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Orijinal araştırma (Original article)

Hymenopteran diversity and abundance in Gölcük Natural Park in Isparta, Turkey

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Summary

Hymenoptera diversity was investigated in Gölcük Natural Park, near Isparta, Turkey during 2008 vegetation period. Twenty one families were recorded during our study. Four species are new records from Turkey. This paper compares Hymenopteran communities in four sampling sites from Gölcük Natural Park. The highest Hymenoptera family level diversity was found near the Natural Park entrance, where the Shannon-Weaver index of diversity was 2.5. Hymenopterans were most abundant in the site close to the old apple orchard, where 33% of all individuals were collected. Most of less frequently recorded families were found in the xeric natural plant site. Hymenopteran families were found to be almost equally partitioned in all four sampling sites. The highest percentage similarity index (0.79) was found between the “close to entrance” and “mesophilic” plant sites. The study revealed that the site close to the old apple orchard provides a special micro-habitat for Hymenoptera.

Key words: Hymenoptera, new records, Turkey, Gölcük, biodiversity

Anahtar sözcükler: Hymenoptera, yeni kayıt, Türkiye, Gölcük, biyoçeşitlilik

Introduction

In recent decades, humans have more than ever been changing the world’s ecosystems to meet the growing demands for food, fresh water, timber, fiber, fuel and minerals (Anonymous, 2005). Biodiversity in itself provides a range of services, including aesthetic, cultural and recreational values, as well as goods that have direct use value, and also enhances many other ecosystem services on which humans depend (Bulte et al., 2005). Conservation International noted that 19 out of 25 biodiversity “hotspots” had population growth rates higher than the global average and 16 of these hotspots account for one quarter of all undernourished people in the developing world (Cincotta & Engelman, 2000).

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There is a large body of research suggesting that natural ecosystem properties greatly depend on biodiversity and that the functioning of ecosystems is associated with biodiversity (Mertz et al., 2007). Biodiversity is also infiltrating administrative language, particularly after the UN global Conference on the Environment and Development held in 1992 (Anonymous, 1992; Haila & Kouki, 1994). The conference declared preservation of biodiversity as one of the major elements of sustainable development (Zilihona & Nummelin, 2001).

Insects are a suitable subject for assessing the impact of disturbance on ecosystem composition and dynamics. Furthermore, insects may serve as "test organisms" for comparing disturbed and undisturbed sampling sites because of the functional relationships among species and the high abundance in many taxa (Dufrene & Legendre, 1997; Zilihona & Nummelin, 2001). The importance of the Hymenoptera in the diversity of the natural habitats, emphasize the need for this group to be considered in the conservation of nature (Nieves-Aldrey & Fontal-Cazalla, 1997; Murguia et al., 2001; Shaw & Hochberg, 2001; Gayubo et. al., 2004).

Gölcük Natural Park (GNP) is located 8 km southwest of Isparta province and its special characteristics make it an important recreation area.

With its diverse vegetation and wildlife, geomorphological structure, aesthetically pleasing landscape and recreational opportunities, GNP is one of the most important areas of the Lakes District in Turkey. GNP, with a total area of 5,925 ha (700 ha lost from intro.), is now a proclaimed National Park, but its condition is deteriorating since it has no master plan and minimal management. Due to the over-usage of only the lake surroundings, instead of total rational use of the area, its natural values have been destroyed (Gül et al., 2005). Reforestation was commenced by Governmental Irrigation Department (DSI) to prevent the lake being filled with sediment. Later, reforested areas came under the control of the Ministry of Forestry. *Robinia pseudoacacia* and *Pinus nigra* were the main species used for the reforestation, but later *Cedrus libani* was also used widely (Karatepe et al., 2005).

In the study area, the first planting (*Pinus, Cedrus* and *Robinia*) was commenced in 1956 by the DSI, but as a protected area it was only established in 1991, and its' area was 6,684 ha. The apple orchard in GNP occupied 39.9 ha and was planted before 1956, but the exact date is not available. Until 2005, agricultural activities continued; orchards were irrigated, cultivated and sprayed, but since that time all agricultural activities have ceased. GNP was opened to the public in 1981 and was heavily used for picnicking, but since 2006 barbeques have been prohibited (Sahdubak & Cengiz, 2007). The park is now listed in the IUCN 4th category.

The vegetation of this natural park has been studied in detail (Fakir, 1998; Fakir & Dutkuner, 1999). Isparta province itself is located on the border between the Irano-Anatolian and Mediterranean basin hotspots (Anonymous, 2008). This is reflected in the flora of the GNP, where endemism is quite high. Twenty two (9.7%) endemic species of the Irano-Anatolian hotspot and 17 (7.5%) endemic to the Mediterranean basin hotspot are represented in this region. Twenty five (11%) plant species are endemic to Turkey (Fakir, 1998). In particular the study assesses the significance of natural parks, reforestation and conservation measures in a global biodiversity hot spot. Hymenoptera were chosen because they are a diverse insect group, relatively easy to identify at the family level, play an important role in ecosystem functioning, are strongly linked with plant associations and reflect the natural condition of the studied area. Consequently, the results of this study have direct and important implications for the conservation management of the GNP, and also the region's biodiversity. No in-depth study on faunistic diversity had been done in GNP. This kind of study can serve as a basis for long term observations on the biodiversity recovery process in GNP and can be used as a reference point for similar studies in the future.

Material and Methods

The study area was divided into four sampling areas with different plant associations: site A - Main entrance to GNP, area close to lake, with reafforested areas, planted with *Robinia pseudoacacia* between 1960-1965 (Fig. 1). Some natural plants such as: *Descurainia sophia, D. kochii, Astragalus oxytropifolius, Fraxinus angustifolia, Viscum album, Crataegus orientalis, Cotoneaster nummularia* and *Pistacea terebinthus* were also represented; site B represented the abandoned 50 year old apple orchard adjoined by a *Robinia pseudoacacia* reforested area planted in 1956. In this area, 6.3% of endemic plants were represented. Among the plants were: *Juniperus oxycedrus, Berberis crataegina, Diplotaxis tenuifolia, Arabis aubrietioides, Minuartia gracilis, Hypericum scabrum, Erodium absinthoides, Rhus coriaria, Pistacia terebinthus, Rubus sanctus, Cotoneaster nummularia, Crataegus orientalis, Sorbus umbellate, Lonicera etrusca, Asteriscus aquaticus, Origanum sipyleum, Salvia tomentosa, Andrachne aspera, Muscari discolor* and *Stipa pulcherama*; site C represented a xeric plant community with areas reforested with *Pinus* and *Cedrus* planted from 1959 to 1969. *Cystopteris fragilis, Delphinium venolosum, Ranunculus argyreus, Ranunculus cuneatus, Alyssum alyssoides, Erysimum leptocapum, Moenchia montica, Dianthus zonatus, Rumex conglomerates, Coronilla emerus, Epilobium lanceolatum, Sideritis perfoliata, Satureja cilicica, Muscari discolor* were the common plants in this site and different species of *Astragalus* also were represented in this area, some of which are endemic such as *A. oxytropifolius* and *A. gymnolobus* (Sahdubak & Cengiz, 2007; Fakir, 1998)), in total, 4.7% of endemic plants were recorded from this site; site D was in a mesophilic plant

community with *Populus* and *Platanus* spp. *Delphinum venolosum, Paronychia davisiim, Alcea apterocarpa, Marribium vulgare, Satureja cilicica, Quercus coccifera, Sorbus umbellate, Berberis crataegina, Spartium junceum, Rosa canina, Iris* sp. were common species for this site, where 18.8% of endemic plants were recorded (Fakir, 1998).

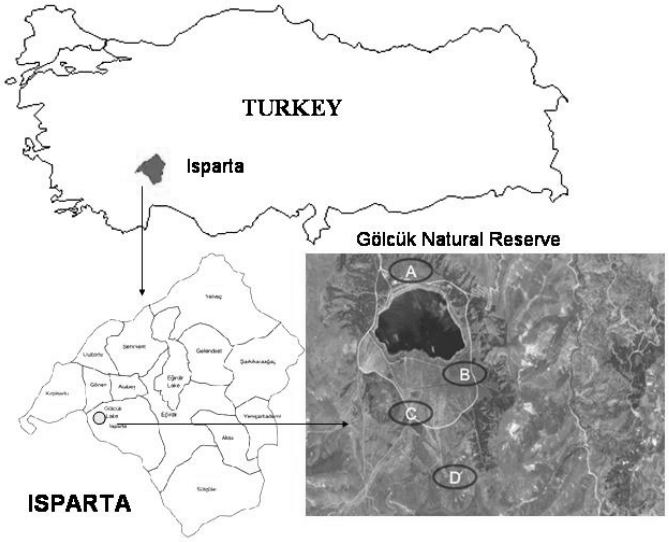

Figure 1. Map of the sampling sites.

Insect samples were collected from March to September, 2008, using the yellow pan trap method. The lowest altitude for trapping was 1227 m and the highest was 1611 m. At all sampling places, 10 yellow pan traps were set because a lot of insects are attracted to yellow. This trapping method involved the use of small yellow 16 cm diameter dishes filled with water to which detergent has been added to break the surface tension. The dishes were placed on the ground in conspicuous places in the early morning. When flying insects land on the surface of the water, they rapidly sink and drown. The pan traps were checked on the second day because insects begin to decompose quickly in water. The collecting process was repeated every two weeks. After collecting the captured insects, they were transferred to jars of 75% alcohol or dried and pinned promptly. Material in alcohol was later dried and mounted. For determination of families and species, we used different keys and web sources (Medvedev, 1978; 1988; Borror et al., 1989; Anonymous, 2009; Bartlet, 2009; Pickering, 2009).

To assess hymenopteran diversity indices and family evenness, models were calculated with the (1) Shannon – Weaver and (2) Shannon equations, respectively:

$$(1)\quad H' = -\sum pi \ln(pi) \qquad (2)\quad J = H'/\ln S$$

where *pi* is the proportion of individuals found in the ith family and S is the number of families.

Species richness indices were calculated with the Margalef's diversity index equation:

$$D_{mg} = \frac{(S-1)}{\ln N}$$

where S is number of recorded species and N is the total number of individuals in the sample.

Dominance measures were calculated with the Simpson index equation:

$$l = \sum ni(ni-1) / N(N-1)$$

where *l* is the Simpson index, *ni* is the number of individuals in the ith family and N is the total number of individuals (Magurran, 2005).

To estimate the total species richness of each site from abundance data, we used the Chao 1 equation

$$S_{Chao1} = S_{obs} + \frac{F_1^2}{2F_2}$$

where S_{obs} = the number of species in the sample; F_1= the number of observed species represented by a single individual (Singletons); F_2 = the number of observed species represented by two individuals (doubletons) (Magurran, 2005).

To estimate the absolute number of species at all sites, we used the Chao 2 equation

$$S_{Chao2} = S_{obs} + \frac{Q_1^2}{2Q_2}$$

where Q_1 = the number of species that occur in one sample only (unique species) and Q_2 = the number of species that occur in two samples (Magurran, 2005).

Coefficient of similarity was calculated with the Jaccard equation:

Cj=j/(a+b-j)

where "a" is the number of species at site A, "b" is the number of species at site B, and j is the number of species found at both sites. MVSP computing program was used for cluster analyses (Kovach, 1999).

All voucher specimens are placed in the Entomological Museum of Department of Plant Protection, Suleyman Demirel University, Isparta, Turkey.

Results

Collections at the four sites resulted in 889 data based specimens, except Formicoidea, Chalcidoidea and Proctotrupoidea. Specimens were identified to family level, but also to species and morphospecies with sufficient confidence. All specimens were sorted into 216 distinct morphospecies, belonging to 21 families. Two genera and 6 species are recorded for the first time.

Apoidea

Anthoporidae

***Ceratina* Latrielle, 1802**

***Ceratina callosa* (Fabricius, 1794)** (new record)

Isparta: Gölcük Natural Park, 37°44´N, 30º29´E, 1406 m, 06.XI.2008; 37°42´N, 30º29´E, 1492 m, 23.X.2008, col. G. Japoshvili. Toplanan 2 birey.

***Nomada* Scopoli, 1770**

***Nomada sybarita* Schmiedeknecht, 1882** (new record)

Isparta, Gölcük Natural Park, 37°44´N, 30º29´E, 1406 m, 19.VI.2008; 37°43´N, 30º30´E, 1400 m, 15.V.2008; 37°43´N, 30º30´E, 1395 m, 01.V., 05.VI., 23.VI. 2008; 37°43´N, 30º29´E, 1438 m, 20.IV.2008; 37°43´N, 30º29´E, 1412 m, 15.V.2008; 37°42´N, 30º29´E, 1455 m, 24.IV.2008, col. G. Japoshvili. Toplanan 14 birey.

Vespoidea

Scoliidae

***Scolia* Fabricius, 1775**

***Scolia schrencki* Eversmann, 1846** (new record)

Isparta, Gölcük Natural Park, 37°44´N, 30º29´E, 1406 m, 07.VIII.2008, col. G. Japoshvili. Toplanan 1 birey.

Tiphiidae

***Tiphia* Fabricius, 1775**

***Tiphia ruficornis* (Klug, 1810)** (new record)

Isparta, Gölcük Natural Park, 37°43´N, 30º29´E, 1419 m, 28.VIII.2008, col. G. Japoshvili. Toplanan 1 birey.

Site B harbored the highest abundance of Hymenoptera, with 33% of the sampled total of hymenopterans collected there. Sites A, C and D had 19%, 27% and 21%, respectively. The number of families found at sites A and C was 19. The number of families at sites B and D were 18 and 15, respectively. The Apidae and Halictidae were the most abundant families at all sites. The Anthoporidae, Megachilidae, Pompilidae and Sphecidae were also common families at all sites.

The highest hymenopteran family level diversity was found at site A where the Shannon-Weaver index of diversity was 2.5 (site B – 2.26; site C – 2.32; site D – 2.28). The greatest diversity was found at site B (95 species), followed by site C (94 species). But the highest species richness was recorded at site C (16.99) (Table 1).

Table 1. Relative abundance of Hymenoptera families recorded at four sites at Gölcük Natural Park, Isparta, Turkey*

Taxon	Sampling sites			
	A	B	C	D
Andrenidae	13	64	33	11
Anthophoridae	8	10	17	10
Apidae	33	56	26	27
Braconidae	2	1	5	2
Chrysididae	3	1	3	2
Colletidae	2	2	-	2
Crabronidae	1	-	2	-
Diapriidae	-	6	-	-
Eumenidae	1	-	2	3
Halictidae	28	47	51	41
Ichneumonidae	6	10	4	3
Megachilidae	7	22	10	14
Mellittidae	-	-	1	-
Mutillidae	11	3	1	-
Pompilidae	20	12	15	16
Proctotrupidae	2	-	1	-
Scoliidae	2	3	-	1
Sphecidae	13	14	4	24
Tenthredinidae	1	34	14	5
Tiphidae	11	1	3	-
Vespidae	7	8	46	25
Total number	171	294	238	186
H'	2.5	2.260	2.32	2.28
E	0.85	0.780	0.79	0.84
D_{mg}	14.98	16.54	16.99	15.88
I	0.105	0.136	0.129	0.125

* Each sampling sites were calculated separately.

The estimated absolute number of species at all sites was 397, which means that 46% of Hymenoptera from GNP is still uncollected. Estimated absolute number for each site was also separately calculated (Table 2). Hihgest estimated number of species was recorded at site A – 302 and lowest at site C – 187, which means that site C was fauna completeness is most high (50%).

Table 2. Basic site-by-site diversity statistics for Hymenoptera

Site	Total specimens	Species observed	Estimated species	Estimated completeness (%)	Singletones	Doubletons	Unique species
A	171	78	302	26	56	7	37 (47%)
B	294	95	275	35	60	10	58 (61%)
C	238	94	187	50	62	21	40 (43%)
D	186	84	196	43	54	13	34 (40%)

Hymenoptera families were found to be almost equally partitioned in all four sampling sites. The highest percentage similarity index (0.79) was found between sites A and D (A/B - 0.76, A/C – 0.73; B/C – 0.68; B/D – 0.74; C/D – 0.62). Fauna similarity according to family data is presented in Figure 2. Family Diapriidae was registered only from site B, and family Mellittidae from only site C; this can be attributed to the specific characters of both microhabitats. As the beta diversity is the total number of species that are unique between communities and sites, table 2 shows that unique species percentage is quite high. Thus, we consider that the between-site diversity (β diversity) in GNP is low.

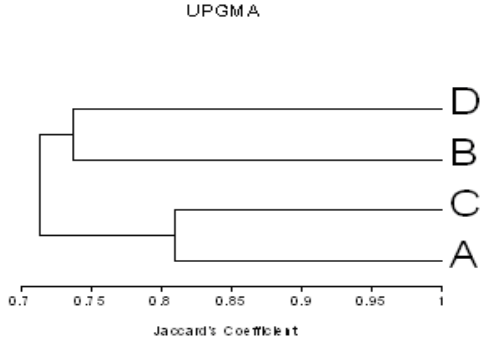

Figure 2. Hymenotperan fauna similarity between sampling sites based on family level.

Discussion

Results of comparison of family composition and structure of Hymenoptera among different studied sites revealed that site B provided an ideal micro-habitat for Hymenoptera because the influence of the apple orchard on creating this microhabitat. Relative abundance among taxa indicate dominance of Andrenidae and Vespidae. Taxonomic richness and relative importance of different family abundances, according to spatial and temporal distributions, indicate that the Hymenoptera should be taken into account in GNP management practices to ensure their health and promote diversity conservation.

It should also be considered that GNP is still at high risk of desertification, although it has been extensively reforested and the general picture is changing in a positive way (Figs. 1, 2, 3). However, the park is still used as a picnic area and human influence reflects negatively on the fauna. The evidence for this is that only 19 % of all samples and 36% of species were collected in site A. Below average percentages for site D (21% and 39%, respectively) may be explained by the high erosion level and low plant diversity. Even though the endemism level was high at this site, it comes from *Astragalus* spp., which is not ideal plant for hymenopterans. It should be considered also that GNP is at high risk of desertification, although it is intensively reforested and its habitat is changing in a positive way (Figs. 3,4,5).

Figure 3. Gölcük lake view in 1956.

Figure 4. Gölcük lake view in 1999.

Figure 5. Gölcük lake view in 2008.

Tilman et al. (1994) reported that destroying an additional 1% of habitat caused eight times more extinction than in similar sized disturbed habitat. It's fact that species with small population sizes will suffer most.

Restoration of natural deciduous forests combining with sustainable conifer plantations are the main objectives of the forest management program in GNP. Hymenopterans taxonomic and ecological diversity should be taken into account for evaluating the conservation of biodiversity in managed forests. We recommend further long term surveys in the GNP involving the use of hymenopteran groups indicative of biodiversity to indirectly assess its overall ecological health. These monitoring measures will help conserve rare and

endangered species and populations. In any conservation efforts, one should bear in mind that each undertaken recovery measure should improve the habitat conditions and increase biodiversity.

Özet

Isparta (Türkiye) Gölcük Doğal Parkı'nda Hymenoptera çeşit ve bolluğu

Bu çalışmada, 2008 yılında Isparta (Türkiye) ili sınırları içinde bulunan Gölcük Doğal Parkı'nın Hymenoptera çeşitliliği incelenmiştir. Çalışmada 21 familyaya ait türler elde edilmiş olup, Türkiye faunası için yeni kayıt olmak üzere dört tür saptanmıştır. Araştırmada Gölcük Doğal Parkı dört örnekleme alanına ayrılmış; bunlardan birincisi, parkın giriş bölümü olup, bu alanda Shannon-Weaver Hymenoptera çeşitlilik indeksi 2,5 değeri ile en yüksek olarak bulunmuştur. Toplanan bireylerin % 33'ünü oluşturan elma bahçesi, hymenopterlerin en bol bulunduğu alan olarak belirlenmiştir. Dört örnekleme alanında familyalar bulunma olasılığı açısından benzerlik gösterirken, kserofil bitki topluğundan oluşan alanda birey sayıları diğer alanlardan daha az olmuştur. Alanlar benzerlik açısından incelendiğinde benzerlik indeks değerine göre 0.79 ile akasya habitatı ile mezofilik bitkilerden oluşan habitatın benzerlikleri en yüksek olmuştur. Çalışmada yaşlı elma bahçesinin hymenopterler için barınma alanı olarak bir mikro habitat oluşturduğu görülmüştür.

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