eq. 7.

$$I_E = (\frac{S}{\overline{X}})^2 + 1 \qquad (7)$$

Where, I_E is the Eberhardt's index of dispersion for point-to-organism distances, S is observed standard deviation of distances and X is the mean of point-to-organism distances. Pielou (1959) presented the Pielou's index in which the P value less than 1 indicates the random spatial pattern of distance, while P=1 shows the uniform pattern and P>1 represents the clumped spatial pattern of distance (Eq. 8). Equation 8 presents the Pielou's index calculation where π equals 3.14, ΣX_i is the total distance from the nearest neighbor to the sample point, D is the Density (m^2) and N is the number of samples.

$$P = \pi D\left(\frac{\sum_{i=1}^{N} X_i}{N}\right) \qquad (8)$$

Hopkines (1954) presented his spatial pattern of distance index using Eq. 9.

$$I_H = \frac{\Sigma(x_i^2)}{\Sigma(x_i^2) + \Sigma(r_i^2)} \quad (9)$$

Where, h is the Hopkins' test statistics for randomness, x_i is the distance from random point i to the nearest organism, and r_i is the distance from random organism i to its nearest neighbor. $I_H = 1$ shows the clumped spatial pattern of distance while I_H values equal to 0 and 0.5 indicate uniform and random spatial pattern of distance, respectively. Murcury (2000) introduced the Holgate's index as indicated in Eq. 10 in which A value greater than 0 indicates the clumped pattern, A=0 shows the random pattern while the A value less than 0 represents the uniform spatial pattern of distance using Eq. 10.

$$A = \frac{\Sigma \frac{d_i^2}{d_2^2}}{n} - 0.5 \quad (10)$$

The variance-to-mean ratio index is among the first indices for calculating the spatial pattern of quadrat using Eq. 11 (Krebs, 1989; Ludwig and Reynolds, 1988).

$$ID = \frac{S^2}{\bar{X}} \quad (11)$$

Where, $\bar{x}$ is the mean population density and S^2 is the variance of population. According to the Eq. 11, ID value equal to n and 0 indicate the clumped and uniform spatial pattern of quadrat, respectively. Ludwig and Reynolds (1988) modified the variance-to-mean ratio index and introduced the Green's index using Eq. 12; in which $\bar{x}$ is the mean population density, S^2 is the variance of population and n is the total population. If GI value equal to 1, it means that the spatial pattern of quadrat is clumped, if the value is equal to 0, indicates the random pattern, while if the GI value is less than 0, means the spatial pattern of quadrat in studied community is uniform.

$$GI = \frac{(\frac{s^2}{\bar{x}}) - 1}{n - 1} \quad (12)$$

Eq. 13 shows the Lioyd's index for spatial pattern of quadrat (Ludwig and Reynolds, 1988).

$$LI = \frac{\bar{x} + (\frac{s^2}{\bar{x}} - 1)}{\bar{x}} \quad (13)$$

Where, $\bar{x}$ is the mean population density and S^2 is the variance of population. The LI value less than 1 indicates the uniform spatial pattern of quadrat, while LI=1 shows the random pattern and LI>1 represents the clumped spatial pattern of quadrat. Morisita's index introduced for calculating the spatial pattern of quadrat using Eq. 14 (Morisita, 1962; Krebs, 1989; Ludwig and Reynolds, 1988).

$$I_d = n\left[\frac{\Sigma X_i^2 - \Sigma X_i}{(\Sigma X_i^2) - \Sigma X_i}\right] \quad (14)$$

Where, I_d is the Morisita's index of dispersion, n is the sample size, Σx_i is the sum of quadrat counts and Σx_i^2 is the sum of quadrat counts squared. The $I_d > 1$ indicates clumped spatial pattern, $I_d < 1$ represents the uniform pattern and $I_d = 1$ indicates the random pattern. Smith and Gill (1975) standardized the Morisita's index and developed two equations for uniformity index using Eq. 15 and Clumped index using Eq. 16.

$$M_u = \frac{X^2_{0.975} - n + \sum X_i}{(\sum X_i) - 1} \quad (15)$$

$$M_u = \frac{X^2_{0.025} - n + \sum X_i}{(\sum X_i) - 1} \quad (16)$$

Where, n is the sample size, Σx_i is the sum of the quadrat counts, $X^2_{0.975}$ is the Chi-squared distribution with *n-1* degrees of freedom and 0.975 quantile values and $X^2_{0.975}$ is the Chi-squared distribution with *n-1* degrees of freedom and 0.025 quantile values. According to the equations, the I_p value equal to 0, means that the spatial pattern of quadrat is random, if the value is higher than 0, indicates the clumped pattern, while if the I_p value is less than 0, means the spatial pattern of quadrat in the studied community is uniform. To reach a more accurate plants distribution, statistical distributions (poisson and negative/positive binomial distributions) were calculated using Ecological Methodology Software. Finally, the distribution curves of the species were created by the relationship between quadrats frequency and the number of individuals in each quadrat. These curves enabled us to differentiate the distribution patterns for the plant species type existing in the selected area.

RESULTS AND DISCUSSION

Diversity analysis

The floristic compositions of vegetation Type 1 and Type 2 are listed in Tables 1 and 2, respectively. Most of the species appeared in the herb layer, and the species of woody plants were very limited. The results shown in Fig. 2 indicate that the numbers of the species belonging to the different families of the two vegetation types are considerably divers. Moreover, in both vegetation types, the species belonging to Garminae had the highest abundancy. However, the dominant cover of vegetation Type 1 was found to be shrub and *Astragalus* genus. Species diversity was higher in vegetation Type 2, and the number of Graminae species was higher in vegetation Type 2 than in vegetation Type 1. The Scrophulariaceae, Malvaceae, Papaveraceae, and Euphorbiaceae families were not found in vegetation Type 1, and vegetation Type 2 had no species of the Boraginaceae, Rosaceae, Thumeliaceae, Capparidaceae, Oleaceae, Sistaceae, and Dispaceae families. The results showed significant differences in the number of Gaminae and Legominosea families between the two vegetation types. Overall, these results indicated that the plant community composition and the abundance of species were significantly different between the two vegetation types (Fig. 2). Yirga *et al*. (2019), in their study, reported the impact of altitude on plant species composition, diversity, and structure at the Wof-Washa highlands of Ethiopia. Furthermore, Al-Aklabi *et al*., (2016) found different combinations of plant species in response to elevation and topography. The differences in species compositions among the forest sites could be mainly attributed to the dissimilarities of the sites in terms of location, altitude, human impact, rainfall, and other biotic and abiotic factors (Yirga *et al*., 2019;

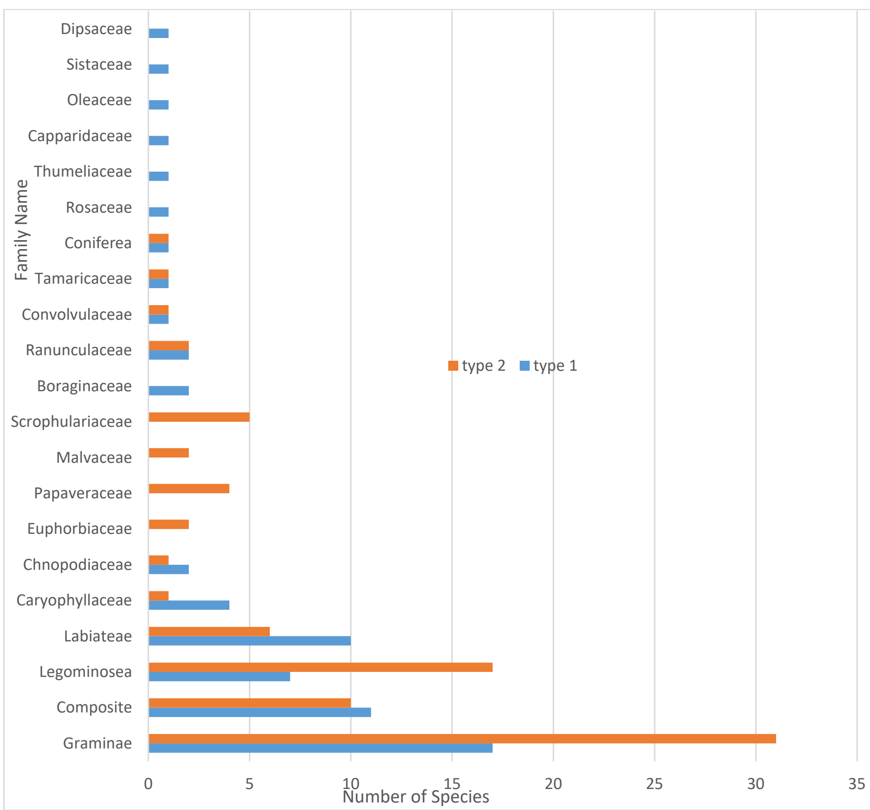

Fig. 2: Comparison of the number of species belonging to the different families in the two vegetation types (Types 1 and 2)

Table 1: The floristic list of vegetation Type 1

No.	Family	Genus	Species	No.	Family	Genus	Species
1	Graminae	*Bromus*	*tomentellus*	33	Legominosea	*Astragalus*	*gossypinus*
2	Graminae	*Bromus*	*sterilis*	34	Legominosea	*Astragalus*	*effusus*
3	Graminae	*Bromus*	*tectorom*	35	Legominosea	*Astragalus*	*raddei*
4	Graminae	*Bromus*	*inermis*	36	Labiateae	*Phlomis*	*herbaventi*
5	Graminae	*Hordeum*	*bolbosum*	37	Labiateae	*Phlomis*	*lanceolatus*
6	Graminae	*Hordeum*	*geniculatum*	38	Labiateae	*Tribolus*	*tristri*
7	Graminae	*Hordeum*	*violaceum*	39	Labiateae	*Teucrium*	*polium*
8	Graminae	*Agropyrun*	*panormitaum*	40	Labiateae	*Salvia*	*sclarea*
9	Graminae	*Agropyrun*	*inermis*	41	Labiateae	*Salvia*	*limbata*
10	Graminae	*Agropyrun*	*cristatum*	42	Labiateae	*Ziziphora*	*junior*
11	Graminae	*Stipa*	*cappensis*	43	Labiateae	*Ziziphora*	*capitata*
12	Graminae	*Stipa*	*pennata*	44	Labiateae	*Stachys*	*inflata*
13	Graminae	*Stipa*	*barbata*	45	Labiateae	*Stachys*	*kurdica*
14	Graminae	*Poa*	*annua*	46	Chnopodiaceae	*Chnopodium*	*botrys*
15	Graminae	*Aegilups*	*columnaris*	47	Chnopodiaceae	*Ferolago*	*macrocarpa*
16	Graminae	*Avena*	*clauda*	48	Rosaceae	*Amygdalus*	*scoparia*
17	Graminae	*Avena*	*ventricola*	49	Caryophyllaceae	*Acanthophyllum*	*bractetum*
18	Composite	*Onopordo*	*acanthium*	50	Caryophyllaceae	*Vaccaria*	*pyramidata*
19	Composite	*Lactuca*	*orientalis*	51	Caryophyllaceae	*Dianthus*	*szowitisianus*
20	Composite	*Tragopogon*	*collinus*	52	Caryophyllaceae	*Dianthus*	*macranthus*
21	Composite	*Tanacetum*	*policephalum*	53	Thumeliaceae	*Paliurus*	*spina*
22	Composite	*Thevenotia*	*persica*	54	Boraginaceae	*Onosma*	*latifolia*
23	Composite	*Scariola*	*orientalis*	55	Boraginaceae	*Ceccinia*	*marantera*
24	Composite	*Gundelia*	*mucronata*	56	Capparidaceae	*Noaea*	*mucronata*
25	Composite	*Artemisia*	*siberi*	57	Ranunculaceae	*Ranunculus*	*arvensis*
26	Composite	*Sirsium*	*echinus*	58	Ranunculaceae	*Anemone*	*biflora*
27	Composite	*Gundelia*	*turneforti*	59	Convolvulaceae	*Convolvulus*	*ammocharis*
28	Composite	*robostus*	*Echinops*	60	Tamaricaceae	*Reaumuria*	*stocksii*
29	Legominosea	*Aechardia*	*orientalis*	61	Oleaceae	*Fraxinus*	*excelsior*
30	Legominosea	*Astragalus*	*brachystachis*	62	Sistaceae	*Helianthemum*	*sulicifolium*
31	Legominosea	*Astragalus*	*schistusus*	63	Dipsaceae	*Ceohalaria*	*microcephala*
32	Legominosea	*Astragalus*	*macropelmatus*	64	Coniferea	*Taraxacom*	*montanum*

Girma, 2011). Table 3 shows the values of the species richness and diversity indices for the plant species existing in the study area. It was found that the values for the species richness indices, named Margalef and Menhinic, were higher in vegetation Type 2 than in vegetation Type 1. In vegetation Type 1, the species are expanded into the areas with more humidity and slope. This can be due to grazing intensity and geographical location of the region, which, in turn, have resulted in loss of the species diversity (Santos and Munhoz, 2012). Considering the values of diversity indices, it was found that all the calculated indices (Simpson-1-D, Shannon-H and Brillouin) were higher in vegetation Type 2 rather than vegetation Type 1 (Table 3).

Spatial patterns

Spatial pattern of species can indicate stand history, population dynamics, and species competition (Haas, 1995), and may explain what controls the co-existence and diversity of species in a rangeland. The spatial distributions of two dominant species in the two vegetation types are shown in Tables 4 and 5. According to the most of the indices, the distribution pattern of *Astragalus gossypinus* is random with more tendency to be clumped. Eberhart indices (the distance of random point from the nearest plant), Hopkines (based on the distance of random point from both the nearest plant and the nearest neighbor), and Holgate (based on the distance of the point from both the nearest plant and the second nearest plant) also show a clumped distribution pattern (Table 4). This finding is consistent with the results of the previous studies (Jannat Rostami *et al*., 2009; Mohebi *et al*., 2011). Since three distance indices including Eberhardt, Hopkines, and Holgate showed a clumped distribution pattern, it can be assumed that distance indices would present the distribution pattern of shrub species better than quadrat indices. Due to

Table 2: The floristic list of vegetation Type 2

No.	Family	Genus	Species	No.	Family	Genus	Species
1	Graminae	*Bromus*	*tomentellus*	43	Legominosea	*Astragalus*	*brachystachis*
2	Graminae	*Bromus*	*sterilis*	44	Legominosea	*Lathyrus*	*pratensis*
3	Graminae	*Bromus*	*tectorom*	45	Legominosea	*Lathyrus*	*aphaca*
4	Graminae	*Bromus*	*inermis*	46	Legominosea	*Visia*	*monantha*
5	Graminae	*Bromus*	*dantoniae*	47	Legominosea	*Visia*	*villosa*
6	Graminae	*Bromus*	*squarrisa*	48	Legominosea	*Robinia*	*pseudoacaci*
7	Graminae	*Hordeum*	*bolbosum*	49	Legominosea	*Glissierhisa*	*glabra*
8	Graminae	*Hordeum*	*glaucum*	50	Legominosea	*Trifolium*	*fragiferum*
9	Graminae	*Hordeum*	*murinum*	51	Legominosea	*Lotus*	*michauxianu*
10	Graminae	*Hordeum*	*geniculatum*	52	Legominosea	*Onobrychis*	*altissima*
11	Graminae	*Hordeum*	*violaceum*	53	Legominosea	*Onobrychis*	*cristugelli*
12	Graminae	*Agropyrun*	*panormitaum*	54	Legominosea	*Sophora*	*alopecuroide*
13	Graminae	*Agropyrun*	*inermis*	55	Legominosea	*Medicago*	*radiata*
14	Graminae	*Agropyrun*	*cristatum*	56	Legominosea	*Medicago*	*rigidula*
15	Graminae	*Agropyrun*	*elongatom*	57	Legominosea	*Sorghom*	*halopens*
16	Graminae	*Agropyrun*	*intermedium*	58	Legominosea	*Trigonella*	*angustifolium*
17	Graminae	*Festuca*	*ovina*	59	Labiateae	*Phlomis*	*rigida*
18	Graminae	*Festuca*	*pratensis*	60	Labiateae	*Marrobium*	*vulgar*
19	Graminae	*Festuca*	*arundinacea*	61	Labiateae	*Teucrium*	*polium*
20	Graminae	*Stipa*	*cappensis*	62	Labiateae	*Salvia*	*limbata*
21	Graminae	*Stipa*	*pennata*	63	Labiateae	*Ziziphora*	*junior*
22	Graminae	*Stipa*	*barbata*	64	Labiateae	*Ziziphora*	*capitata*
23	Graminae	*Poa*	*angustifolia*	65	Euphorbiaceae	*Euphorbia*	*strobitacea*
24	Graminae	*Poa*	*bulbosa*	66	Euphorbiaceae	*Euphorbia*	*aellenii*
25	Graminae	*Poa*	*annua*	67	Papaveraceae	*Papaver*	*tenuifolium*
26	Graminae	*Aegilups*	*columnaris*	68	Papaveraceae	*Papaver*	*lacerum*
27	Graminae	*Aegilups*	*triuncialis*	69	Papaveraceae	*Glauciun*	*elegans*
28	Graminae	*Festuca*	*pratensis*	70	Papaveraceae	*Fumaria*	*vaillantii*
29	Graminae	*Festuca*	*arundinacea*	71	Malvaceae	*Alcea*	*ficifolia*
30	Graminae	*Secale*	*montanum*	72	Malvaceae	*Malva*	*neglecte*
31	Graminae	*Boissiera*	*sqarus*	73	Scrophulariaceae	*Scrophularia*	*striata*
32	Composite	*Tragopogone*	*collinus*	74	Scrophulariaceae	*Scrophularia*	*microcarpa*
33	Composite	*Lanacetum*	*polysephalum*	75	Scrophulariaceae	*Verbascum*	*macronata*
34	Composite	*Carthamus*	*lanatus*	76	Scrophulariaceae	*Linaria*	*lineolata*
35	Composite	*Anthemis*	*brachystephan*	77	Scrophulariaceae	*Plantago*	*major*
36	Composite	*Anthemis*	*rulneraria*	78	Caryophyllaceae	*Dianthus*	*macranthus*
37	Composite	*Onopordo*	*acanthium*	79	Ranunculaceae	*Ranunculus*	*arvensis*
38	Composite	*Lactuca*	*orientalis*	80	Ranunculaceae	*Anemone*	*biflora*
39	Composite	*Tragopogon*	*collinus*	81	Convolvulaceae	*Convolvulus*	*ammocharis*
40	Composite	*Scariola*	*orientalis*	82	Tamaricaceae	*Reaumuria*	*stocksii*
41	Composite	*Gundelia*	*turneforti*	83	Chnopodiaceae	*Chnopodium*	*botrys*
42	Legominosea	*Astragalus*	*gossypinus*	84	Coniferea	*Taraxacom*	*montanum*

seeding near the mother base in *A. gossypinus* and providing appropriate moisture conditions, the spatial arrangement of these shrubs is mainly triple and quadruple or quintuple. The presence of small masses among the individual shrubs makes some changes in distribution parameters. In such a plant community, when selecting random points, more points would be observed among small clumps as compared to shrubs. In other words, the measured distances of the random points would be placed in the border of the clumps of shrubs. Therefore, the distance indices developed based on the point distance from the nearest plant, plant's distance from the nearest neighbor, and point distance from the second nearest plant would be more accurate in determining the clumped distribution pattern. However, it has been observed that individual shrubs are not appropriate

Table 3: The values of species richness and diversity indices for plant species in the studied area

Species	Index	Type 1	Type 2
Species richness	Menhinic	7.559	7.794
	Margalef	9.746	10.46
Species diversity	Simpson-1-D	0.618	0.774
	Shannon- H	4.416	4.459
	Brillouin	1.147	1.44

Table 4: The value of the distance and quadrate indices for distribution pattern of *Astragalus gossypinus*

Distance and quadrate indices	Calculated value	Distribution pattern
Johnson and Zimer	2.32	Random with tendency to clumped
Eberhart	1.80	Clumped
Pielou	1.08	Random with tendency to clumped
Hopkines	0.98	Clumped
Holgate	0.78	Clumped
Variance-to-mean ratio	1.25	Random with tendency to clumped
Green	0.43	Random with tendency to clumped
Lioyd	1.077	Random with tendency to clumped
Morisita	1.06	Random with tendency to clumped
Standardized Morisita	0.28	Random with tendency to clumped

Table 5: The value of the distance and quadrate indices for distribution pattern of *Bromus tomentellus*

Distance and quadrate indices	Calculated value	Distribution pattern
Johnson and Zimer	1.98	Random
Eberhart	1.27	Random
Pielou	0.84	Random with tendency to uniform
Hopkines	0.34	Random with tendency to uniform
Holgate	0.047	Random with tendency to clumped
Variance-to-mean ratio	0.95	Random
Green	0.0052	Random with tendency to clumped
Lioyd	1.406	Random with tendency to clumped
Morisita	1.09	Random with tendency to clumped
Standardized Morisita	0.0620	Random with tendency to clumped

options for determining the distribution pattern of these communities. This finding is consistent with Digel (1983) theory and results of the previous studies (Zare Chahooki *et al*., 2010) which considered distance indices more accurate than quadrat indices. In these communities, the quadrat indices, due to having problems of number, area, and quadrat shape, are less efficient than the distance indices. In plant population measurements, the data of distribution pattern can be used instead of field measured data for at least random and regular spatial distribution patterns (Jamali *et al.,* 2020).

Hennenberg and Steinke (2006) proved that the plant ecologists could use the distance methods in both density estimation and statistical testing when the spatial pattern of the studied population was randomly distributed (Hennenberg and Steinke 2006).

A key feature in the present study is quantification of the indices under which the distribution processes operate. Acceptance of the fact that the groups of a species with the same morphological characteristics are not randomly distributed relative to others, allows for inference about the role of exogenous and endogenous spatial diversities in determining the pattern of plant community in space. Calculation of the Johnson and Zimer, Eberhart, and variance-to-mean ratio indices demonstrated that distribution of *Bromus tomentellus* in the second vegetation type was random (Table 5). Moreover, Pielou and Hopkines indices showed a random with tendency to uniform pattern, and other indices indicated a random with tendency to clumped pattern. This means that, almost all indices, including the distance and the quadrat indices, showed a random distribution pattern; however, the accuracy of the distance indices was higher. Therefore, it was confirmed that, compared to quadrat indices, the accuracy of distance indices in determining the distribution pattern of *B.tomentellus* was higher. This could be attributed to the fact that, in the study area, *B.tomentellus* was semi-dense; therefore, the distance among the clumps was close to plants within the clumps. In such communities, the distance indices show a more accurate distribution pattern. Due to the presence of fewer plants within the quadrats and having lower variance, the quadrat indices showed a random distribution pattern. Thus, most of the indices, including the distance and quadrat, presented a random distribution pattern in this study. In addition, based on the point distance from both the nearest plant and near plant, the distance indices presented this pattern

Table 6. Distribution frequency of the species

Species	Value of df	Value of P
A. gossypinus	3	Negative binomial 0.154 Poisson 0.0016
B.tomentellus	3	Negative Binomial 0.00 Poisson 0.74

appropriately. Generally, both of the distance and quadrat indices proved to be proper for measuring the distribution of the species. The distribution patterns were calculated based on statistical distributions using Poisson and negative binomial distributions and Ecological Methodology Software (Table 6). It was shown that the distribution of *Astragalus gossypinus* was negative binominal (P ≥ 0.05) (representing the clumped distribution pattern), and the distribution of *Bromus tomentellus* was Poisson (P ≥ 0.05) (representing the random distribution pattern. It was suitable to use the counting and distance indices for determining the distribution pattern in the areas with appropriate species density, and it was better to mainly use the distance indices to determine the distribution pattern in the areas with light and small mounds. Therefore, the distance indices were of high priority in determining the distribution pattern in the two areas. The results showed that the average distances among *Astragalus gossipinus* and *Bromus tomentellus* were 130 cm and 5.8 cm respectively. Understanding of the average distance among the plants can be helpful in determining the planting distances and the number of seedlings required for the plants with forage value in similar areas.

The distribution curves of the species were created by the relationship between the quadrat's frequency and the number of individuals in each quadrat (Fig. 3). As shown in Fig. 3, the shape of the distribution frequency curve of *A. gossypinus* completely tends to the left (clumped distribution). However, the shape of the distribution curve of *B. tomentellus* is more symmetrical and tends to be slightly right (random distribution). Therefore, these curves confirm the results of the above-mentioned methods. According to the obtained results, the distribution pattern is clumped in communities with a dominant cover of shrub, and quadrat indices are less efficient compared to distance indices. However, in high-diversity communities with predominant covers of gross and forb, the spatial distribution is random and quadrat and distance indices are more convergent.

CONCLUSION

In this study, it was attempted to evaluate the biodiversity and spatial distribution patterns of two dominant types of vegetation in rangelands of Kermanshah, Iran. The most important species of the first vegetation type (Type 1) were *Astragalus gossypinus* (dominant species), *Astragalus brachystachis, Bromus tomentellus*, and *Gundelia turnefortii* and the dominant family of the second vegetation type (Type 2) was Poaceae with the dominant species of *Bromus tomentellus* and other species such as *Hordeum bulbosum* and *Gundelia turnefortii* (belonging to the compositae family). Results showed that the number of Graminae species was higher in vegetation Type 2 than in vegetation Type 1. The Scrophulariaceae, Malvaceae, Papaveraceae, and Euphorbiaceae families were not found in vegetation Type 1. Calculation of the Johnson and Zimer, Eberhart, and variance-to-mean ratio indices demonstrated that distribution of *Bromus tomentellus* in the second vegetation type was random and the distribution pattern of *Astragalus gossypinus* is random with more tendency to be clumped. It was shown that the distribution of *Astragalus gossypinus* was negative binominal (P ≥ 0.05) (representing the clumped distribution pattern), and the distribution

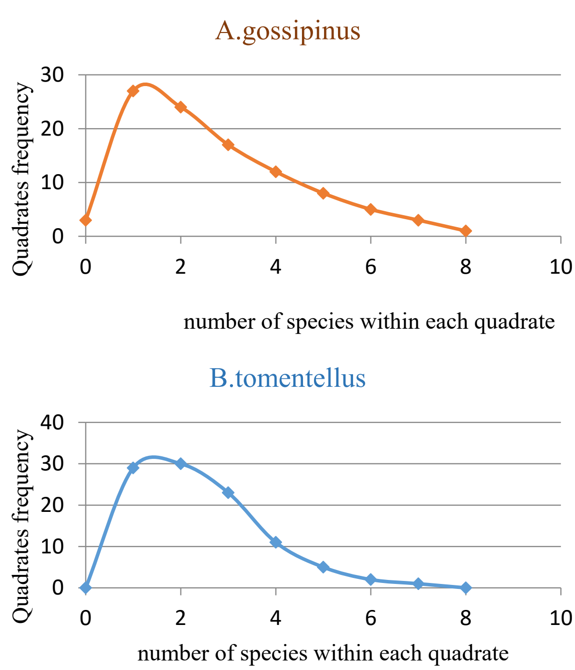

Fig. 3: Curves for distribution frequency of the species

of *Bromus tomentellus* was Poisson (P ≥ 0.05) (representing the random distribution pattern and the distribution pattern is clumped in communities with a dominant cover of shrub, and quadrat indices are less efficient compared to distance indices. All in all, results of species diversity and richness indices showed that, compared to vegetation Type 1, vegetation Type 2 had higher values for these indices. Therefore, it was recommended to protect vegetation Type 1 against adverse environmental and human factors to make it more diverse. The surveyed sites had a certain number of exclusive species, which could be due to differences in environmental factors or other aspects which were not measured in this study. The distribution patterns of two dominant species were different, which could be due to structures of species growth and reproduction. Moreover, when the spatial patterns of species were more uniform, the distance and quadrat indices were more convergent. It was found that effective public policies were required for conservation of the Northern Zagros rangelands as an important biodiversity reservoir. This study can provide a baseline for performing more detailed studies by focusing on the systems of the Zagros rangelands as well as the distribution and dynamics of the flora.

AUTHOR CONTRIBUTIONS

Z. Mohebi performed the experiments and literature review, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. H. Mirzaee performed experimental design, helped in the literature review and manuscript preparation.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

ABBREVIATIONS

A.	Astragalus
B.	Bromus
Eq.	Equation
Fig.	Figure
m^2	Square meters
p	Probability level
R	Species richness
I_E	Eberhart's index
P	Pielou's index
I_H	Hopkins' test
A	Holgate's index
M_u	Morisita's index
GI	Green's index
LI	Lioyd's index
ID	The variance-to-mean ratio index

REFERENCES

Al-Aklabi, A.; Al-Khulaidi, A.W.; Hussain, A.; Al-Sagheer, N., (2016). Main vegetation types and plant species diversity along an altitudinal gradient of Al Baha region, Saudi Arabia. Saudi J. Biol. Sci., 23 (6): 687-697 **(11 pages).**Askari, Y.; Kafash Saei, E.; Delpasand, S.; Rezaei, D., (2013). Evaluation of Crategus sp. spatial pattern in the Central Zagros Forest. Int. J. Adv. Biol. Biomed. Res., 1(2): 179-185 **(7 pages).**

Buschini, M.L.T., (1999). Spatial distribution of nests of Nasutitermes sp. In a cerrado area in southeastern Brazil. Entomol., 28(4): 618-621 **(4 pages).**

Crist, T.O.; Veech, J.A.; Gering, J.C.; Summerville, K.S., (2003). Partitioning species diversity across landscapes and regions: A hierarchical analysis of α, β, and γ diversity. The American Naturalist., 162 (6): 734-743 **(10 pages).**

Elliot, J.M., (1979). Some method for statistical analyze of sample of Benthic invertebrates. 2nd ed., Freshwater Biological Association. **(397 pages).**

Erfanzadeh, R.; Omidipour, R.; Faramarzi, M., (2015). Variation of plant diversity components in different scales in relation to grazing and climatic conditions. Plant Ecol. Divers., 8(4): 537-45 **(9 pages).**

Girma, A., (2011). Plant Communities, Species Diversity, Seedling Bank and Resprouting in Nandi Forests. PhD dissertation, Universitat Koblenz-Landau, Germany. 68–72 **(5 pages).**

Haidari, M.; Rezaei, D., (2013). Study of plant diversity in the Northern Zagros forest (Case study: Marivan region). Int. J. Adv. Biol. Biomed. Res., 1(1): 1-10 **(10 pages).**

Haas, P., (1995). Spatial pattern analysis in ecology based on Ripley's K-function: Introduction and methods of edge correction. J. Veg. Sci., 6(4): 575-582 **(8 pages).**

Hennenberg, K. J.; Steinke, I., (2006). On the power of plotless density estimators for statistical comparisons of plant populations. Canada. J. Bot., 84: 421–432 **(12 pages).**

Hopkins, B.; Skellam, J.G., (1954). A new method for determining the type of distribution of plant individuals. Ann. Bot., 18(2): 213-227 **(15 pages).**

Jamali, H.; Ebrahimi, A.; Ghehsareh Ardestni, E.; Pordel, F., (2020). Evaluation of plotless density estimators in different plant density intensities and distribution patterns. Global Ecol. Conserv., 23: 1-13 **(13 pages).**

Jamali, H.; Ghehsareh Ardestani, E.; Ebrahimi, A.; Pordel, F., (2020). Comparing distance-based methods of measuring plant density in an arid sparse scrubland: testing field and simulated sampling. Environ. Monit. Assess., 192(6) **(12 Pages).**

Jannat Rostami, M.; Zare chahuki, M.A.; Azarnivand, H., (2009). Survey and analysis of spatial pattern of plant species in marginal rangelands Hoz-e-Soltan Qom. J. Watershed Manage. Res., 84: 72-80 **(9 pages).**

Johnson, R.B.; Zimmer, W.J., (1985). A more powerful test for dispersion using distance measurements. Ecology., 66(5): 1669-1675 **(7 pages).**

Karimi, M., (2017). Investigation of topography and tectonics of Faraman region. International Conference on Agriculture, Environment and Natural Resources in the Third Millennium. Gilan, Iran **(13 pages).**

Krebs, C.H.J., (1989). Ecological methodology. Harper and Row, NY, USA **(653 pages).**

Krebs, C.H.J., (1999). Ecological methodology2nd.Ed. A. Wasley Longman. NY, USA.

Ludwig, J.A.; Reynolds, J.F., (1988). Statistical ecology. Awiley-interscience **(337pages).**

Luiza, F.A.; de Paula Sara, L.; Colmenares, T., (2020). High plant taxonomic beta diversity and functional and phylogenetic convergence between two Neotropical inselbergs. Plant Ecol. Divers., 13(1):61-73 **(13 pages).**

Lohe, R.N.; Tyagi, B.; Singh, V.; Tyagi, P.; Khanna, D.R.; Bhutiani, R., (2015). A comparative study for air pollution tolerance index of some terrestrial plant species. Global J. Environ. Sci. Manage., 1(4): 315-324 **(10 pages).**

Magurran, A.E., (1988). Ecological Diversity and Its Measurement. Springer Netherlands **(114 pages).**

Malhado, A.C.; Petter, J.M., (2004). Behavior of dispersion indices in pattern detection of a population of Angico. Andenathera peregrine. Braz. J. Biol., 64(2): 243-249 **(7 pages).**

Mohebi, Z.; Zare Chahouki, M.A.; Tavili, A.; Jafary, M.; Fahimipour, E., (2011). Comparing the efficiency of distance and quadrate indices in determining Artemisia sieberi and Astragalus ammodendron distribution pattern in Markazi province. J. Watershed Manage. Res., 94: 27-35 **(9 pages).**

Morisita, M., (1962). I^{δ} index, a measure of dispersal of individuals. Res Population Ecology., 4: 1-7 **(7 pages).**

Odum, E.P., (1986). Ecologia Guanabara Koogan, Rio de Jeneiro, R.J., Brazil. **(434 pages).**

Petrere, M.J., (1985). The variance of the index (R) of aggregation of Clark and Evans. Oecologia. 68: 158-159 **(2 pages).**

Pielou, E.C., (1977). Mathematical ecology. 2nd. Wiely, NY, USA.

Pielou, E.C., (1959). The use of point to plant distances in the study of the pattern of plant population. J. Ecol., 47(3): 607-613 **(7 pages).**

Sadeghirad, A.; Nasrollahi, M.; Azarnivand, H.; Tavili, A., (2014). Evaluation of vegetation cover and floristic composition in Simani watershed of Kermanshah province. J. Plant Ecosyst. Conserv., 2(4): 17-30 **(14 pages).**

Santos, F.F.M.; Munhoz, C.B.R., (2012). Diversidade de espécies herbáceo-arbustivas e zonação florística em uma vereda no Distrito Federal. Heringeriana., 6: 21-27 **(7 pages).**

Schowalter, T., (2012). Insect Herbivore Effects on Forest Ecosystem Services. J Sustain Forest., 31: 518-536 **(18 pages).**

Schuler, A., (2006). Assessment of Biodiversity for Improved Forest Planning. Kluwer Academic, Dordrecht. 353-360 **(8 pages).**

Scott, L.M., (2015). Spatial Pattern, Analysis of. International Encyclopedia of the Social & Behavioral Sciences (Second Edition). Wright, J.D., Ed.; Elsevier: Oxford, UK. 178-184 **(23185 pages).**

Smith-Gill, S.J., (1975). Cyto-physiological basis of disruptive pigmentary pattern in the leopard frog, Rana pipiens, II. Wild type and mutant cells specific pattern. J. Morph., 146: 35-54 **(10 pages).**

Sühs, R.B.; Hoeltgebaum, M.P.; Nuernberg-Silva, A.; Fiaschi, P.; Neckel-Oliveira, S.; Peroni, N., (2019). Species diversity, community structure and ecological traits of trees in an upper montane forest, southern Brazil. Acta Bot. Bras., 33(1):153-62 **(10 pages).**

Yirga, F.; Marie, M.; Kassa, S.; Haile, M., (2019). Impact of altitude and anthropogenic disturbance on plant species composition, diversity, and structure at the Wof-Washa highlands of Ethiopia. Heliyon., 5(8): 02284 **(13 pages).**

Zare Chahouki, M.A.; Imani, J.; Arzani, H., (2010). The Comparison of spatial and quadrate indices to identify distribution pattern of F.ovina, B. tomentellus and P.ferulacea (Case study: Saral Kurdistan province). J. Watershed Manage. Res., 95: 65-71 **(7 pages).**

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