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RESEARCH PAPER

Investigation of the effect of *Crataegus* species on diversity indices in the natural species (*Anagyris foetida* L.)

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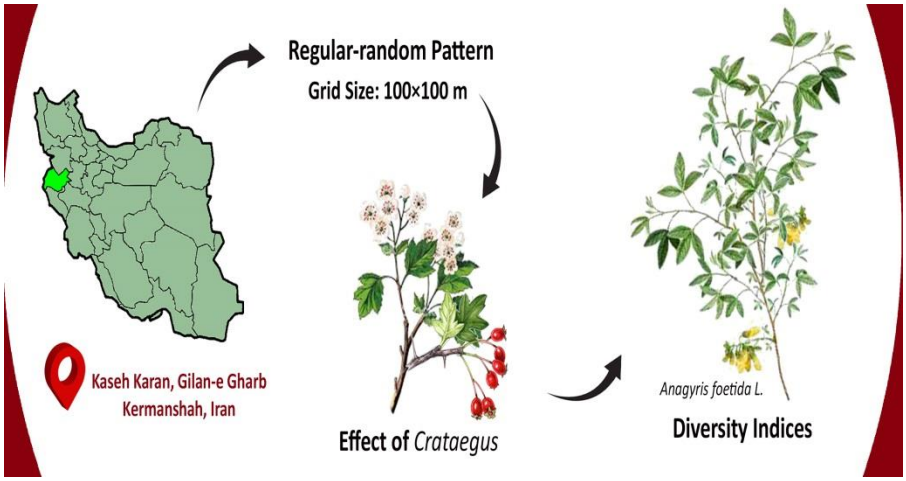
Highlights

- Species diversity as a combined index of species richness and relative abundance is the most important component in biodiversity.
- Plant diversity is discussed in three levels of trees, shrubs and grasses.
- Due to the importance of biodiversity in the Zagros forests, this study aimed to investigate the effect of *Crataegus* species on diversity indices in the natural population of *Anagyris foetida* L.

Graphical Abstract



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Abstract

Species diversity is one of the most important topics in vegetation ecology. The aim of this study was to investigate the effects of *Crataegus* species on diversity indices in the natural population of *Crataegus* species. For this purpose, 55 samples of 10R circles of 100 × 100 m network with a regular random pattern were identified in a mass with an area of 55 ha in Gilan-e Gharb Kaseh Karan section in Kermanshah province. For harvesting tree and shrub species, the mentioned pieces were used and for herbaceous species, 4 m2 samples were used in the center of the circular pieces. Simpson, Shannon, Mann-Heninck and Margalef diversity indices were calculated for all sample plots. First, the influence of the four geographic directions (east, north, west, and south) and elevation (two elevations) below and above 1100 m on the diversity indices was investigated. In the next phase, four clusters were identified based on the presence and absence of *Crataegus* species in the sample plots and on the image created using the diversity indices to compare the diversity indices. The statistical results showed that the two factors of geographic direction and altitude had no effect on the diversity indices. However, *Crataegus* species did affect the diversity indices, such that species diversity was lower in the sample plots where *Crataegus* species were present.

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1. Introduction

Species diversity as a combined index of species richness and relative abundance is the most important component in biodiversity (Hui and Pommerening, 2014). Therefore, awareness of its condition can be a good guide for optimal ecosystem management (Pretzsch and Schütze, 2016). Biodiversity has been addressed in various international conventions. The Biodiversity Convention pursues strategic goals such as reducing the pressure on biodiversity and improving the status of biodiversity by protecting genetic, species and ecosystem diversity (Pretzsch and Schütze, 2016; Saffariha et al., 2021). One of the main goals of natural resource management is to preserve plant diversity in the ecosystem. Plant diversity is discussed in three levels of trees, shrubs and grasses. Tree species diversity forms the basis of forest biodiversity, which provides food and habitat resources for other species (Hosseini, 2014). Physiographic factors are among the factors that can affect the diversity and richness of plant species (Asadi and Jalilian, 2021; Enright et al., 2005). In one study, the effect of afforested *Ailanthus altissima* on plant species diversity in the Jokandan Talesh region was investigated. The results showed that the mean of Simpson, Shannon diversity indices and species richness index (R = S) were higher in natural forests. The Smith-Wilson uniformity index was higher in *Ailanthus altissima*. None of the indexes showed a significant difference between the two regions (*Ailanthus altissima* and natural forest) (Pourbabaei and Haghgooy, 2013). Due to the importance of biodiversity in the Zagros forests, this study aimed to investigate the effect of *Crataegus* species on diversity indices in the natural population of *Anagyris foetida* L.

2. Materials and Methods

2.1. Location of the area

The study area is adjacent to Kaseh Karan village, in the east of Gilan-e Gharb city of Kermanshah province in western Iran. The average annual temperature is between 12 and 18 °C and the average annual rainfall is between 400 and 500 mm.

2.2. Research method

After determining the habitat of *Anagyris foetida* L. in Gilan-e Gharb city, west of Kermanshah province, a population with an area of 55 ha was identified. In the next step, using a regular-random pattern with a grid size of 100×100 m and using circular sample pieces of 10R, all tree species were harvested to calculate diversity indexes. At the same time, in the center of each circular sample plot, grass species were harvested using 4 m^2 sample plots. The sample plots were located in terms of location from an altitude of 1000 to 1200 m above sea level and in terms of geographical directions in all major directions (east, north, west, and south). In the next step, using Past software, diversity indexes were calculated for each sample. In this study, Simpson, Shannon-Wiener, Margalef and Mann-Heninck indexes were used to study species diversity (Badehian et al., 2021).

3. Results and Discussion

Descriptive statistics of the studied population showed that in terms of abundance of *Anagyris foetida* L., 60.61% and other species constituted 39.39% of the population. However, *Anagyris foetida* L. was the most abundant and on the other hand, the abundance of any species was not more than 90%. Thus the studied population was mixed. In this study, because the sample plots were located in different geographical directions and also differed in terms of altitude, and previous studies had reported the impact of these two factors on significant diversity indices. Therefore, first, the effect of geographical directions on diversity indexes was investigated (Table 1). In the next step, the effect of altitude was investigated. In this case, the height classes were considered less than 1100 m and more than 1100 m. As Table 2 shows, the diversity indexes of Simpson, Shannon, Mann-Heninck and other than Margalef in the height classes (two classes) were not statistically significant at the level of 5% (Because all results are greater than 0.05) (Haidari et al., 2019; Moradipour et al., 2018; Zhao et al., 2005).

After it was found that the two factors of geographical direction and altitude had no statistical effect on diversity indexes (Tables 1 and 2), the studies continued. In the next step, cluster analysis and Ward's algorithm

were used and its dendrogram was drawn (Sepahvand et al., 2021). After drawing the dendrogram and with the aim that there are at least 10 sample plots in each cluster, in the place of 3/3 of the sample plots, four clusters were identified (Fig. 1).

Table 1. Results of analysis of variance of Simpson, Shannon-Wiener, Margalef and Mann-Heninck indexes in geographical directions.

Index	Sum of squares (ss)	Degrees of freedom (df)	Sig
Margalef	1.035	3	0.793 ns
Mann-Heninck	0.719	3	0.869 ns
Shannon	0.343	3	0.952 ns
Simpson	0.939	3	0.816 ns

ns: The difference is not significant. *: The difference is significant.

Table 2. Results of analysis of variance of Simpson, Shannon-Wiener, Margalef and Mann-Heninck indexes of altitude.

Index	Mann whitney test	Wilcoxon test	Z	Sig
Margalef	126.500	1161.500	-2.151	0.031*
Mann-Heninck	178.000	1213.000	-1.027	0.305 ns
Shannon	154.000	1189.000	-1.549	0.121 ns
Simpson	181.500	1216.500	-0.949	0.342 ns

ns: The difference is not significant. *: The difference is significant.

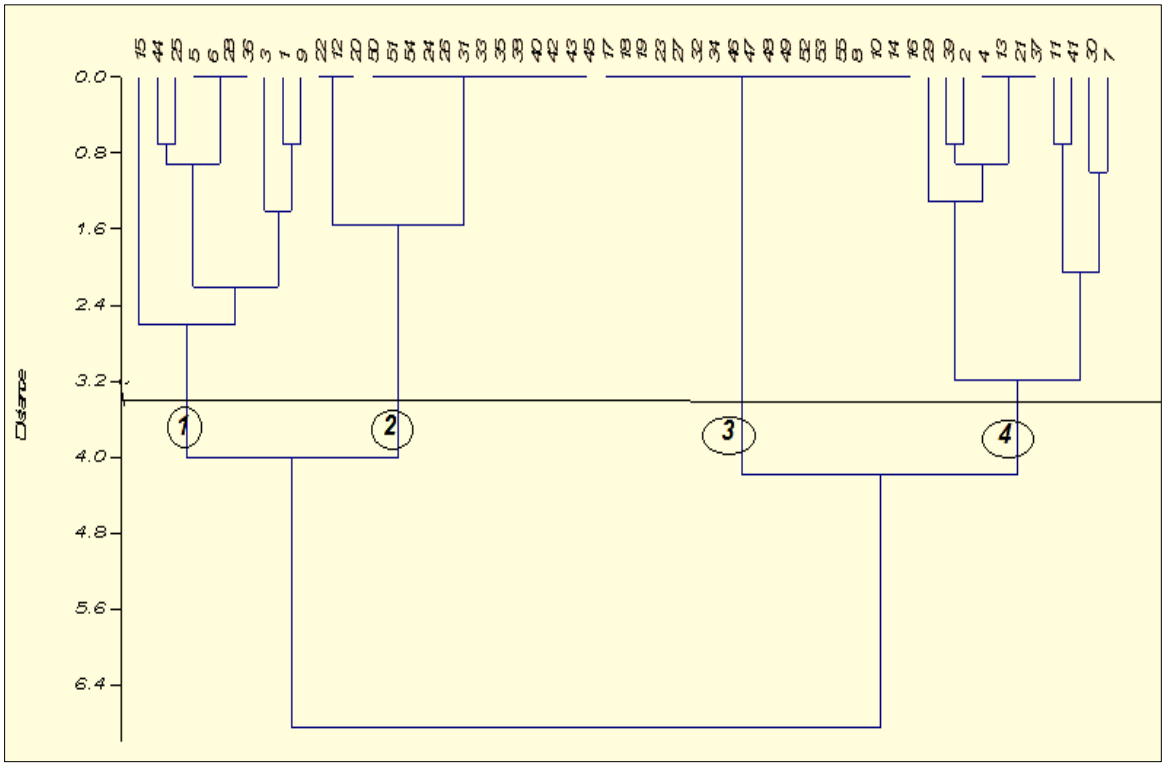

Figure 1. Dendrogram of similarity of the population of *Anagyris foetida* L. in Gilan-e Gharb.

Due to the significant difference between the means of diversity indexes in the four clusters, Duncan's test was performed to classify the clusters. Because the results of all four clusters were similar for comparing the means, only one of the results, which is related to the Simpson index, is given (Table 3). The details of the clusters were then examined and it was seen that the presence or absence of *Crataegus* species in this clustering

was evident. Therefore, to investigate the effect of *Crataegus* species on diversity indexes, based on a completely randomized design, variance analysis of diversity indexes was performed for the four clusters (Dixit, 2020).

Table 3. Duncan test result to compare the mean of clusters according to different indexes.

Margalef		Mann-Hennick		Shannon		Simpson		Repetition	Cluster code (treatments)
1	2	1	2	1	2	1	2	-	-
0.3014	-	0.4292	-	0.4514	-	0.2983	-	10	1.00
0.3424	0.6126	-	0.5499	0.4587	-	0.3007	-	11	4.00
-	0.6231	-	0.5831	-	0.8368	-	0.5037	16	2.00
-	0.819	-	0.6002	-	0.8518	-	0.5143	18	3.00
0.376	-	1.000	0.321	0.923	0.842	0.964	0.841	-	-

4. Conclusion

Diversity is one of the major topics in ecological research and is used in many cases to manage natural resources. This index is an important criterion for the health of ecological systems and the environment. Today, the protection of biodiversity is one of the general issues in environmental policy. In the present study, the results showed that the abundance of any species was not more than 90%, so the study population is a mixed population and its dominant species is *Anagyris foetida* L. As Table 1 shows, the factors of different geographical directions (north, south, east, and west) were not statistically significant on Simpson, Shannon, Mann-Heninck and Margalef indexes. That is, geographical directions in this study did not affect the diversity indexes. The results of this study on the effect of altitude (1000 to 1100 m and 1100 to 1200 m) on the diversity of plant species showed (Table 2) that the indices of Simpson, Shannon, Mann-Heninck in the two altitudes were not statistically different. However, for the Margalef diversity index, the effect of these heights was significant at the level of 5%. In this case, it was seen that altitude was statistically unaffected by most indicators of diversity and the reason could be the low altitude of the study area. Because the area under study was limited to two slopes of 100 meters. After it was found that geographical directions (Table 1) and altitude classes (Table 2) did not affect diversity indexes. Using Ward's algorithm in cluster analysis and dendrogram drawing (Fig. 1), using the data collected in this study, four clusters were extracted from the sample plots. In the next step, using analysis of variance, Simpson, Shannon, Mann-Heninck and Margalef diversity indices were compared. The results showed that these indicators were statistically significant. Due to the significance of the results of the analysis of variance of clusters, the Duncan test was performed to compare the mean of clusters for all variability indexes (Table 3). As the results show, clusters with codes 1 and 4 were in one group and clusters with codes 2 and 3 were in one group. In reviewing the data of the above two groups, it was found that the cause of this difference was the presence of *Crataegus* species in the sample plots. That is, clusters in which *Crataegus* species were present (clusters 1 and 4) were in one group and clusters that were not present in *Crataegus* (clusters 2 and 3) were in another group. This result is consistent with the fact that woody species are more responsive to physiographic factors and landforms.

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