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Full Length Research Paper

Oak gall wasps (Hymenoptera: Cynipidae) species composition using diversity and similarity indexes across different locations of Oak forest, West-Azerbaijan, Iran

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Patterns of the distribution of species diversity are the result of ecological, physical and historical factors. Beta diversity is an important property of ecosystems because it provides information about the partitioning of habitats by species. The objectives of this study were to determine the level of oak gall wasps diversity present in five different locations and to study the similarity among these locations. The highest amount of Simpson (0.95) and Shannon (2.6) entropy index were recorded in Ghabre-hossein and Dare-ghabr. The Jaccard and Sorensen coefficients revealed extremely close results with multiple site similarity. The multiple-similarity measures indicated that similarity in gall composition and community between collecting sites was generally between 0.25 and 0.97. Our results suggest that more oak gall wasps species had an aggregated distribution, and gall wasps diversity shows a strong beta diversity component. Presence of the rare gall wasps species affected on multiple site similarity value. Difference in the local distribution of oak species, especially oak subspecies, and the climate of the locations shall be considered as one main factor in species diversity and the distribution of gall wasp species in different locations.

Key words: Diversity, gall, wasps, similarity, community, distribution.

INTRODUCTION

The number of equally-common species required to give a particular value of an index is called the "effective number of species". This is the true diversity of the community. Converting indices to true diversities (effective numbers of species) gives a set of common behaviors and properties. After conversion, diversity is always measured in units of the number of species (Jost, 2006). Beta diversity is generally thought of as the change in diversity among various Alpha diversities (variation in species composition among geographic regions) (Magurran, 2004). There exists a wide variety of methods for measuring Beta diversity, among which similarity measures are the simplest and the most commonly used for calculating Beta diversity from abundance or presence/absence data (Wolda, 1981; Koleff et al., 2003). Both diversity and similarity indices can be used to compare differences between communities or samples from communities (Peet, 1974; Koleff et al., 2003, Magurran, 2004). The classical Jaccard (1912) and Sorensen (1948) indices were based on both the number of species present in samples and the numbers only seen in each of them (Koleff et al., 2003). Sorenson's measure is regarded as one of the most effective presence/absence similarity measures (Sørensen, 1948; Wolda, 1981). Lennon et al. (2001) noted that if samples differ greatly in terms of their species richness, Sorenson measures will always be large. Another simple mathematical equation that measures the similarity of pairs of sites is the Jaccard index (Magurran, 1988). The widely used Sorensen and Jaccard similarity index led to identification of species composition in each of the two sites and the species shared between them (Novotny and Weiblen, 2005). Morisita index

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Table 1. Study area with different habitats in West-Azerbaijan province (2009).

Location	Latitude/Longitude	Climate	Habitat / Oak species
Ghabre-hossein	36°28′N 45°18′W	Very humid and cold	*Q. infectoria, Q. brantii, Q. libani*
Mirabad	36°15′N 45°22′W	Very humid and cold	*Q. infectoria, Q. brantii*
Rabat	36°14′N 45°33′W	Humid Mediterranean	*Q. infectoria, Q. brantii*
Vavan	36°16′N 45°28′W	Very humid Mediterranean	*Q. infectoria, Q. brantii*
Dare-ghabr	36°11′N 45°24′W	Very humid Mediterranean	*Q. infectoria, Q. brantii, Q. libani*

(Morisita, 1959), percent similarity, and also the Pearson correlation coefficient are largely dependent on the dominant species in the populations. Most evaluations of similarity between multiple sites are based on the average, or plots, of pair wise similarities (Lennon et al., 2001; Basset et al., 2004). Pair wise comparison of neighboring sites will suffice if the goal is to look at how species composition changes along a physical or environmental gradient, but if we view our sites as a random collection of samples from a larger region, a multiple-site similarity measure is required (Diserud and Odegaard, 2006). Since several sites were involved, then cluster analysis was used to demonstrate the Beta diversity of the collection sites. Cluster analysis starts with a matrix exhibiting the similarities between each pair of sites. The two most similar sites of the matrix are combined to form a single cluster with successive clustering of similar sites following to form a dendrogram for visual inspection (Magurran, 1988). Low similarity between sampled sites suggests that Beta diversity might have an important role in the regional diversity of species. Gall wasps, with more than 1300 species, represent one of the largest radiations of gall inducing insects (Melika and Abrahamson, 2002; Melika, 2006). Many studies have documented galling species lists and richness, especially gall wasps, but few studies have been directed toward understanding how the gall-inducing species are locally distributed (Veldtman and McGeoch, 2003). The recent surveys were conducted about the Cynipids fauna in Iran (Azizkhani, 2006; Nazemi et al., 2008; Tavakoli et al., 2008; Zargaran et al., 2008) but the oak cynipid gall wasps diversity remains little-studied. In this study, alpha and beta diversity were measured in different locations.

MATERIAL AND METHODS

At first some stations were determined in west-southern region of West Azerbaijan province, Sardasht and Piranshahr. Sampling was performed in the areas such as: Ghabre-hossein, Mirabad, Vavan, Rabat and Dare-ghabr (Table 1 and Figures 1 and 2). The Cynipids galls in these areas were collected during the inspections made since the early growth season till the end of the season (2009). The best number of samples was been determined to be 40 trees based on Southwood and Henderson formula (2000) so that , , where t is student's T-test of standard statistical tables, D is predetermined of the confidence limit for the estimation of the mean express as a decimal, m is sampling mean and s is the standard deviation. In each tree, as unit of sampling, all of the occurred galls by the oak gall wasps, on four branches (each branch length was 50 Cm) in four geographical directions were counted in the stations. The diversity of Gini-Simpson's index is calculated using the following formula:

$$H_{SW} = -\sum_{i=1}^{N_o}[p_i * \log p_i] \quad d = 1 - \sum_{i=1}^{N}\frac{n_i(n_i-1)}{N(N-1)}$$

Where, ni is the number of individuals of a particular morphotype and N is the total number seen in the sample. Shannon-Weiner entropy index is calculated using formula: where pi is the proportion of the total number of individuals belonging to a morphotype, and No is the total number of morphtypes seen in this sample.

Conversion of common indices to true diversities

These measurements were conducted base on the following formula (Jost, 2006).

Index x:	Diversity in terms of x:	Diversity in terms of p_i:
Gini-Simpson index $x = 1 - \sum_{i=1}^{S} p_i^2$	$1/(1-x)$	$1/\sum_{i=1}^{S} p_i^2$
Shannon entropy $x = -\sum_{i=1}^{S} p_i \ln p_i$	$\exp(x)$	$\exp(-\sum_{i=1}^{S} p_i \ln p_i)$

Community similarity

Similarity coefficients are the methods for directly comparing diversity of different sites; usually compare the number of common species. Comparison will involve a simple presence-absence matrix for two areas, A and B.

Measure of similarity indexes

Sorensen similarity index is calculated from Cs = 2a / (2a + b + c)
Jaccard similarity index is calculated from Cj = a / (a + b + c)

Where, c is the number of species found in site A; b is the number of species in site B and a is the number of species shared by the two sites (Magurran, 2004).

Morisita similarity index is calculated from the formula:

$$C_{\lambda} = \frac{2\sum X_{ij} X_{ik}}{\lambda_1 + \lambda_2 \; N_j N_k}$$

Figure 1. Map of sampling regions in oak forests of Sardasht and Piranshahr city of West-Azerbaijan (Iran) (From: Nazemi et al., 2008). Blue zoon indicates study areas.

Figure 2. Oak forests of Ghabre-hossein region in Piranshahr city of West-Azerbaijan province (Iran).

Where: Cλ= Morisita's index of similarity between sample j and k; Xij, Xjk = Number of individuals of species j in sample j and sample k; Nj = ∑ Xij = Total number of individuals in sample j; Nk = ∑ Xjk = Total number of individuals in sample k.

$$\lambda_1 = \frac{\sum X_{ij}\ X_{ij} - 1}{N_j\ N_j - 1}\ ; \quad \lambda_2 = \frac{\sum X_{ik}\ X_{ik} - 1}{N_k\ N_k - 1}$$

The Morisita index is the least sensitive to sampling intensity and was formulated for counts of individuals (Morisita, 1959; Magurran, 1988).

Percentage similarity

This index is sometimes called the Renkonen index. The index is then calculated as:

$$P = \sum_i \text{minimum}\ p_{1i}, p_{2i}$$

Where: P = Petrcentage similarity between sample 1 and 2; P1i = Percentage of species i in community sample 1; P2i = Percentage of species i in community sample 2.

Multiple site similarity

The level of similarity between the sites sampled, based on presence of galls, was calculated using a multiple site similarity measure (range = 0-1), according with Diserud and Odegaard (2006):

$$C_S^T = \frac{T}{T-1}\left(\frac{\sum_{i<j} a_{ij} - \sum_{i<j<k} a_{ijk} + \sum_{i<j<k<l} a_{ijkl} - \cdots}{\sum_i a_i}\right),$$

Where ai is the number of species in site Ai, I =1 Ai and Aj; and aikj is the number of species shared by sites Ai, Aj and Ak, in T sites.
For a given number of sites T, decreases with increasing number of 'rare' species, that is, species observed in only one or a few sites. Conversely, increases with increasing number of species observed in several sites (Diserud and Odegaard, 2006)… T; aij is the number of species shared by sites. Pearson's correlation coefficient (using SPSS 17.0 software) was used to test the relationship between paired trait variables: value of multiple sites similarity and rare species in samples.

Cluster analysis

This is used when research is being conducted on more than one site and starts with a table or matrix giving the similarity between each pair of sites (by using any similarity coefficient). The two most similar sites are combined to form a single cluster. The analysis then proceeds by successfully combining similar sites until all are combined into a single figure (dendrogram). The Jaccard's and Sorensen's similarity index and also multiple-sites similarity value were used in a cluster analysis to illustrate similarity patterns at the five sites.

RESULTS

In this research, five sites were studied in the spring, summer and fall seasons. The identified gall wasps (asexual generation that have been collected in summer and fall) were (30 species) classified in seven genera: Andricus (20 species), Cynips (3 species), Neuroterus (4 species), Pseudoneuroterus (1 species), and Aphelonyx (2 species) (Table 2 and Figures 3 to 6). The highest and the least number of gall wasp species collected from Ghabre-hossein (24 species), and Mirabad station (7 species), respectively (Figure 7). The genus Andricus had the highest number of species and the genus Pseudoneuroterus, was only with a single species in all sites (Table 2). The species Pseudoneuroterus macropterus was only collected on Quercus brantii in Rabat station (Figure 7). The highest and the least value of Gini-Simpson indices were recorded from Dare-ghabr and Mirabad regions, respectively (Table 3). Also, the highest and the least value of Shannon's entropy indices was found from Dare-ghabr and Mirabad regions, respectively (Table 3). Converting to effective number of species showed that the difference is in fact huge for example; the oak gall wasps community in Dare-ghabr with a Gini-Simposn index of 0.9556 has the same diversity as a community with 22.52 equally-common species, while oak gall wasps community in Mirabad with a Gini-Simposn index of 0.8120 has the same diversity as a community with 5.32 equally-common species. The second community is therefore only about 1/4 as diverse as the first community, and etc. Species richness indicates this subject (Table 3). The results of pair wise comparison of similarity showed that the highest similarity of Sorensen (0.92), Jaccard (0.85), and percent similarity (89.33) recorded between Dare-ghabr and Ghabre-hossein (Figures 8 and 9) and the lowest index of Sørensen (0.25), Jaccard (0.14), and percent similarity (29.08) found between two regions Mirabad and Vavan (Table 4). The highest and the least value of Morisita index of similarity was observed (0.82) and (0.25) between Rabat and Mirabad stations, respectively (Table 4). The multiple-similarity measures indicated that similarity in the gall composition and community between collecting sites was generally between 0.25 and 0.97. The similarity coefficient values of three group's community as below are the same (Table 5 and Figure 10): 1); Ghabre-hossein vs. Dare-ghabr, 2); Ghabre-hossein vs. Mirabad vs. Rabat vs. Dare-ghabr, and 3); Ghabre-hossein vs. Mirabad vs. Vavan vs. Dare-ghabr. The measured similarity with multiple sites showed that the least similarity value (0.25) as Sorensen was found between Vavan and Mirabad stations but the highest similarity value (0.97) recorded among Ghabre-hossein, Mirabad, Vavan and Dare-ghabr stations (Table 5) whereas the least similarity was been observed between Mirabad and Vavan. The reason of this change in value of similarity is the entrance of the stations which have the

Table 2. Collected species of gall wasps from oak trees in different locations of West-Azerbaijan province (2009).

No.	Oak gall wasps species	Location of gall formation	Number of Larvae Chamber	Sexual or asexual generation	Quercus Host
1	*Andricus aries* (Giraud, 1859)	Shoot	one	Asexual	*Q. infectoria*
2	*A. askewi* (Melika and Stone, 2001)	Shoot	one	Asexual	*Q. infectoria*
3	*A. caputmedusae* (Hartig, 1843)	Shoot	many	Asexual	*Q. infectoria*
4	*A. conglomeratus* (Giraud, 1859)	Shoot	one	Asexual	*Q. infectoria*
5	*A. coriarius* (Hartig, 1843)	Shoot	many	Asexual	*Q. infectoria*
6	*A. galeatus* (Giraud, 1859)	Shoot	one	Asexual	*Q. infectoria*
7	*A. hystrix* (Trotter, 1899)	Shoot	one	Asexual	*Q. infectoria*
8	*A. kollari* (Hartig, 1843)	Shoot	one	Asexual	*Q. infectoria*
9	*A. lucidus* (Hartig, 1843)	Shoot	many	Asexual	*Q. infectoria*
10	*A. mediterraneae* (Trotter, 1901)	Shoot	one	Asexual	*Q. infectoria*
11	*A. megalucidus* (Melika et al., 2003)	Shoot	many	Asexual	*Q. infectoria*
12	*A. panteli* (Kieffer, 1901)	Branch	many	Asexual	*Q. infectoria*
13	*A. polycerus* (Giraud, 1859)	Branch	one	Asexual	*Q. infectoria*
14	*A. quercuscalicis* (Borgsdorf, 1783)	Fruit	one	Asexual	*Q. infectoria*
15	*A. quercustozae* (Bosc, 1792)	Shoot	one	Asexual	*Q. infectoria*
16	*A. seckendorffi* (Wachtl, 1879)	Shoot	many	Asexual	*Q. infectoria*
17	*A. sternlichtii* (Bellido and Melika, 2003)	Shoot	one	Asexual	*Q. infectoria*
18	*A. theophrastea* (Trotter, 1901)	Shoot	one	Asexual	*Q. infectoria*
19	*A. tomentosus* (Trotter, 1901)	Shoot	one	Asexual	*Q. infectoria*
20	*A. megatruncicolus* Giraud	Shoot	one	Asexual	*Q. infectoria*
21	*Aphelonyx cerricola* (Giraud, 1859)	Shoot	many	Asexual	*Q. brantii*
22	*Aphelonyx persica* (Melika et al., 2004)	Shoot	one	Asexual	*Q. brantii*
23	*Cynips cornifex* (Hartig, 1843)	Leaf	one	Asexual	*Q. infectoria*
24	*C. quercus* (Fourcroy, 1785)	Leaf	one	Asexual	*Q. infectoria*
25	*C. quercusfolii* (Linnaeus, 1758)	Leaf	one	Asexual	*Q. infectoria*
26	*Neuroterus saliens* (Kollar, 1857)	Leaf	many	Asexual	*Q. brantii*
27	*N. lanoginosus* (Giraud, 1859)	Leaf	one	Asexual	*Q. brantii*
28	*N. numismalis* (Geoffroy, 1785)	Leaf	one	Asexual	*Q. infectoria*
29	*N. quercus-baccarum* (Linnaeus, 1758)	Leaf	one	Asexual	Q. infectoria
30	*Pseudoneuroterus macropterus* (Hartig, 1843)	Shoot	many	Asexual	Q. brantii

rich community to the multiple site similarity formula. Since several sites were involved in this investigation cluster analysis was used to demonstrate the diversity of the collection sites. Beta diversity is shown in Tables 4 and 5 and the cluster analysis dendrogram in Figures 8 to 10. The low similarity among tracks for gall wasps species composition demonstrates that when the focus is conservation, the optimization of species richness may come from preserving the highest number of microenvironments (or areas within the same environment), because diverse and specific faunas may be associated even to close by areas. The least value of Whittaker's βW (1.09) was found among Ghabre-hossein vs. Mirabad vs. Vavan and Dare-ghabr stations (Table 5). Relationship between multiple sites similarity and the rare oak gall wasps species showed in Figure 11. The value of Pearson's correlation coefficient between multiple sites similarity index and the rare species showed a significant negative correlation (r = -0.669, n = 15, P<0.001).

DISCUSSION

Three oak species *Quercus infectoria*, *Q. brantii* and Quercus libani grow in west Azerbaijan. These tree species are of uneven distribution in the stations under study, so that all three oak species are found in Ghabre-hossein and Dare-ghabr stations, while only two species *Q. infectoria* and *Q. brantii* grow in two stations Rabat and Vavan. These oak species are of several sub-species which are under identification in the term of a comprehensive research plan. Our results showed that there are no galls in spring and summer-fall on *Q. libani*.

30 oak gall wasps species were collected in this

Figure 3. The occurred gall by *Andricus quercustozae* (Bosc, 1792) on *Quercus infectoria* (Original).

Figure 4. The occurred gall by *Cynips quercusfolii* (Linnaeus, 1758) on *Quercus infectoria* (Original).

Figure 5. The occurred gall by *Aphelonyx cerricola* (Giraud, 1859) on *Quercus brantii* (Original).

Figure 6. The occurred gall by *Neuroterus saliens* (Kollar, 1857) on *Quercus brantii* (Original).

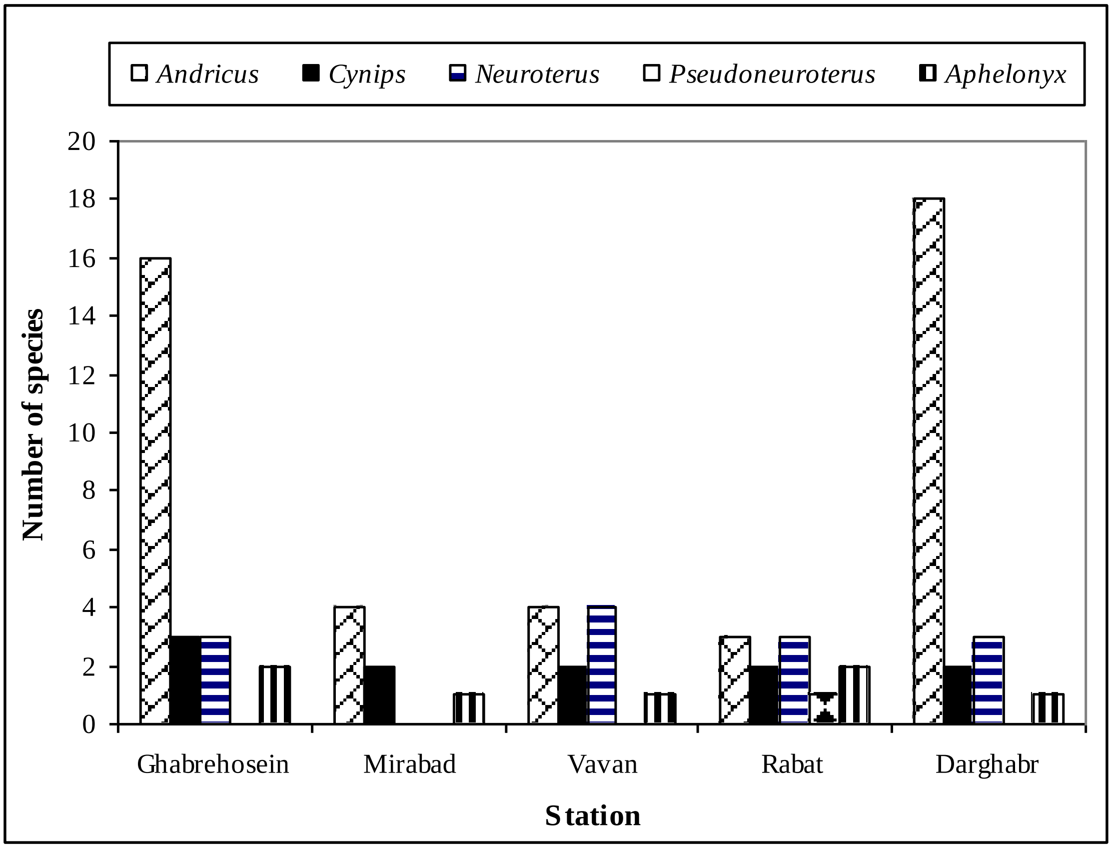

Figure 7. Distribution of oak gall wasps species in different sites of oak forests (2009).

Table 3. Values of species diversity indexes and true diversity of oak gall wasps species West-Azerbaijan province (2009).

Stations	Diversity						
	Simpson D	Species richness	Gini-Simpson	True diversity	Shannon's H'	True diversity	Shannon's evenness
Ghabre-hossein	0.0454	24	0.9546	22.02	2.5562	12.88	0.9022
Mirabad	0.188	7	0.812	5.32	1.7929	6.07	0.9214
Vavan	0.1248	9	0.8752	8.01	1.9671	7.15	0.8779
Rabat	0.1044	11	0.8956	9.58	2.1916	8.95	0.914
Dare-ghabr	0.0444	24	0.9556	22.52	2.6895	14.02	0.8978

research, so that the 20 species belong to the genus Andricus. Cynipid-genera can be large about 1000 species are distributed in 41 genera, with a mean of 24 species per genus. Some genera are very large, with 300 species in Andricus, and 150 species in Callirhytis (Price, 2005). Considering the dominance of the oak species Q. infectoria in all regions studied, the most abundant number of galls was found on this oak species. There are specific relationship between gall-inducing wasp species and the host oak tree species, and host plant distribution has a determinative impact on the distribution of a particular gall wasp species. The most diversity in the number as well as the abundance of gall wasps was recorded in Gabre-hossein where Q. infectoria had formed about 90 percent of the local vegetation. Some species of gall wasps were collected from only a single area (Figure 7). Where factors like altitude and regional climate are similar in some areas under comparison, the differences in the geographical distribution of oak subspecies may be attributed to the difference in the presence of the regions. This implies to the important role of the host plant sub-species distribution in the

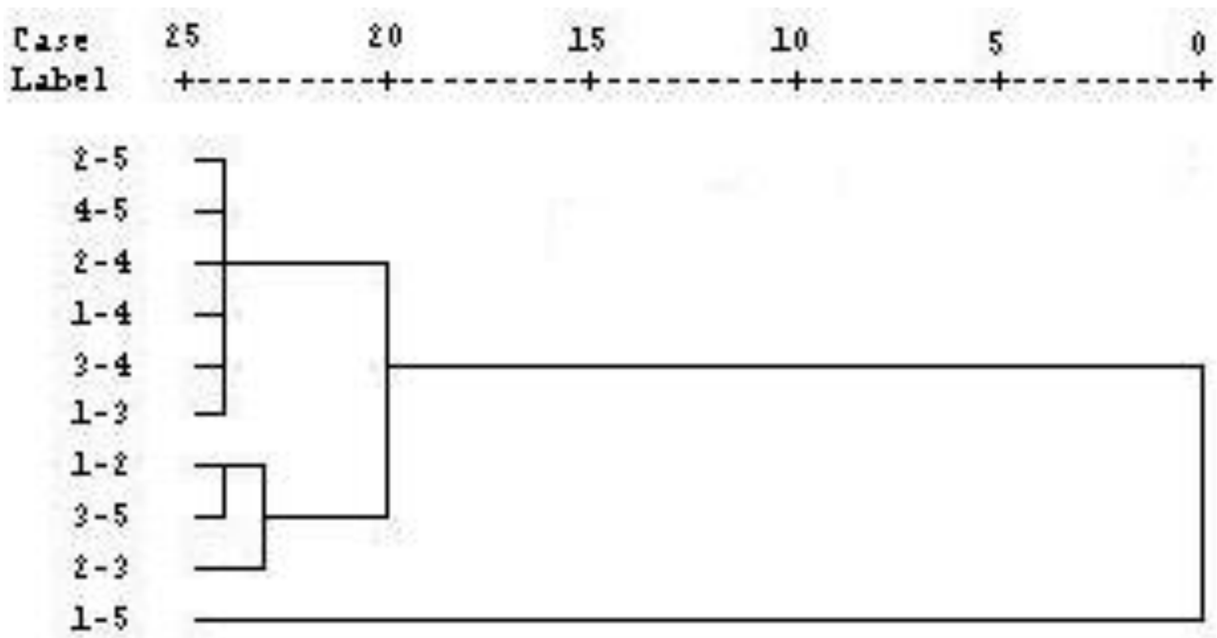

Figure 8. Sørensen cluster analysis dendrogram of similarity coefficients for oak gall wasps1: Ghabre-hossein, 2: Mirabad, 3: Vavan, 4: Rabat, 5: Dare-ghabr; For example: Ghabre-hossein and Dare-ghabr (1 to 5) have the highest similarity values.

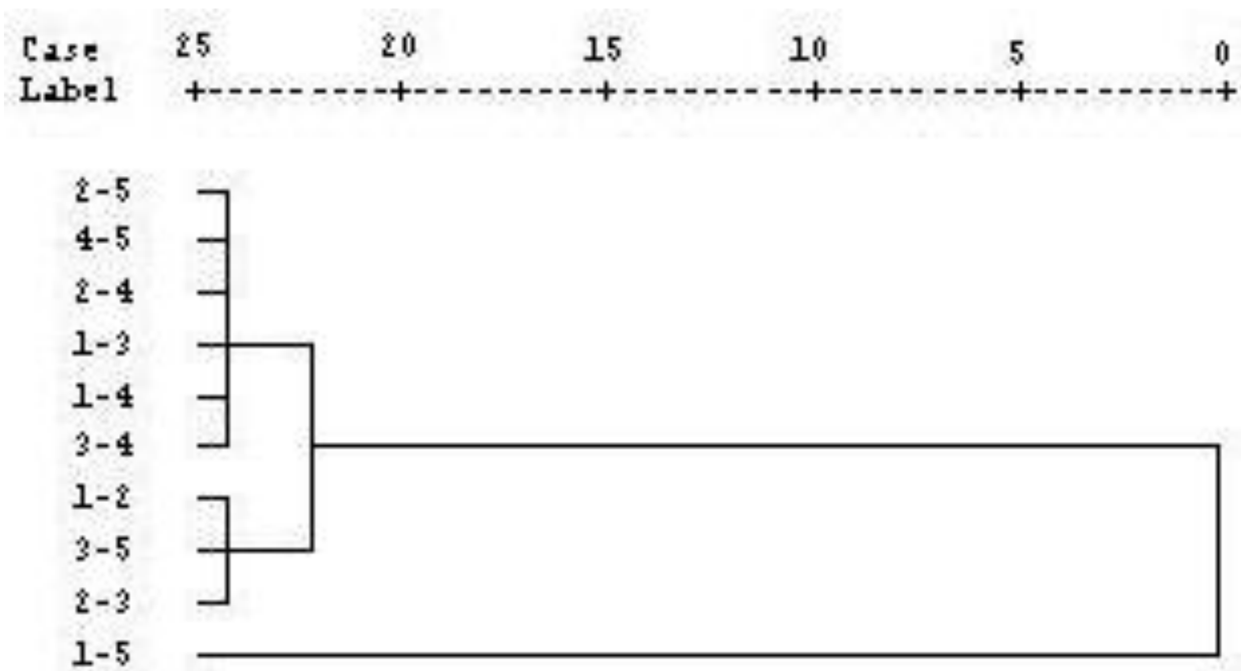

Figure 9. Jaccard cluster analysis dendrogram of similarity coefficients for oak gall wasps; 1: Ghabre-hossein, 2: Mirabad, 3: Vavan, 4: Rabat, 5: Dare-ghabr.

determination of gall wasp distribution. The role of plant species richness in determining species richness of galling insects is also controversial (Blanche, 2000). The rare studies done in the tropical rain forests were performed on the understudy (Genimar-Reboucas, 2003).

Ghabre-hossein and Mirabad stations are of similar

Table 4. Values of different similarity indexes of oak gall wasps species between pair wise different sites (2009).

Indexes		Sites					Sites
		Dare-ghabr	Rabat	Vavan	Mirabad	Ghabre-hossein	
Similarity indexes	Morisita	0.82	0.69	0.28	0.69	1	Ghabre-hossein
	Percent similarity	89.33	52.74	52.07	34.11	100	
	Sørensen	0.92	0.51	0.48	0.39	1	
	Jaccard	0.85	0.35	0.32	0.24	1	
	Morisita	0.27	0.25	0.59	1	0.69	Mirabad
	Percent similarity	40.23	41.31	29.08	100	34.11	
	Sørensen	0.45	0.44	0.25	1	0.39	
	Jaccard	0.3	0.29	0.14	1	0.24	
	Morisita	0.63	0.62	1	0.59	0.28	Vavan
	Percent similarity	32.02	48.21	100	29.08	52.07	
	Sørensen	0.36	0.5	1	0.25	0.48	
	Jaccard	0.23	0.34	1	0.14	0.32	
	Morisita	0.57	1	0.62	0.25	0.69	Rabat
	Percent similarity	42.18	100	48.21	41.31	52.74	
	Sørensen	0.46	1	0.5	0.44	0.51	
	Jaccard	0.3	1	0.34	0.29	0.35	
	Morisita	1	0.57	0.63	0.27	0.82	Dare-ghabr
	Percent similarity	100	42.18	32.02	40.23	89.33	
	Sørensen	1	0.46	0.36	0.45	0.92	
	Jaccard	1	0.3	0.23	0.3	0.85	

Each cell is the pair wise similarity value between two sites.

Table 5. Multiple site similarity indexes of oak gall wasps among different sites in 2009.

Similarity (Whitaker)	Sites	Sites	Sites	*Sites
1	2			0.39 (βw=1.61)
	3			0.48 (βw=1.52)
	4			0.51 (βw=1.49)
	5			0.92 (βw=1.08)
2	1			0.39 (βw=1.61)
	3			0.25 (βw=1.75)
	4			0.44 (βw=1.56)
	5			0.45 (βw=1.55)
3	1			0.48 (βw=1.52)
	2			0.25 (βw=1.75)
	4			0.50 (βw=1.50)
	5			0.36 (βw=1.64)
4	1			0.51 (βw=1.49)
	2			0.44 (βw=1.56)
	3			0.50 (βw=1.50)
	5			0.46 (βw=1.54)
1		3		0.53 (βw=1.94)
	2	4		0.57 (βw=1.86)

Table 5. Contd.

		5		0.80 (βw=1.40)
	3	4		0.62 (βw=1.76)
		5		0.80 (βw=1.40)
	4	5		0.80 (βw=1.40)
2	3	4		0.56 (βw=1.88)
		5		0.50 (βw=2.00)
	4	5		0.54 (βw=1.92)
3	4	5		0.54 (βw=1.92)
1		3	4	0.76 (βw=1.72)
	2		5	0.97 (βw=1.09)
		4	5	0.94 (βw=1.18)
	3	4	5	0.71 (βw=1.87)
2	3	4	5	0.70 (βw=1.90)

* Sites: 1: Ghabre-hossein; 2: Mirabad; 3: Vavan; 4: Rabat; 5: Dare-ghabr.

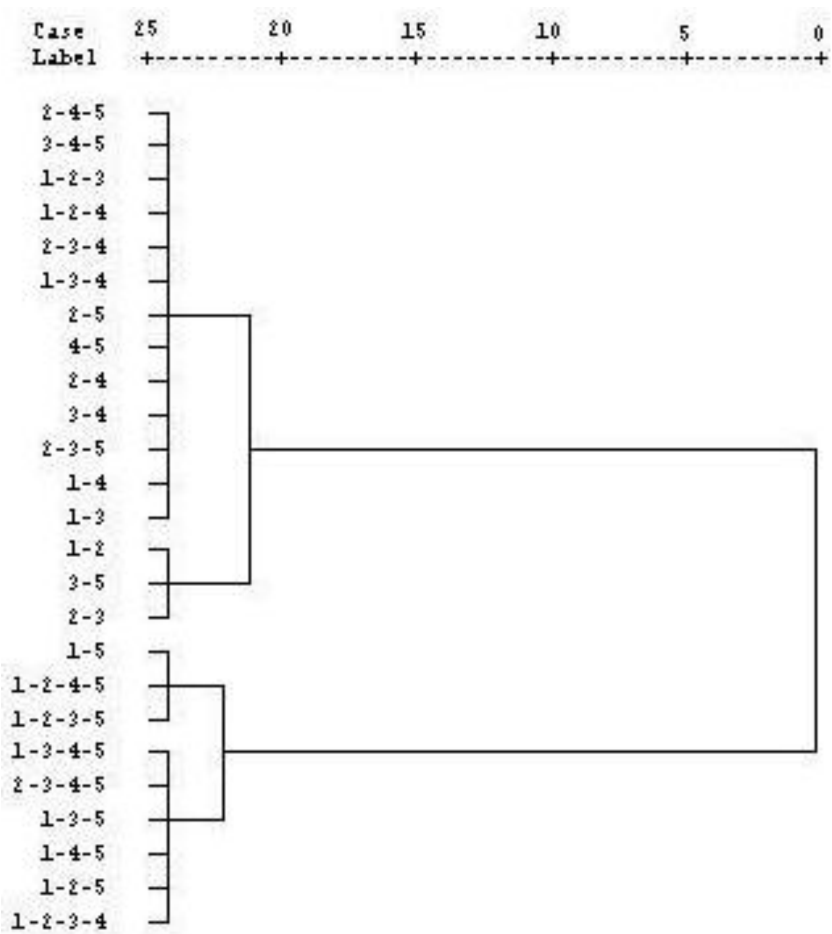

Figure 10. Multiple-sites similarity cluster analysis dendrogram for oak gall wasps; 1: Ghabre-hossein, 2: Mirabad, 3: Vavan, 4: Rabat, 5: Dare-ghabr.

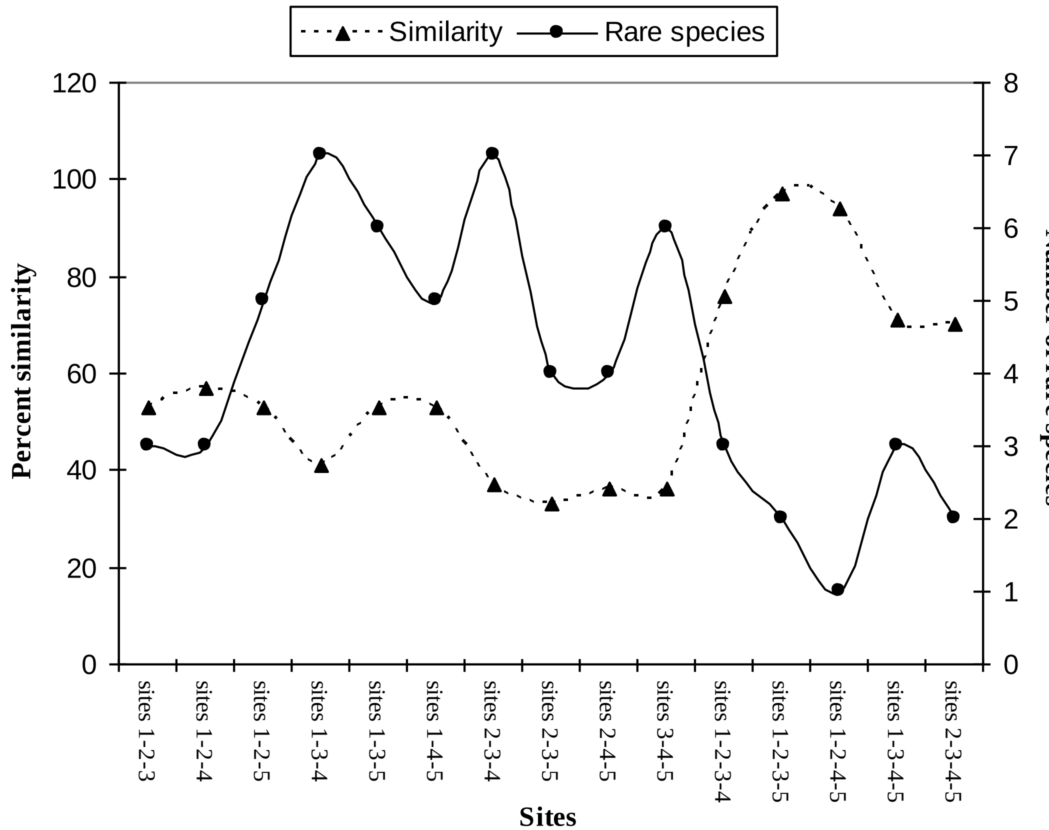

Figure 11. Multiple site similarity value and presence of rare species of oak gall wasps (2009).

climate, however, the specific diversity of gall wasps was found very different. The difference must be sought in vegetation discrepancies of two regions. Ghabre-hossein and Dare-ghabr despite of their different climates were of similar vegetations, a fact that had ended to a similar rate of specific diversity in both districts (24 species in Ghabre-hossein and also in Dare-ghabr). Local climate affects gall wasp diversity and impacts on the distribution of some gall wasp species. With change in latitude and presence of different oak species in the sites, species richness of oak gall wasps was very different. Higher species diversity is generally thought to indicate a more complex and healthier community because a greater variety of species allows for more species interactions, and indicates good environmental conditions. Oak gall wasps species richness might be expected to increase with the richness of host plant species (Starzomski et al., 2008). Also, abiotic factors, such as water stress, and other biotic factors (plant age and natural enemies) may also affect tropical gall wasps species richness at different scales (Veldtman and Mcgeoch, 2003; Cuevas-Reyes et al., 2004). Little data are available on species richness of oak gall wasps on Q. infectoria and Q. brantii in Iran. Chodjai (1980) reported 36 oak gall wasps related with Q. infectoria from Iran. Azizkhani (2006) reported 24 gall wasps on Q. infectoria and Q. brantii. Gall wasps exhibit a high degree of host plant specificity and chemistry may be crucial for the success of these insects (Cook et al., 2002; Rokas et al., 2003). When there is a degree of dominance, the Shannon effective number of species will be less than the species richness, and the Gini-Simpson effective number of species will be less than the Shannon effective number of species (Jost, 2006). The greater dominance in the community led to the greater differences between these three numbers (Table 3). Diversity varies among sites and depends on habitat, altitude and etc. Higher species diversity is generally thought to indicate a more complex and healthier community because a greater variety of species allows for more species interactions, hence greater system stability, and indicates good environmental conditions. If a community has only a few species or if only a few species are very abundant, species diversity is low (Table 3). At the smaller scales, vegetation has a moderating influence on local climates and may create quite specific micro-climates. Some organisms are dependent on such micro-climates for their existence. Diversity of gall inducing insects to be intimately bound to plant diversity, since the presence of a larger number of plants in a given environment would denote more ecological niches to be explored (Wright and Samways, 1998; Cuevas-Reyes et al., 2003, 2004). Other studies, however, do not find a link between these variables (Fernandes and Price, 1988; Blanche, 2000), the host plant structural complexity (Fernandes and Price, 1988) and altitudinal/latitudinal variation (Price et al., 1998). Some diversity indices merely take into account the presence or absence of species in the samples while others incorporate information on the relative abundance of the species (Table 4). The preferable index in a given case depends on the questions asked and the kind of data available (Mountford, 1962; Morisita, 1959). A high similarity indicates that there are few species differences between sites, yielding low β-diversity values (Table 5). Different species usually behave differently and can have strongly variable effects on their resources such as food. A numerical difference between two localities in one species may be much more 'important' than the difference in another species (Wolda, 1981).

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