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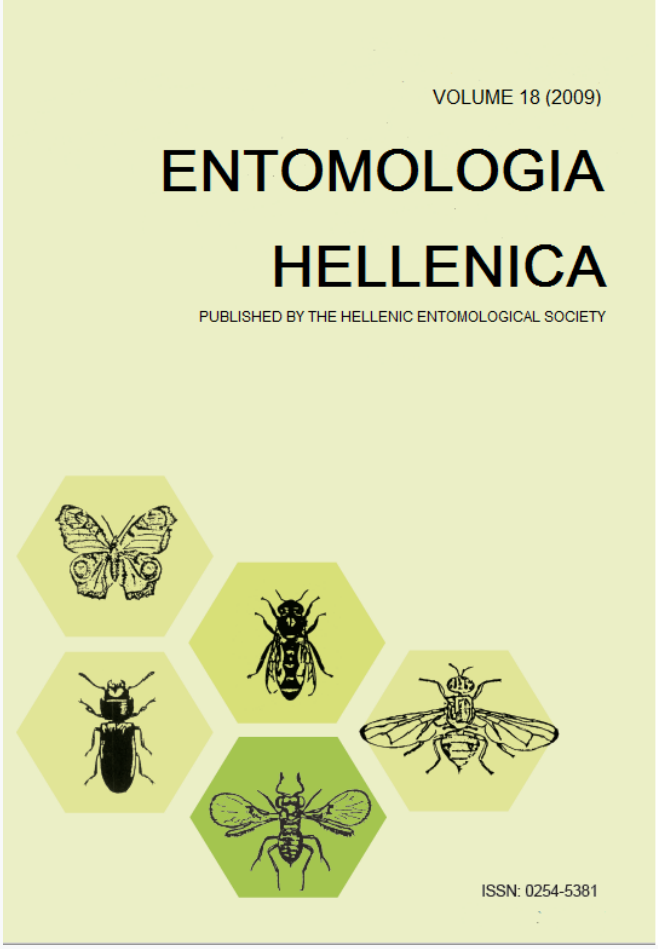

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Coleoptera diversity and abundance in Golcuk Natural Park, in Isparta, Turkey

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ABSTRACT

Coleoptera diversity was investigated at Golcuk Natural Park, Isparta, Turkey. Thirty four families of Coleoptera were recorded during the survey. Coleopterans were most abundant in a site close to an old apple orchard where 33% of all sampled individuals were found. Less frequently recorded families were found in a site close to the main entrance and picnic area. Coleopteran families were found to be unequally partitioned in all six microhabitats. The highest similarity index (0.85) was found between sites close to the Park entrance and close to the old apple orchard. Distribution of the abundance of coleopteran families was significantly different between all studied habitats. The study revealed that the site close to the old apple orchard and sites with xerophilic natural plants provide special micro-habitats for Coleopteran fauna.

KEYWORDS: Coleoptera, similarity, Golcuk, biodiversity.

Introduction

In the last decades, humans have more than ever been changing the world's ecosystems to meet the growing the demands for food, freshwater, timber, fiber, fuel and minerals (MA 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 enhances many other ecosystem services on which human depend (Bulte et al. 2005). Conservational International noted that 19 out of 25 biodiversity "hotspots" had population growth rates higher than global average and 16 of these hotspots account for one quarter of all undernourished people in the developing world (Cincotta and Engelman 2000).

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 (UNEP 1992, Haila and Kouki 1994). The conference declared preservation of biodiversity as one of the major elements of the sustainable development (Zilihona and 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

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functional relationships among species and the high abundance in many taxa (Zilihona and Nummelin 2001).

In the study area the first planting was started in 1956 by the Govermental Irrigation Department (DSİ), but it was established as a protected area on July 5th, 1991. The protected area included 6684 ha. An apple orchard in Golcuk Natural Park (GNP) occupies 39.9 ha which were planted before 1956. Unfortunately no exact data is available on when it was planted. Until 2005 agricultural activities was continued and orchards were irrigated, cultivated and sprayed with chemicals, but since that period all agricultural activities were stopped. GNP was opened for the public in 1981 and it was heavily used as a Picnic area, but since - 2006 barbeque fires are prohibited (Sahdubak and Cengiz 2007). GNP - belongs to IUCN 4th category.

The vegetation of this natural park has been studied in detail (Fakir 1998, Fakir and Dutkuner 1999). Isparta province itself is located on the border between the Irano-Anatolian and Mediterranean basin hotspots (BH 2008), this is reflected in the flora of the GNP as well: 22 (9.7%) endemic species for Irano-Anatolian hotspot and 17 (7.5%) endemic for Mediterranean basin hotspot are represented in this region. Twenty five species (11%) are endemic for Turkey (Fakir 1998). As the data shows, the endemism is quite high in GNP. In particular the study assesses the significance of Natural parks, reforestation and conservation measures in a global biodiversity hot spot. Coleoptera was chosen because it is a diverse insect order, and is fairly easy to identify to family level and play an important role in the ecosystem, and also, they are strongly linked with plant associations and reflect the biodiversity of the studied area. The results of this study have implications in the conservation management of the area.

No particular studies on the fauna of GNP have been conducted. This kind of study can serve as a basis for future long term observations on the biodiversity recovery processes in GNP and can be used as a reference case study in similar faunistic studies in future.

Materials and Methods

GNP is located 8 km southwest of Isparta province and for many years, it has been known as a special place for visitors that come to rest, have fun and do sports.

GNP is one of the most important protected areas of the Lakes District in Turkey, with its diverse vegetation and wild life, geomorphological structure, excellent landscape and recreational potential. Currently the GNP has a total area of 5925 ha, was designated as a National Park, but over the years the park has been eroding since it has no master plan. Recreational usage of the park has been centered around the lake, and other parts of the park have been underused, thus its natural values have declined drastically (Gul et al. 2005). Reforestration was started by DSİ in 1956 in order to prevent the lake to be filled with drift material. Later reforested areas were controlled by the Ministry of Forestry. *Robinia pseudoacacia* and *Pinus nigra* were the main species primarily used for reforestation, but later *Cedrus libani* was also used widely (Karatepe et al. 2005).

The study area was divided into six sampling areas with different plant associations: A - Main entrance to GNP, this is the area which is close to the lake, with areas reforested with *Robinia pseudoacacia* which were planted between 1960-1965. Some natural plants like: *Crataegus orientalis*, *Cotoneaster nummularia*, *Pistacea terebinthus* and other plants are also represented in this site which has high human activity (picnic area); B - This

sampling site represents an old (50 years old) apple orchard (39.9 ha) which is surrounded by a *Robinia pseudoacacia* reforested area planted in 1956. 6.3% of the *Robinia pseudoacacia* reforested area is composed of endemic plants; C – This site is represented by xerophilic natural plants with a reforested area with pine trees (*Pinus* sp.) and cedars (*Cedrus* sp.) planted between 1959 – and 1969 (Sahdubak and Cengiz 2007). About 4.8% of the plants that were recorded from this area were endemic also; D – Xerophilic natural shrubland with different dominant *Astragalus* spp., many of them which are endemic; E – Natural park highland, which was reforested in 1989 with *Cedrus* sp. and *Robinia pseudoacacia*; F – Natural *Quercus coccifera* and *Cistus laurifolius* forest, with mesophilic plantations.

Data were collected from April 15 to November 15, 2008 using pitfall traps. In all sampling places we set 10 pitfall traps and distance between them was 15-20 m. The pitfall traps consisted of circular pots (11cm in diameter and 11 cm depth) and were dug into the soil with the opening at the soil surface. At the beginning of the study, dry traps were used, but a month later, it was necessary to slightly change the methodology, material were damage by the insects themselves, and other animals such as mice, shrews and lizards. We put in the traps 2% formaldehyde, to avoid this type of damage. Traps were checked weekly. After the material was collected, it was preserved in 75% alcohol, and once in the laboratory, two drops of Acetic acid were added in order to soften the material for 30 minutes. Once the insects were softened, these were pinned or mounted on cards. For determining families and species we used different keys and web sources (Medvedev 1965; Borror et al. 1989; Pickering 2009; FE 2009; Bartlet 2009).

Diversity indices and family evenness models were calculated by Shannon – Weaver and Shannon equations respectively:

$$H' = -\sum pi \ln(pi)$$

$$J = H' / \ln S$$

where *pi* is the proportion of individuals found in the i^{th} family and *S* is the number of families.

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

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

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

Dominance measures were calculated by the Simpson index equation:

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

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

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

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

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).

The similarity coefficient was calculated by the Jaccard equation:

$$Cj=j/(a+b-j)$$

where a = the number of species in site A, b = the number of species in site B and j = the number of species found in both sites.

MVSP computing program was used for cluster analyses (Kovach 1999).

Results

Collections from six sites resulted in 11655 databased specimens. Specimens were identified to family level, but also to species and morphospecies with sufficient confidence. All species were sorted into 214 distinct morphospecies, belonging to 34 families. The coleopteran communities of 6 micro-habitats at GNP are shown in Figure 1.

The greatest diversity was found at site B (98 species), followed by site E (91 species) (Table 1). Estimated absolute number of species in all sites was 395, which means that 46% of coleopteran fauna is still undiscovered at the GNP. Site B harbored the highest abundance of Coleoptera, where 33% of all sampled Coleoptera was collected (site C - 26%, site A - 17%, site F - 13%, site E - 10% and site D only 0.6%). 76% of the recorded families were represented in site A. The number of families found in sites A and B were 26 and 24 respectively (Table 2). The number of families in sites C and E was 22 respectively, and sites F and D had 19 and 9 families respectively. Coleopteran families were found to be unequally partitioned in all four sampling sites. The lowest number of samples was recorded from site D (0.6%), which also had lowest number of families as

FIG. 1. Map of sampling sites.

Table 1. Basic site-by-site diversity statistics for beetles.

Site	Total specimens	Species observed	Estimated species	Estimated completeness (%)	Singletones	Doubletons	Unique species
A	1973	76	127	60	35	12	11(14%)
B	3823	98	165	59	40	12	36(37%)
C	3072	79	105	75	27	14	22(28%)
D	70	18	38	47	9	2	1(6%)
E	1193	91	111	82	27	18	36(40%)
F	1524	52	97	54	19	4	11(21%)

well (26%). The highest species richness was observed at site E, the place that was reforested after 1989. The lowest species richness was recorded at site D, which site has a high erosion level and its flora is dominated with *Astragalus* sp., with a microhabitat with other xerophilic features. However highest diversity index (1.7) at the family level was observed at site D as well (site C – 1.05; site E – 0.97; site B – 0.84, F-0.73). The lowest Shannon-Weaver diversity index was found at site A (0.69). The site D does not cluster with any of the others sites in the cluster analyses (Figure 2). The family Carabidae was the most abundant group in all sites, followed by the families Tenebrionidae. The Silphidae, Buprestidae, Chrysomelidae and Curculionidae were also common families at all sites. The families Cetoniidae and Lagriidae were recorded from all sites as well, but in low number.

The highest percentage similarity index (0.85) was found between A and B sites (A/E - 0.66, B/F – 0.65; B/E – 0.64; A/F – 0.61; B/C – 0.59; A/C – 0.55; C/E, C/F, E/F – 0.52; D/E – 0.41; D/F – 0.4; B/D – 0.38). The lowest similarity indexes were found between A/D and C/D – 0.35 respectively. Distributions of abundance of Coleopteran families were different between all studied sampling sites.

The family Alleculidae was recorded only from site F, Glaphyridae only from site E, Ostomatidae only from site E, and Ptinidae and Ripiphoridae only from C site. From the results of this study, we consider that the between-site diversity (β diversity) in Golcuk Natural Park is high.

Discussion

The present study revealed that site B provides a special sampling site for Coleoptera. This, could be attributed to the influence of the apple orchard in the forming of microhabitats suitable to Coleoptera – has played an important role in structuring the coleopteran fauna of this site. The lowest percent was found at site D, which we explain by the high erosion level and poor flora. The park is still used as a picnic area and human appearance influence on the fauna continues to be affected negatively. The evidence for this is that only 19 % of all insect samples were collected there.

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. Tilman et al. (1994) observed that destroying an additional 1% of the habitat caused eight times more extinction than similar sized disturbed habitats. It is a fact that species with small population sizes will suffer most. We recommend further long-term surveys in the GNP using some coleopteran groups as

Table 2. Relative abundance of coleopteran families recorded in four sites at Golcuk Natural Park, Isparta, Turkey.

Taxon	**Sampling sites**					
	A	B	C	D	E	F
Alleculidae	-	-	-	-	-	0.0007
Anisotomidae	0.0025	0.0010	-	-	-	0.0026
Anthicidae	-	0.0008	0.0003	-	-	-
Anthribidae	0.0020	0.0034	-	-	-	0.0007
Buprestidae	0.0071	0.0042	0.0173	0.0143	0.0075	0.0164
Bruchidae	0.0005	0.0010	-	-	0.0008	-
Cantharidae	0.0010	0.0010	-	-	0.0025	0.0013
Carabidae	0.8642	0.8234	0.7142	0.2000	0.8114	0.8458
Cerambycidae	0.0010	-	-	-	0.0008	-
Cetoniidae	0.0005	0.0037	0.0085	0.0714	0.0092	0.0059
Chrysomelidae	0.0152	0.0081	0.0055	0.0429	0.0092	0.0020
Coccinellidae	0.0005	0.0062	0.0023	-	-	0.0039
Cucujidae	0.0046	0.0037	0.0010	-	-	-
Curculionidae	0.0020	0.0062	0.1426	0.0143	0.0159	0.0033
Elateridae	0.0071	0.0188	0.0020	-	0.00226	0.0020
Geotrupidae	0.0015	0.0008	-	-	0.0025	0.0026
Glaphyridae	-	-	-	-	0.0101	-
Histeridae	0.0010	0.0029	0.0003	-	0.0025	-
Lagriidae	0.0005	0.0005	0.0003	0.0714	0.0025	0.0020
Meloidae	-	-	0.0036	-	-	0.0007
Melolonthidae	-	-	0.0010	-	0.0142	-
Melyridae	0.0056	0.0018	0.0010	-	0.0075	0.0007
Mordellidae	0.005	-	0.0003	-	-	-
Oedemeridae	0.005	-	-	-	-	-
Ostomatidae	-	-	-	-	0.0008	-
Pyrochoridae	0.0020	0.0016	-		-	-
Ptinidae	-	-	0.0007	-	-	-
Ripiphoridae	-	-	0.0003	-	-	-
Rutellidae	0.0005	0.0779	0.0010	-	0.0025	-
Scarabaeidae	0.0010	0.0005	0.0013	-	0.0117	0.0066
Scolytidae	0.0005	0.0005	-	0.0143	0.0017	-
Silphidae	0.0015	0.0010	0.0007	0.2143	0.0017	0.0348
Staphylinidae	0.0314	0.204	0.0534	-	0.0360	0.0079
Tenebrionidae	0.0451	0.0102	0.0426	0.3571	0.0260	0.0604
Total number	1973	3823	3072	70	1193	1524
H'	0.69	0.84	1.05	1.7	0.97	0.73
E	0.21	0.26	0.34	0.78	0.31	0.25
D_{mg}	9.88	11.76	7.71	4.00	12.70	6.96
l	0.75	0.68	0.54	0.23	0.66	0.72

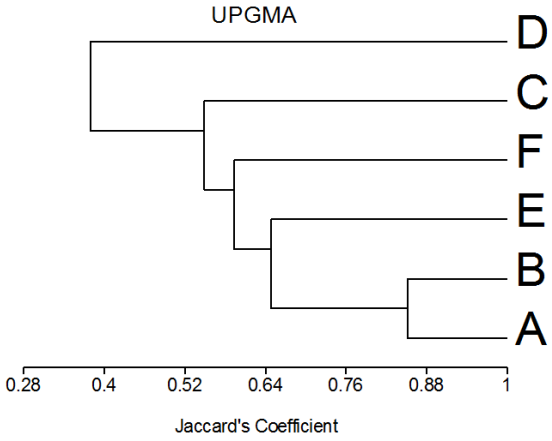

FIG. 2. Coleopteran fauna similarity between sampling sites based on family level.

taxonomic indicators for assessing the natural processes undergoing in the park. Conservation measures will help to conserve and monitor rare and endangered species and populations. In any conservation efforts one should bear in mind that each undertaken recovery measure should consider the improvement of the habitat conditions and increase biodiversity. We suggest that conservation efforts and monitoring in the study area should use selected coleopteran groups as taxonomic indicators in order to help adjusting mitigation measures.

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Ποικιλότητα και αφθονία Κολεοπτέρων στο Εθνικό Πάρκο Golcuk, στην Isparta της Τουρκίας

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ΠΕΡΙΛΗΨΗ

Έγινε καταγραφή των ειδών των Κολεοπτέρων που υπάρχουν στο Εθνικό Πάρκο Golcuk της πόλης Isparta της Τουρκίας. Κατά την επισκόπηση που έγινε καταγράφηκαν Κολεόπτερα που ανήκουν σε 34 οικογένειες. Τα περισσότερα από αυτά, το 33% του συνολικού αριθμού των ατόμων των δειγμάτων, βρέθηκαν κοντά σε εγκαταλελειμμένο μηλεώνα. Στην περιοχή κοντά στην κύρια είσοδο του πάρκου και συγκεκριμένα στο χώρο αναψυχής καταγράφηκε μικρότερος αριθμός οικογενειών. Τα είδη των διαφόρων οικογενειών των Κολεοπτέρων βρέθηκαν κατανεμημένα σε έξι μικρο-βιότοπους. Ο μεγαλύτερος δείκτης ομοιότητας (0.85) βρέθηκε μεταξύ των περιοχών κοντά στην είσοδο του πάρκου και κοντά στον εγκαταλελειμμένο μηλεώνα. Η κατανομή της συχνότητας εμφάνισης των ειδών των διαφόρων οικογενειών εμφάνισε σημαντική διαφορά μεταξύ όλων των βιότοπων που μελετήθηκαν. Από τη μελέτη φάνηκε ότι στην περιοχή κοντά στον εγκαταλελειμμένο μηλεώνα και σε περιοχές με ξηροφιλική φυσική βλάστηση αποτέλεσαν ιδιαίτερους μικρο-βιότοπους για την πανίδα των Κολεοπτέρων.