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Contribution to the Knowledge on the Distribution of Chironomidae and Chaoboridae (Diptera: Insecta) Species of Lakes on Taurus Mountain Range (Turkey)

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ABSTRACT

In order to identify the Chironomidae and Chaoboridae fauna of 11 high altitude lakes located in the Taurus Mountains Range in south-west Anatolia (Turkey), two expeditions were conducted in July 1996 and July 1997. As a result, a total of 19 taxa were determined; of them 17 taxa belong to Chironomidae and two to Chaoboridae. All the recorded taxa are firstly recorded from the study area. The ecological requirements and the distribution of the identified species are presented.

Key words: Chironomidae, Chaoboridae, Fauna, Taurus Mountains, Turkey.

INTRODUCTION

Lakes on high mountains are unique habitats in terms of faunal composition because they constitute isolated environments. Mountain lakes offer a unique model situation to test environmental changes on the catchment scales (Manca *et al*., 1998).

Bio-ecological characteristics of such lakes in Europe and America have already been determined and most of them have been exploited for fishing sport. In Turkey all such lakes are still pristine, but knowledge gained from limnological studies of the high altitude lakes of Turkey is still incomplete. Hence, the ecological and biological (fauna) features of mountain lakes in the Taurus Range need to be described (Yıldız *et al*., 2007).

Having very rich inland water sources, Turkey has more than 200 natural lakes (Egemen, 2011). Although various limnological studies have been conducted at easily accessible lowland lakes, only a few limnological studies have been performed on Turkey's glacial and tectonic lakes (Geldiay and Tareen, 1972; Ustaoğlu, 1980; Taşdemir *et al*., 2004; Toksöz and Ustaoğlu, 2005; Ustaoğlu *et al*., 2008; Yıldız *et al*., 2009; 2010). One study was performed on the macro-invertebrate fauna of Lake Eğrigöl, located in the Taurus Mountains (Yıldız *et al*., 2005). In addition, five studies were conducted on the Mollusca (Balık *et al*., 2003), Malacostraca (Ustaoğlu *et al*., 2004), zooplankton (Ustaoğlu *et al*., 2005), Oligochaeta (Yıldız *et al*., 2007) and Insecta (Topkara *et al*., 2009) fauna of the same lakes studied in the present paper.

The goal of the study is to collect and identify Chironomidae and Chaoboridae specimens as well as to identify the physico-chemical characteristics of the water bodies.

MATERIAL AND METHODS

Study Area

The Taurus Mountains are the western most branches of the great mountain chain that stretches across all of Asia, the Himalayan Mountain Belt. The Taurus Mountain Range follows the southern border of Anatolia. This range has an average elevation of around 2500 m. and extends through south-central Turkey. The western part has a particular significance in that it separates the southern Turkish coastline, which has a typical Mediterranean climate, from dry and steppe-like central Anatolia (Kumlutaş *et al*., 2004).

The range is snow-covered during the winter season. In spring, the rivers swell from the melt-off and flow out to the Mediterranean. There are interesting rock formations, waterfalls, karstic underground rivers and caverns in the area because of karstic topography and hydrography.

Geographical situation of the Taurus Range and research stations are illustrated in the Fig. 1. and Table 1.

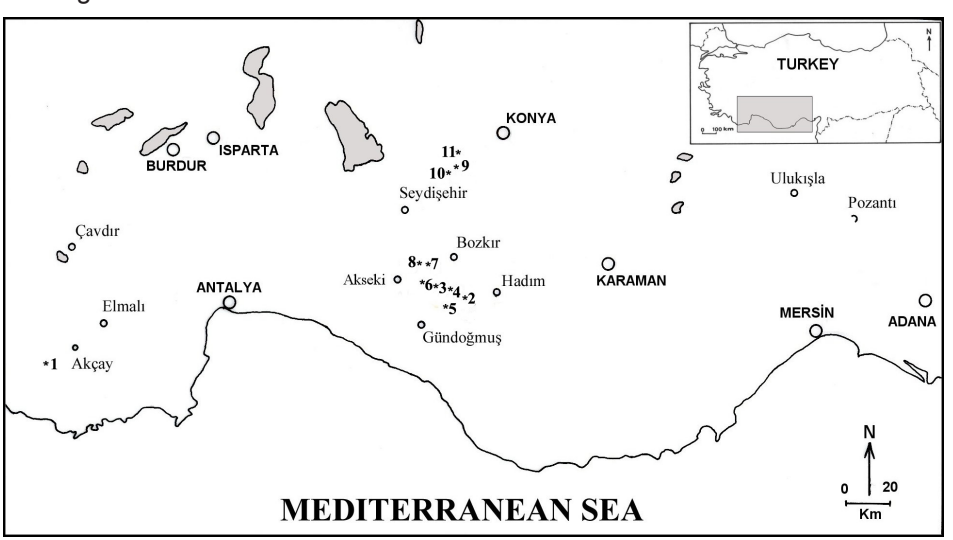

Fig. 1. Sampling stations in the Taurus Mountain Range of Turkey.

Sampling

Due to the high altitude, most of the explored areas are generally covered with snow and ice for 7-8 months of the year and only in warm months, i.e. July and August, the layer melts. Therefore, 2 expeditions were conducted in July 1996 and July 1997.

Table 1. Investigated localities and sampling dates.

Station number	*Localities*	*Altitude (m)*	*Depth (cm)*	*Surface area (ha)*	*Presence of macrophytes*	*Sample Type*
1	Yesil Lake	1600	*	0.2	-	Profundal
2	Dipsiz Lake	1600	300	6	+	Profundal
3	Kovali Lake	1650	160	2.5-3	+	Profundal
4	Dipsiz Lake	1690	1300	1	+	Littoral,Profundal
5	Suluklu Lake	1690	*	*	+	Littoral,Profundal
6	Gavur Lake	1850	90	*	+	Littoral,Profundal
7	İlvat Lake	1890	180	100	+	Littoral,Profundal
8	Kizilot Lake	1950	95	200	+	Profundal
9	Duruca Lake	1950	250	100	+	Profundal
10	Karin Lake	2000	90	3	+	Profundal
11	Susam Lake	2070	190	3-4	-	Littoral,Profundal

* Could not be measured

Some of the physicochemical parameters were measured in the field. pH with a Hanna HI 8014 model pH-meter, conductivity with a Hanna HI 8033 model conductivity meter, dissolved oxygen was measured with the help of the titration method (Winkler method), transparency was measured with Secchi–disc and the others in laboratory; salinity was measured with the help of the Mohr-Knudsen method, alkalinity and temporary hardness were measured with HCl titration method, Ca^{++}, Mg^{++} and total hardness were measured with EDTA titration method (Golterman, 1971).

The Chironomidae and Chaoboridae specimens were collected from mud samples, obtained by an Ekman - Birge grab (15 x 15cm) or with a hand-net the samples were sieved through a sieve with a mesh size of 500 µm. The samples were fixed in 4 % formaldehyde solution in the field. Later they were preserved in 70 % alcohol until identification of species' level after washing in the laboratory. After the permanent preparation of sorted Chironomidae specimens with Euparal, larvae were identified using a stereomicroscope and a binocular microscope. Chaoboridae larvae were investigated under a stereo-microscope (Olympus SD30). The reference materials are stored in the collection of the first author as permanent whole mount.

For taxonomic identification of the specimens the following publications were used: Şahin (1991), Cranston (1982), Hirvenoja (1973), Wiederholm (1983), Epler (1995), Klink and Moller Pillot (2003); Chaoboridae were identified using Balvay (1977).

Community parameters, such as number of species, number of individuals, diversity index (log_2 transformed) (H') (Shannon-Weaver, 1949) and evenness index (J') (Pielou, 1975) were calculated for each station.

RESULTS

As a result of the measurements performed during 1996-1997, depth, transparency, temperature, pH, conductivity, dissolved oxygen, salinity, alkalinity, Ca^{++}, Mg^{++}, total hardness and temporary hardness taken from the stations are presented in Table 2.

Table 2. Some measured physico-chemical features of localities, in 1996 and 1997 (Trans: Transparency; T: Temperature; Cond.: Conductivity; D. O.: Dissolved Oxygen; Sat.: Oxygen Saturation; S: Salinity; Alk.: Alkalinity; T.H.: Total Hardness; Temp. H.: Temporary Hardness).

Sta.	*Date*	*Trans. (cm)*	*T (ºC)*	*pH*	*Cond. (µS/20ºC)*	*D.O (mg/l)*	*Sat. (%)*	*S. (‰)*	*Alk. (meq/l)*	*Ca^{++} (mg/l)*	*Mg^{++} (mg/l)*	*T.H (mg/l)*	*T.H. (d°H)*
1	1996	*	11.0	8.0	166	8.8	98	0.02	1.6	32.06	19.45	160	8.9
2	1996	130	25.5	7.5	203	4.8	71	0.21	2.0	36.07	26.75	200	11.2
3	1996	100	22.5	7.3	114	4.8	68	0.16	2.0	24.04	34.04	200	11.2
4	1996	210	25.5	7.9	200	5.6	84	0.13	3.0	52.10	36.48	280	16.8
	1997	*	23.5	7.8	202	7.3	107	0.05	1.0	32.06	53.50	300	5.6
5	1997	*	24.5	7.3	240	8.0	119	0.08	1.4	64.12	43.77	340	7.8
6	1996	40	27.0	6.7	72	6.0	94	0.13	1.4	16.03	21.88	130	7.8
7	1996	180	25.5	9.4	52	6.7	104	0.08	0.8	24.04	29.18	180	4.4
	1997	110	16.0	10.0	60	8.0	103	0.08	0.8	24.04	34.04	200	4.4
8	1996	70	25.5	9.4	76	8.4	132	0.10	1.4	36.07	26.75	200	7.8
	1997	100	16.0	10.1	84	8.3	108	0.08	0.6	32.06	38.91	240	3.3
9	1996	250	23.0	9.2	65	7.8	117	0.08	1.2	24.04	31.61	190	6.7
	1997	135	16.0	9.3	83	9.6	124	0.05	0.6	32.06	34.04	220	3.3
10	1996	60	25.5	8.7	127	8.8	138	0.07	2.0	40.08	34.04	240	11.2
	1997	5	15.0	10.7	153	8.0	102	0.08	0.6	32.06	34.04	220	3.3
11	1996	90	22.0	8.5	106	6.0	89	0.10	2.4	32.06	12.16	130	13.4
	1997	*	16.0	8.4	122	8.3	108	0.05	0.4	32.06	48.64	280	2.2

* Could not be measured

At the present study totally 19 taxa were determined. Of the determined taxa, 2 belong to Chaoboridae and 17 to Chironomidae. Tanypodianea was represented by 2 taxa, Orthocladiinae by 4 taxa, Chironominae by 11 taxa. Chironominae (with 11 taxa) had the maximum number of taxa in the present study. Among the identified taxa, *C. tentans* group was the predominant species and was found at three stations.

Ablabesmyia (*Ablabesmyia*) *monilis*, *Procladius (Holotanypus) sp.,Chironomus anthracinus group*, *Glyptotendipes* (*C.*) *scirpi* and *Chaoborus crystallinus* were the most common (at 2 stations), and the remaining ones were found at one station.

The average densities of total chironomid and chaoborid larvae at the benthos of the lakes were respectively 6503 ind.m^{-2} and 1336 ind.m^{-2}. Among all samples, the Chironominae subfamily was the most dominant one (85% of the specimens) and was followed by the Orthocladiinae (9%) and Tanypodinae subfamilies (6%). The tribe

Chironomini (83%) had greater abundance value than the tribe Tanytarsini (17%) within the Chironominae subfamily. Distribution of the species and their numbers in samples at the investigated stations are given in Table 3.

Table 3. Distribution of species and their numbers in samples at the investigated stations.

Chironomidae	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Ablabesmyia (*A.*) *monilis* (Linnaeus, 1758)			45				178				
Procladius (*H.*) sp							89	45			
Psectrocladius (*P.*) *sordidellus* group (Zetterstedt, 1838)					445						
Cricotopus (*C.*) *flavocinctus* (Kieffer, 1924)								45			
Cricotopus (*I.*) *intersectus* group (Stäger, 1839)							45				
Cricotopus (*I.*) *sylvestris* group (Fabricius, 1794)							45				
Chironomus (*C.*) *anthracinus* group Zetterstedt, 1860										134	134
Chironomus (*C.*) *plumosus* group (Linneaus,1758)										935	
Chironomus (*C.) tentans* group (Fabricius,1794)								1602	45	668	
Cryptochironomus defectus (Kieffer, 1913)							178				
Endochironomus tendens (Fabricius, 1775)				178							
Glyptotendipes (*C.*) *scirpi* (Kieffer, 1915)		89	89								
Parachironomus gr. *arcuatus* (Goetghebuer, 1919)										178	
Polypedilum (*P.*) *sordens* (Van der Wulp, 1874)				223							
Micropsectra notescens group (Walker,1856)				801							
Micropsectra junci group (Meigen, 1818)	267										
Paratanytarsus lauterborni (Kieffer,1909)								45			
Chaoboridae											
Chaoborus (*C.*) crystallinus (De Geer, 1776)			267			668					
Chaoborus (*C.*) *flavicans* (Meigen,1830)		401									

The depths of the lakes of the present study did not exceed 2-3 m, except Dipsiz Lake-Bozkır (13 m). Thus, there were no profundal zones in the investigated lakes.

The Ilvat Lake had the highest species richness with 5 taxa and was followed by the Kızılot and Karın lakes with 4 taxa.

Although, when the abundance values taken into account the Karin lake was the richest one with 1914 ind.m^{-2} and it was followed by the Dipsiz lake with 1202 ind. m^{-2} (Fig. 2), Ilvat lake was found to have the highest values for the diversity index (H= 2.085) and the evenness index (J′= 0.8979) into the lakes (Table 4).

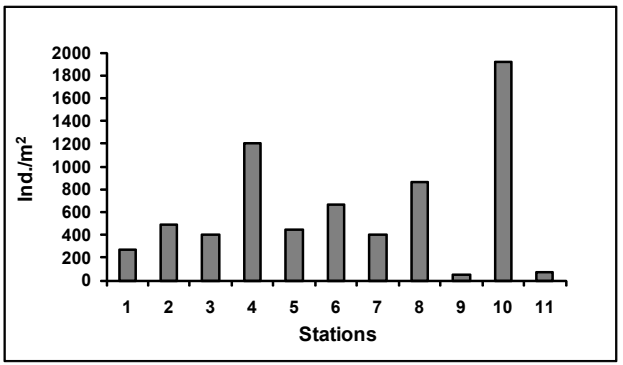

Fig. 2. Abundance (ind.m^{-2}) values of the lakes.

Table 4. Evenness and diversity index values of the lakes regarding to their altitudes.

Station number	Localities	Altitude (m)	Ind/m²	J'	H(log-2)
1	Yesil Lake	1600	45	0	0
2	Dipsiz Lake	1600	490	0,684	0,684
3	Kovali Lake	1650	401	0,7725	1,224
4	Dipsiz Lake	1690	1202	0,7878	1,249
5	Suluklu Lake	1690	445	0	0
6	Gavur Lake	1850	668	0	0
7	İlvat Lake	1890	401	0,8979	2,085
8	Kizilot Lake	1950	868	0,2566	0,5132
9	Duruca Lake	1950	45	0	0
10	Karin Lake	2000	1914	0,8108	1,622
11	Susam Lake	2070	67	0	0

DISCUSSION AND CONCLUSION

In high elevation mountainous areas, macro-invertebrates have adapted to unique and often extreme environmental conditions (Mani, 1968). The abundance of chironomid larvae usually does not reach very high values in high mountain lakes mainly due to the low productivity of these lakes (Tátosová and Stuchlik, 2006). This is also illustrated by Bretschko's (1974) study of Vorderer Finstertaler See, situated in Austria, 2237 m a.s.l. (after Armitage *et al*., 1995). Similarly, the chironomid assemblages of alpine Tatra lakes are characterized by lower species richness and total absence of taxa from the tribe Chironomini (Bitušík *et al*., 2006).

The same statement could not be true if inlets and outlets of high altitude Alpine lakes are also considered (Maiolini *et al*., 2006), where the number of species found may be higher.

Our study shows similarity with the above mentioned studies in terms of low species richness.

Some important differences can be observed respect to chironomid fauna found in other Alpine lakes, as the absence of some species of Orthocladiini (*Heterotrissocladius marcidus, Corynoneura* spp.) and Tanytarsini (*Paratanytarsus austriacus*), which are dominant in other mountain lakes (Rossaro *et al.*, 2009), emphasizing the relative lower representation of the tribes of Orthocladiini and Tanytarsini respect to Chironomini in the present case. Orthocladiini (Orthocladiinae) and Tanytarsini (Chironominae) were the most frequent tribes captured in the littoral area of high altitude lakes in the Alps, as previously recorded by Bretschko (1974), Wathne *et al*. (1995), Boggero *et al*. (1996) and by Franceschini and Lencioni (2002) (after Boggero *et al*., 2006).

The ecology of the investigated lakes on the Taurus Mountain Range distinctly differs from the other high mountain lakes reported in Europe, such as those lakes in the Tatra Mountains (Bitušík *et al*., 2006). The area, where the lakes located, has a carstic character and human transportation is not too hard. Many of the lakes have mesotrophic character while a few ones were eutrophic lakes most probably because of existence of human settlements near the lakes and the ground structure of the area. As observed during the field studies, many of the lakes (such as Karın and Kovalı Lakes) have well developed aquatic macrophytes in their littoral zones. These lakes were mainly of eutrophic character and showed relatively high diversity index values (Table 4). As a contrast of their high diversity values, because of their trophic characters, some species typical for high mountain lakes (some Diamesinae, *Heterotrissocladius*, *Micropsectra radialis*, *Paratanytarsus austriacus*, *Pseudodiamesa arctica* and *Prodiamesa olivacea*) couldn't be found in these lakes.

Rosenberg and Resh (1993) described Chironomids as excellent indicators of water quality and noticed that although *C. plumosus* and *C. tentans* are for representative of eutrophic lakes, *Tanytarsus* and *Micropsectra* genera are found mostly in oligotrophic lakes. Brundin (1949), Bryce and Hobart (1972) and Saether mentioned during their studies about indicator species, which determine the trophy conditions of lakes in 1979.

According to the taxa (*Ablabesmyia monilis*, *Procladius (Holotanypus) sp*., *Cricotopus intersectus* group, *Cricotopus sylvestris* group, *Cryptochironomus defectus*) determined in the Lake Ilvat, it can be classified as a clean mountain lake (Rosenberg and Resh,1993, Klink and Moller Pillot, 2003). The Lake Kızılot is was the second richest lake (with 4 taxa). It can be classified as a clean mountain lake in terms of the determined species (*Procladius (Holotanypus) sp*., *Cricotopus flavocinctus*, *Chironomus tentans* group, *Paratanytarsus lauterborni*). The Lake Karın was also one of the richest in terms of species richness (with 4 taxa) and can be classified as a eutrophic lake according to the species found (*Chironomus anthracinus* group, *Chironomus plumosus* group, *Chironomus tentans* group, *Parachironomus* gr *arcuatus*) and their ecological requirements (Bryce and Hobart, 1972). The Lake Dipsiz (Bozkır) was inhabited by three species (*Endochironomus tendens*, *Polypedilum sordens*,

Micropsectra notescens group) and can be classified as a clean lake according to the ecological requirements of the determined species (Bryce and Hobart, 1972, Wiederholm, 1983). The species found in the Lake Kovalı (*Ablabesmyia monilis*, *Glyptotendipes scirpi*, *Chaoborus crystallinus*) suggest classifying it as a eutrophic lake. The Lake Dipsiz (Seydişehir), has also eutrophic character with two species (*Glyptotendipes scirpi*, *Chaoborus flavicans*) (Saether, 1979, Xie *et al*., 1998). The Lake Yeşil is used as a drinking water source for the village close to it. Only one species was found (*Micropsectra junci* group) from the lake. The Lake Sülüklü shows oligotrophic features and one species (*Psectrocladius* (*P*) *sordidellus* group) was found in it (Rieradevall *et al*. 1999). *Chaoborus crystallinus* was found only in the Lake Gavur.

In the Lake Duruca only *C*. *tentans* group was found. In the Lake Susam only *Chironomus* (*Chironomus*) *anthracinus* group was found.

Ablabesmyia is eurytopic and cosmopolitan genus. The larvae inhabit small and large standing and flowing waters in warm, temperate and cold climatic zones. They live in shallow water as well as in deeper parts of lakes (Fittkau and Roback, 1983). *Ablabesmyia* (*A*) *monilis* lives in all kind of standing waters and sporadically in lotic environments, probably in waters with a good oxygen supply (Klink and Moller Pillot, 2003). Species of *Ablabesmyia monilis* is determined at two lakes (Kovalı, Ilvat) and it is observed between 1650- 1890 meters of altitude, 7, 3- 10, 0 of pH, 22,5- 25,5 C^o of heat, 52- 114 μS_{25C^o} of conductance.

Larvae of the majority of *Procladius* species prefer muddy substrata of standing or slowly flowing water bodies, especially ponds and small lakes. A few species also colonize the profundal zone of large, deep lakes (Fittkau and Roback, 1983). The *Procladius* (*Holotanypus*) sp taxon determined from 2 regions (İlvat, Kızılot) and it is observed between 1890-1950 meters of altitude, 9.4-10.1 of pH, 16-25.5 C^o of heat and 52-84 μS_{25C^o} of conductance.

Cricotopus generally inhabits lakes and ponds where submerse vegetation is available. Some of the represents of this genus live on the stones and moss in the rivers while some others live on the muddy bottoms. The subgenus *Cricotopus* is more frequent in lotic habitats in respect of the subgenus *Isocladius,* which is common in standing waters (Hirvenoja, 1973).

Three species were found at the Ilvat and Kızılot lakes and it is observed between 1890-1950 meters of altitude, 9. 4-10. 1 of pH, 16-25.5 C^o of heat and 52-84 μS_{25C^o} of conductance.

Larvae of *Chironomus* graze on detritus or are filter-feeders, predominantly in soft sediments of standing water. A few species are halophilous, or halobiontic. The genus *Chironomus* includes several hundred species and has a worldwide distribution ranging from the tropics to the arctic (Wiederholm, 1983). Three species belong to this genus were found at four localities (Kızılot, Duruca, Karın, Susam) and they were observed between 1950-2070meters of altitude, 8.4-10.7of pH, 15.0-25.5 C° of heat and 65-153 μS_{25C^o} of conductance.

Larvae of *Glyptotendipes* occur in detritus-rich littoral sediments and in Aufwuchs of lakes, ponds, small water bodies and running water (Wiederholm, 1983). *Glyptotendipes* (*Caulochironomus*) *scirpi*, larvae mine in solid plants (Klink and Moller Pillot, 2003).

Species of *Glyptotendipes (Caulochironomus) scirpi* is determined from 2 regions (Dipsiz-Seydişehir, Kovalı) and it is observed between 1600-1650 meters of altitude, 7.3-7.5 of pH, 22.5-25.5 C° of heat, 114-203 μS_{25C^o} of conductance.

Micropsectra spp. have been recorded from a wide range of habitats, including hygropetric situations, thermal springs and temporary pools. They are particularly characteristic of muddy deposits in slack regions of streams and small rivers (rhitron) and of mesotrophic-oligotrophic lakes, including the profundal zone. Many species are cold stenothermic (Wiederholm, 1983). Two species of this genus were found at two localities (Yesil and Dipsiz lakes) and they were observed between 1600-1690 meters of altitude, pH 7.8-8.0, water temperature 11.0-25.5 C° and conductivity 166-202 μS_{25C^o}.

Density of *Chaoborus* spp. is higher in eutrophic than in oligotrophic waters (Xie *et al*., 1998). Two species of this genus were found at three localities (Dipsiz, Kovalı, Gavur) and the min and max values of the lakes, where they were observed, are as follows: altitude (between 1600-1850m), pH (between 6.7-7.5), and water temperature (between 22.5-27.0 C°) and conductivity 72-203 μS_{25C^o}.

The present study may be evaluated as a pioneering research in determining the biological diversity in the Taurus Range, which will contribute to a better understanding of the biodiversity of Turkey and be a resource for future studies of glacier lakes in Turkey.

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