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Full Length Research Paper

Comparative diversity of insects in various habitats of Kovada Lake National Park Basin (Isparta, Turkey)

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The study was conducted in nine habitats representing different ecosystems in Kovada Lake Natural Park basin located in Isparta province. Pitfall traps were used for collecting various insects during 2007-2008 by regular weekly samplings. Consequently, a total of 64 insect species belonging to 15 families and 4 orders were recorded from the natural park basin. According to Shannon-Wiener and Simpson indices of diversity, Forest Coast Habitat was the most diverse in 2007. Analyses using Jaccard's similarity index indicated a high similarity between habitats Meadow Area and Maquis habitats. In the latter year (2008), the Shannon-Wiener and Simpson index values showed higher diversity for Forest Coast Habitat again. As for the similarity comparison, Fruit Plantation and Meadow Area habitats were determined as the most closed ones. According to the two-year data, the most diverse habitats were determined as Forest Coast and Open Area, respectively, using Shannon-Wiener and Simpson indices. Similar to species diversity, Maquis and Open Area habitats were found the most closed ones as a result of Jaccard's similarity analyses.

Key words: Kovada Lake, pitfall trap, insects, Shannon-Wiener, Simpson, Jaccard indices.

INTRODUCTION

Plant, animal and microorganism communities have created a biological diversity and form the greatest impact of protection of the natural balance. It is impossible to protect the whole world in current conditions. Therefore, the best method is protection of species, communities and their living places (Kocataş, 2004). In order to better preserve them, it is necessary to know the communities' composition and how they are distributed in the environment. Concepts of biological diversity or biological richness are not of a standard definition; they are expressed in different ways according to different authors. Magurran (2004) define the biological diversity as simply "diversity and abundance of species in a particular area". Biological diversity consists of three major parts, genetic diversity, species diversity and ecosystem diversity (Smith, 1996). Biodiversity studies compare diversity of two different areas or measure the change in a certain area depending on the time or other factors (Magurran, 2004). Species diversity is the simplest measure of the number of species (S), or species richness (Poole, 1974; Price, 1997). A single number does not give more information about the structure of the community, but accelerates making any comments.

Turkey is located at the crossroads of three continents and has an extremely important position for biological diversity in the world. Conservation International (CI) organization identified 34 hot spots around the world that are specific areas of the Earth's land surface and have a disproportionately large number of extant species (Myers, 2001). Our country's western and southern coastlines, the Mediterranean basin, is one of those hot spots included (Myers et al., 2000). The selected study area,

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Kovada Lake, is located within the boundaries of the city of Isparta in Southern Turkey. It is determined as a National Park in 1970. The National Park concept have been expressed in scientific and aesthetic ways, national and international protection of rare natural and cultural resource values, recreation and tourism areas of the nature. The study area was defined as a first level protected area in 1992, covering an area of 6534 hectares with its surroundings.

National Park has 259 genera and 361 species of plants belonging to 75 families of which 28 species are found as endemic (Bayram, 2007). The Lake has karstic morphology and 7900 da in size. In the study area, 153 waterfowl bird species were recorded mainly including wild duck, goose, shelduck, partridge and woodcocks (Anonymous, 2003). It is shown as an international important wetland due to its features and usage such as drinking water, irrigation, aquaculture, fisheries, hydropower, and recreation (Anonymous, 2004). Although many studies on many topics have been conducted in Kovada Lake (Kazancı et al., 1999; Gündoğdu, 2002; Yücedağ and Carus, 2005; Arslan and Şahin, 2006) there is no study conducted on the biological diversity of insects. The aim of this study is to determine the insect biodiversity of the Kovada Lake Natural Park basin and will be a preliminary step in order to detect the insect species and biodiversity in the area.

MATERIALS AND METHODS

Study sites

Studies were carried out in Kovada Lake National Park (Figure 1). The study area was divided into nine different sampling sites with different plant associations. Information about habitats including altitude, size and vegetation types are given as follows:

Sand rest habitat (SRH)

This is the closest area to the lake among the others. The size of the area is 2.8 da at an altitude of 927 m. It has rather poor vegetation including *Verbascum* spp. and *Platanus orientalis* L. trees commonly.

Maquis and forest habitat (MFH)

The habitat forms a dry stream bed with an altitude of 943 m and 2.94 da size. *Juniperus oxycedrus* L., *Thuja orientalis* L., *Crataegus monogyna* Jacq, *Cistus ladeniferus* Weisse, *Pistacia lentiscus* L., *Rosa canina* L., *P. orientalis L. comprise* the dominant vegetation of the area.

Meadow area habitat (MAH)

This area is located at the south part of the Kovada Lake. It has 941 m altitude and 2.75 da size. Unlike other habitats, it has only annual herbaceous vegetation. *Echium italicum* L., *Glaucium corniculatum* ssp. *corniculatum* (L.), *Trifolium resupinatum* L. var. *resupinatum*, *Anthemis arvensis* L., *Leontodon tuberosus* L., *Achillea multifida* Boiss., *Cardaria draba* (L.) are the most common plant species.

Mixed forest habitat (MFoH)

This habitat is selected from a forest area at 974 m altitude, with a land area of 2.65 da. *Quercus robur* L. and *Pinus nigra* Arnold are the most common plant species of the area mixed with some annual plants like *Ornithogalum oligophyllum* Clarke and *Cyclamen cilicium* Boissier&Heldreich.

Forest coast habitat (FCH)

It includes a land area of 2.78 da at an altitude of 929 m. The dominant plant species are *P. lentiscus* L., *Quercus robur* L., *Quercus coccifera* L. and *Cardus rechingeranus* Kazmi.

Open area habitat (OAH)

The area is like a plain valley dried from the lake. *C. draba* (L.) and *A. multifida* Boiss. are the common species of the vegetation accompanied by some annual plants.

Fruit plantation habitat (FPH)

The habitat has an altitude of 919 m, covering about 3.08 da land area. Because of some cultural practices, apple crop is the dominant vegetation together with some other vegetable crops. Shrubs were removed from the area in order to grow apple.

Maquis coast habitat (MCH)

Platanus orientalis L. represent the dominant vegetation of the area, altitude is 911 m and size 1.84 da. *Xanthium strumarium* L. and some members of the plant family Poaceae are other species observed in the area.

Maquis habitat (MH)

Unlike other two habitats including maquis, the area has only scrubs. It has 911 m altitude and 0.82 da size. Vegetation constitute of species mainly including *P. lentiscus* L., *J. oxycedrus* L., *T. orientalis* L., *C. monogyna* Jacq., *C. ladeniferus* Weisse, *Q. coccifera* L. and *R. canina* L.

Sampling method and collection

Studies were carried out from April 2007 to October 2008. Insect samples were collected using the pitfall trap method. At all sampling areas, 10 pitfall traps were settled 25 m far from each other. Pitfall trap method involved the use of 15 cm depth and 17 cm diameter small cups. They were carefully placed in the ground taking into consideration top of the cup and surface of the ground were in the same level. Traps were checked weekly and the fallen insects collected in to the killing bottles. Samples were mounted at the laboratory and identified to families. All specimens are deposited in the Entomological Museum of Isparta, Turkey (EMIT).

Data analyses

BioDiversity Pro (Biodiversity Professional Version 2) (McAleece et

Figure 1. Location of Kovada Lake National Park Basin (Turkey).

al., 1997) and Multi-Variate Statistical Package (MVSP) (Kovach, 2005) were used to assess species diversity and similarity of collected insects in the study sites. The Shannon's index of species diversity (H'), Simpson's index (D) and Berger-Parker index of dominance (d) − Equations 1, 2 and 3, respectively, were used to assess the insect diversity (Magurran, 2004).

Shannon's diversity index is defined as:

$$H' = -\sum p_i \ln(p_i) \quad (1)$$

Simpson's index is defined as:

$$D = \sum p_i^2 \quad (2)$$

and Berger-Parker index of dominance is defined as:

$$d = N_{max} / N \quad (3)$$

Where p_i is the proportion of individuals found in the ith species, S is the number of species, N is the total number of individuals and N_{max} is the number of individuals in the most abundant species. For Simpson's index and Berger-Parker index of dominance, the reciprocal forms (1/D and 1/d) were used so that an increase in the value of index accompanies an increase in diversity and a reduction in dominance. Jaccard's (C_j) coefficient was used in order to determine the similarity among the sites (Equation 4):

$$C_j = a / a+b+c \quad (4)$$

Where a is the total number of species common in both sites, b is the number of species present only in site A, c is the number of species present only in site B (Magurran, 2004).

RESULTS

As a result of the study, a total of 64 insect species belonging to 15 families and 4 orders were recorded from the Kovada Lake National Park basin. In the field surveys of 2007, we found 3 orders, 13 families and 52 species. For the year 2008, 4 orders, 15 families and 57 species were found. Carabidae and Tenebrionidae were the most common families in the both study years (Table 1). Comparing the species diversity of habitats according to the Shannon-Wiener and Simpson's index values, FCH was distinctly more diverse than others for both study years. Although MFoH had least species number (16), SRH was determined as the least diverse habitat based on the index results (H', D and d) of total evaluation.

In 2007, in parallel with species number, diversity index values were higher for FCH, OAH and MFH, respectively.

Table 1. Species and individual numbers of the 15 families recorded from Kovada Lake National Park basin (S: number of species, N: number of individuals).

Family	2007		2008		Total	
	S	N	S	N	S	N
Coleoptera						
Carabidae	22	642	19	972	24	1614
Tenebrionidae	9	803	8	1214	9	2017
Scarabeidae	7	134	8	259	8	393
Melolonthinae	1	7	1	22	1	29
Histeridae	1	45	1	21	1	66
Elateridae	1	9	1	62	1	71
Cetonidae	3	79	5	219	6	298
Lucanidae	1	3	2	69	2	72
Cicindelidae	1	4	1	9	1	13
Brachyceridae	1	88	1	129	1	217
Staphilinidae			1	35	1	35
Hymenoptera						
Formicidae	3	155	5	294	5	449
Mutulidae	1	18	2	37	2	55
Dermaptera						
Forfuculidae	1	11	1	20	1	31
Orthoptera						
Grylloptalpidae			1	4	1	4
Total	52	1998	57	3366	64	5364

Moreover, in 2008, FCH was the most diverse again, followed closely by FPH and OAH. Although species number of MH was higher than those in FPH and OAH, index results was lower for MH based on individuals' distribution (Table 2). In 2007, according to the cluster analysis based on species composition (Jaccard's coefficient of similarity), MAH, SRH and MH formed a separate group more close to each other of which MAH and MH were the most similar with a similarity percentage of 33.3%. OAH and FCH were followed with the 25% similarity. MFH and MCH were significantly separated from others, and were not similar to any other habitats (Figure 2).

In 2008, in contrast with the previous year, Jaccard's index revealed a closer relationship between the habitats FPH and MAH resulting in with a similarity percentage of 37%. FCH and OAH showed similar results (32%). Another remarkable point in the diagram was the MFH and SRH that were clearly separated from the other 7 habitats. However, MFH representing one of the least diverse habitats was the least similar among those 7 habitats (Figure 3). MH and OAH had the highest similarity (41.7%) when using two years data combined. According to the cluster analysis results, MFH showed no similarity with any other habitat. Similar to that, SRH was clearly differentiated and moved away from the other habitats (Figure 4.).

DISCUSSION

FCH was found as the most diverse habitat separately in each study years and in combined data. This was closely followed by FPH, OAH and MH. Similar results of diverse habitats were obtained in other studies conducted in different protected areas (Aslan and Ayvaz, 2009). OAH was dominated by different annual herbaceous plants, so that it served as a suitable area to meet the nutritional needs of different species. As was highlighted by previous studies carried out in similar selected habitats, herbaceous plants were dominant (Karaca et al., 1993; Vessby et al., 2002). Similarly, FCH was rather suitable for different insect species because of combining forest trees and other different plant species near forest border. The positive edge effect on diversity was supported by some previous studies as in the Forest Coast habitat in this study (Magura et al., 2000; Chacoff and Aizen, 2006). Diversity values were generally lowest in the MAH

Table 2. Number of species, individual and the different index values found in all habitats.

Year		Habitats*								
		SRH	**MFH**	**MAH**	**MFoH**	**FCH**	**OAH**	**FPH**	**MCH**	**MH**
	S**	12	14	6	10	24	21	9	10	10
	N	220	191	97	108	462	355	215	214	136
2007	H'	0.906	1.032	0.710	0.896	1.295	1.134	0.847	0.732	0.820
	D	0.835	0.882	0.767	0.842	0.939	0.892	0.836	0.686	0.810
	D	3.400	3.872	2.205	3.182	6.078	3.356	4.574	1.877	2.978
	S	12	11	15	10	31	19	19	15	20
	N	323	240	481	204	551	449	364	379	375
2008	H'	0.831	0.889	1.005	0.901	1.417	1.180	1.227	1.076	1.088
	D	0.771	0.840	0.849	0.851	0.955	0.922	0.936	0.893	0.871
	D	2.307	4.068	2.824	3.647	8.379	5.000	8.465	3.742	2.795
	S	19	19	17	16	38	27	24	20	24
	N	543	431	578	312	1013	804	579	593	511
Total	H'	1.001	1.108	1.027	1.033	1.460	1.250	1.264	1.076	1.154
	D	0.828	0.888	0.846	0.872	0.956	0.919	0.932	0.851	0.876
	D	2.648	3.981	2.702	3.880	9.309	4.139	6.580	2.695	2.847

*SRH: Sand rest habitat, MFH: Maquis and forest habitat, MAH: Meadow area habitat, MFoH: Mixed forest habitat, FCH: Forest coast habitat, OAH: Open area habitat, FPH: Fruit plantation habitat, MCH: Maquis coast habitat, MH: Maquis habitat. **S: Species, N: Individual, H': Shannon-Wiener index, D: Simpson's Index, *d*: Berger-Parker's Index.

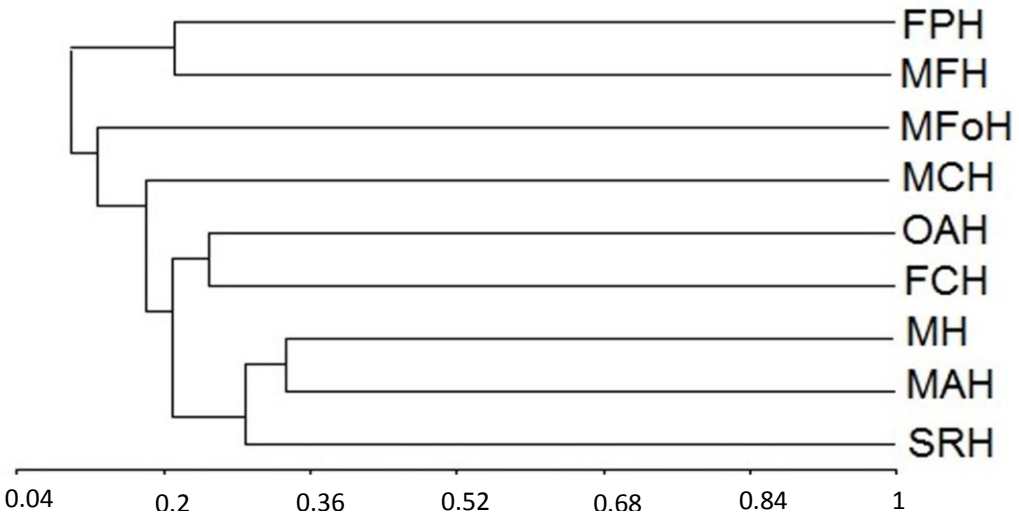

Figure 2. Similarity between insect communities inhabiting study sites based on Jaccard's index in 2007.

and SRH. This is probably due to the uniform or poor vegetation structure of these habitats. Only two plant species found in the SRH, which may be the most important factor of low occurrence of insect diversity. It is known that structure and composition of vegetation, topography, abiotic factors (temperature, humidity), and human actions are the main influential factors on insect diversity (Balog and Markó, 2007; Aslan, 2010).

The most sampled families throughout the study were Carabidae and Tenebrionidae with species numbers 24 and 9, respectively. Showing the edge effects such as the FCH, species of the family Carabidae diversity have found higher values in the previous studies (Magura and Tóthméréz, 1997; Avgın, 2006). Tenebrionidae family members at the similar habitat to the FCH (oak trees planted with the shrub form) reported the most diverse

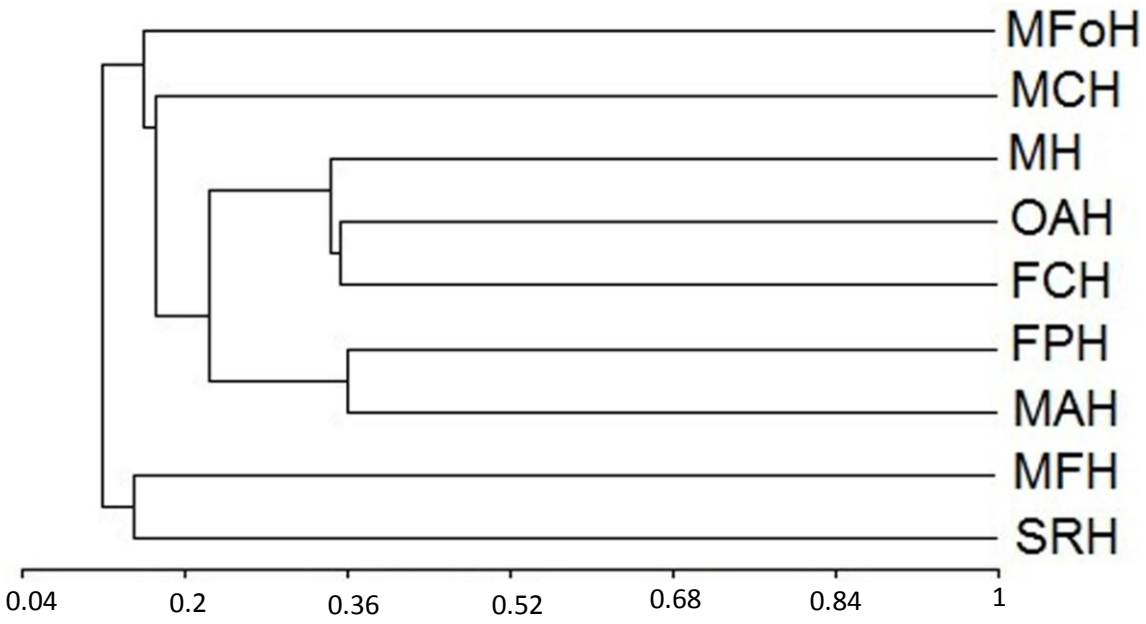

Figure 3. Similarity between insect communities inhabiting study sites based on Jaccard's index in 2008.

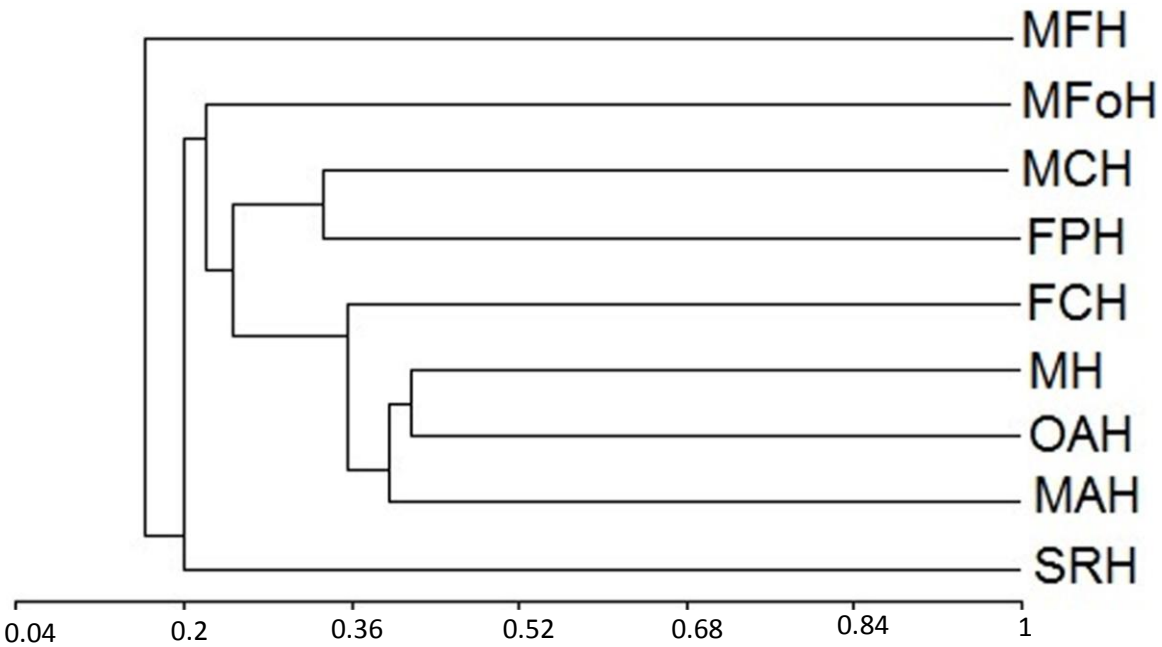

Figure 4. Jaccard's similarity index of habitats according to the two years (2007-2008) data.

habitat in another publication (Mercan et al., 2004). Among the species belonging to the family Tenebrionidae, *Dailognatha quadricollis* represents the dominant species with an abundance percentage of 10.97%. This is a common species, known to have a very wide distribution (Tezcan et al., 2004). It was also reported as the most dominant species in another study conducted in Kasnak Oak Nature Reserve, which is very close to the study area (Aslan et al., 2008). Carabidae and Tenebrionidae members are usually adapted to herbaceous plants and arid areas (Lovei and Sunderland, 1996; Ward and Ward, 2001; Mercan et al., 2004). The collected individuals belonging to these families confirm this thesis in all worked habitats in Kovada Lake National

Park.

Because of the pitfall trap sampling method, only the flightless and living on the surface of the soil insects were sampled and diversity considered in this assessment. In addition, in the light of all data obtained by pitfall trap sampling method indicate it to be an effective method for sampling specific groups, suitable for use in all habitats and not required special tools and equipments. Compared with the previous studies conducted in different protected areas, in terms of sampled number of species and individuals, Kovada Lake National Park Basin's fauna appears to be poor. Factors such as being park area open to visitors as well as illegal hunting, livestock grazing and the contamination of irrigation water to the lake may be some possible factors responsible from this result. Agricultural activities in surroundings and orchards within the boundaries of the National Park negatively affect the fauna and diversity.

We regard this study as only a preliminary step in the description of the biodiversity of Kovada Lake Natural Park basin and can be used as a reference case study in similar diversity studies in the future.

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