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RELATIONSHIPS BETWEEN CHIRONOMID COMMUNITIES (DIPTERA: CHIRONOMIDAE) AND ENVIRONMENTAL PARAMETERS IN SAZLIDERE STREAM (TURKISH THRACE)

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Abstract. In this study, Sazlidere stream in European part of Turkey was studied from September 1995 to August 1996 to identify chironomid larvae present, determine physicochemical properties of the water, and describe the relationships between species composition of the chironomid communities and environmental parameters. Samplings were made monthly at four different stations of the stream. A total of 57 chironomid taxa was identified and 421 individuals per m^2 were recorded in average. Also, the structure of sediment in each station was revealed to determine the substratum preference of the larvae.

Although chironomids have broad ecological tolerance, it was found only one species, *Procladius* (*Holotanypus*) sp., in station 3. which was determined by the most polluted locality. Results were also supported statistically by Shannon diversity index. Species diversity for chironomid larvae was found to be the highest at 2. station and substratum with mud/detritus had the highest diversity, too.

According to Bray-Curtis index, it was found that stations 1. and 2., seasons spring and winter are the most similar to each other for larval chironomid communities, both in terms of number of species and number of individuals.

Furthermore, Spearman correlation index indicated that the stronger relationships between the distribution of larval chironomid individuals and some environmental variables such as water temperature, pH, DO, BOD, COD, and NO_2^{-1}-N.

Key words: Chironomidae larvae, Species diversity, Sazlidere Stream, Turkish Thrace

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Introduction

Larval period of Chironomidae is the largest in their life cycle. Most larvae are aquatic, and are found in all types of freshwater habitats worldwide owing to their broad ecological tolerance (Freimuth and Bass, 1994; Armitage *et al.*, 1995; Francis, 2004). Under certain conditions, such as low level of dissolved oxygen, larval chironomids may be the only insect present in benthic sediments (Armitage *et al.*, 1995). In many cases chironomid larvae could be very important for benthic biomass. The dynamics (distribution both in terms of species and number of individuals) and biomass production of these larvae may vary in different types of water bodies, in time of year, etc. (Epler, 2001). The abundances and distribution of the taxa are related to current environmental conditions, such as water temperature, conductivity, pH, water clarity, and so forth (Francis, 2004 and references there in; Ozkan and Camur-Elipek, 2006).

Until the present, Kirgiz (1988), Sahin (1991), Kirgiz and Guher (1992), Ozkan and Kirgiz (1995), Sever (1997), Ozkan (2003), Ozkan and Camur-Elipek (2006) discussed the Chironomidae larvae in the European part of Turkey (Turkish Thrace).

Increased number of settlements, industrial factories and agricultural areas around the Sazlidere

Stream (Turkish Thrace) has threatened the quality levels of the water (Anonymous, 1989). This research was carried out to determine the species composition and diversity of Chironomidae larvae of Sazlidere Stream in relation to some environmental features.

Methods

Study Area. The Sazlidere Stream is the left-hand tributary of the Meric River (Maritza, Evros) and never dries out during the summer. The stream is 59 km long and its maximum depth is 80 cm. The bank of Sazlidere is accompanied by macrovegetat-ion consisting of *Phragmites australis*, *Lemna* sp., *Cyperus* sp., *Lipidium* sp. (Secmen and Leblebici, 1991). The stream is characterized by variable habitat structure along its gradient, due to those agricultural areas, settlements and different factories surrounding it and their sewage water pouring into the stream (Anonymous, 1989).

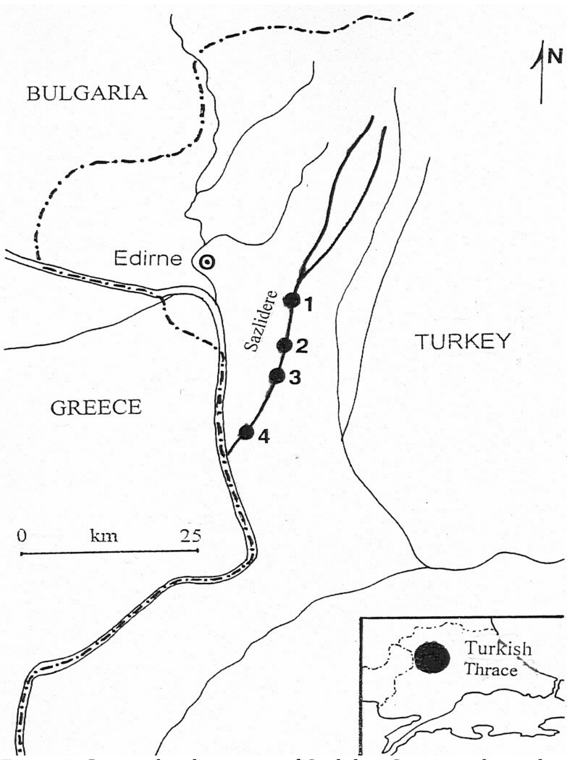

Figure 1. Geographical situation of Sazlidere Stream and sampling stations.

Four characteristic stations were chosen along the stream for sampling in this study (Figure 1): Station 1: Near the Iskender Village. There is no factory around this location. Sewage water does not reach the stream from settlements at this location; Station 2: About 50 meters ahead of a sewage inflow of a textile factory; Station 3: About 100 meters ahead of a sewage inflow of a paper factory. There are a lot of agricultural areas and settlements around this location; Station 4: About 200 meters from the mouth to the Meric River. There is no factory around this location.

Sampling. The sampling stations were sampled monthly from September 1995 to August 1996 to determine the composition of the chironomid larvae and the physicochemical features of the water. In February 1996, sampling could not be made because of excessive rain.

Sediment samples were taken with the help of an Ekman dredge (15×15 cm^2) and washed through a 0.5 mm mesh net. The remaining Chironomidae larvae were kept in plastic bottles preserved in 70% ethanol. Also, the structure of sediment was recorded in each station to determine the preference of the larvae. In the laboratory, samples were examined by preparing temporary (using a glycerine-water (1:5) solution) or permanent preparations (using Canada balsam). Chironomid larvae were identified at the lowest possible taxonomic level using the following works: Chernovskij (1961), Fittkau (1962), Beck and Beck (1969), Bryce and Hobart (1972), Sæther (1977), Moller-Pillot (1978-1979, 1984), Sahin (1984, 1987, 1991), Fittkau and Roback (1983), Sahin *et al.* (1988), Armitage *et al.* (1995), and Epler (2001).

While some physicochemical parameters including water temperature, conductivity, and pH were measured in surface water (using ordinary thermometer, Jenway 3040 mark ion analyser, and WPA CM35 mark conductivity meter, respectively) at the time of the sampling of benthos, water samples taken by Ruttner water sampler were carried to the laboratory to measure the other parameters including dissolved oxygen, biological and chemical oxygen demands, Ca^{+2}, Mg^{+2}, Cl^{-1}, NO_3^{-1}-N, NO_2^{-1}-N, $PO4^{-3}$, and Cr^{+6}. Some classical titration methods and spectrophotometer were used to determine the above parameters (Egemen and Sunlu, 1999). Quality grades of the water at the sampling sites were determined using SKKY (2004).

Statistical Analysis. Data belonging to chironomid larvae were also evaluated statistically. Shannon diversity index and Bray-Curtis similarity index were computed (Krebs, 1999). Relationships between the distribution of chironomid larvae and environmental variables were determined using Spearman correlation in SPSS 9.0 for windows.

Results and Discussion

A total of 57 chironomid taxa was collected in Sazlidere stream during this study. The average number of chironomid larvae was 421 ind./m^2. Thirty five species were found in muddy/detritus-rich substratum (MD), 33 species in sandy (S), 23 species in sandy/muddy (SM), 18 species in muddy (M), and 8 species in all substratum types (A) (Table 1).

At all the stations considerable differences were observed in the composition of chironomid communities. Station 2. was found to be having the highest number of taxa followed by stations 1. and 4., respectively. On the other hand, only one taxon,

Table-1. Distribution of Chironomidae species in Sazlidere Stream according to the stations, seasons and the substratum types of the habitats.

	1st station	2nd station	3rd station	4th station	Spring	Summer	Autumn	Winter	Sand	Mud	Sand/Mud	Mud/Detritus	Average	Abundance
Camptochironomus tentans (Fabricius, 1805)	16	-	-	126	-	126	16	-	16	-	126	-	36	8.6%
Chaetocladius sp.	6	2	-	-	2	-	-	6	6	-	-	2	2	0.5%
Chironomus anthracinus Zetterstedt, 1860	110	28	-	8	42	80	16	6	78	30	12	26	36	8.6%
Chironomus aprilinus Meigen, 1830	12	4	-	10	-	16	8	2	12	-	12	2	6	1.4%
Chironomus plumosus (Linnaeus, 1758)	4	-	-	110	-	110	4	-	4	-	109	-	28	6.7%
Chironomus riparius Meigen, 1804	-	-	-	4	-	4	-	-	-	-	4	-	1	0.2%
Chironomus sp.-1	40	32	-	8	18	32	12	18	26	16	22	16	20	4.8%
Chironomus sp.-2	8	-	-	28	-	34	2	-	8	-	28	-	9	2.2%
Cladotanytarsus mancus Walker,1856	92	-	-	-	2	38	52	-	89	2	-	-	23	5.5%
Clinotanypus pinguis (Loew,1861)	10	-	-	-	-	-	-	10	2	8	-	-	2	0.5%
Cricotopus albiforceps (Kieffer,1916)	4	-	-	-	-	-	2	2	2	2	-	-	1	0.2%
Cricotopus bicinctus (Meigen, 1818)	8	-	-	4	8	2	-	2	2	-	10	-	3	0.7%
Cricotopus fuscus (Kieffer,1909)	2	-	-	-	-	-	2	-	2	-	-	-	1	0.2%
Cricotopus sylvestris (Fabricius, 1794)	4	2	-	2	2	2	4	-	4	-	2	2	2	0.5%
Cricotopus vierriensis Goetghebuer, 1835	-	2	-	-	2	-	-	-	-	-	-	2	1	0.2%
Cryptochironomus defectus (Kieffer, 1913)	6	4	-	-	4	4	2	-	6	-	-	4	2	0.5%
Cryptochironomus sp.	-	2	-	2	-	4	-	-	-	2	2	-	1	0.2%
Dicrotendipes nervosus (Staeger, 1839)	2	-	-	2	-	2	2	-	2	-	2	-	1	0.2%
Diplocladius cultriger Kieffer, 1908	-	2	-	-	-	-	-	2	-	-	-	2	1	0.2%
Einfeldia pagana (Meigen, 1838)	-	2	-	-	-	-	-	2	-	-	-	2	1	0.2%
Hydrobaenus pilipes (Malloch, 1915)	-	2	-	-	2	-	-	-	-	-	-	2	1	0.2%
Macropelopia sp	2	-	-	-	2	-	-	-	-	-	-	2	1	0.2%
Micropsectra sp.-1	-	4	-	-	4	-	-	-	-	-	-	4	1	0.2%
Micropsectra sp.-2	-	4	-	-	4	-	-	-	-	-	-	4	1	0.2%
Microtendipes chloris (Meigen, 1818)	26	22	-	-	26	-	4	18	16	8	2	22	12	2.9%
Monopelopia tenuicalcar (Kieffer, 1918)	2	-	-	-	-	-	2	-	2	-	-	-	1	0.2%
Paracladius conversus (Walker, 1856)	4	18	-	-	16	2	-	4	2	2	-	18	5	1.3%
Paralauterborniella nigrohalteralis (Malloch, 1915)	4	-	-	-	2	-	2	-	2	2	-	-	1	0.2%
Paratanytarsus lauterborni (Kieffer, 1909)	2	-	-	-	-	-	2	-	2	-	-	-	1	0.2%
Paratendipes albimanus (Meigen, 1818)	-	2	-	-	2	-	-	-	-	-	-	2	1	0.2%
Paratendipes nubilus (Meigen, 1830)	2	-	-	2	-	-	-	4	4	-	-	-	1	0.2%
Paratendipes sp.	-	-	-	2	2	-	-	-	-	-	2	-	1	0.2%
Paratrissocladius excerptus (Walker, 1856)	-	4	-	-	4	-	-	-	-	-	-	4	1	0.2%
Paratrichocladius rufiventris (Meigen, 1830)	4	-	-	-	-	-	-	4	4	-	-	-	1	0.2%
Polypedilum convictum (Walker, 1856)	8	8	-	4	10	6	2	2	4	4	4	8	5	1.3%
Polypedilum exsectum (Kieffer, 1916)	-	12	-	-	4	-	8	-	-	-	-	12	3	0.7%
Polypedilum nubeculosum (Meigen, 1804)	-	28	-	8	18	6	-	12	-	-	12	24	9	2.2%
Polypedilum nubifer (Skuse, 1889)	36	4	-	42	2	48	32	-	36	2	42	2	20	4.8%
Polypedilum pedestre (Meigen, 1830)	4	2	-	-	2	-	-	4	4	-	-	2	1	0.2%
Polypedilum scalaenum (Schrank, 1803)	6	-	-	2	-	6	2	-	6	-	2	-	2	0.5%
Polypedilum sp.	4	-	-	-	2	-	2	-	2	-	2	-	1	0.2%
Potthastia gaedii (Meigen, 1838)	4	-	-	-	4	-	-	-	-	-	4	-	1	0.2%
Prodiamesa olivacea (Meigen, 1818)	14	50	-	-	50	2	-	12	12	2	4	46	16	3.8%
Procladius (Holotanypus) sp.	93	65	4	-	42	2	80	40	93	2	6	61	41	9.7%
Psectrocladius barbimanus (Edwards, 1929)	-	2	-	-	2	-	-	-	-	-	-	2	1	0.2%

Table 1. Continued

	1^{st} station	2^{nd} station	3^{rd} station	4^{th} station	Spring	Summer	Autumn	Winter	Sand	Mud	Sand/Mud	Mud/Detritus	Average	Abundance
Psectrocladius calcaratus (Edwards, 1929)	-	22	-	-	22	-	-	-	-	-	-	22	5	1.3%
Psectrocladius limbatellus (Holmgren, 1869)	-	8	-	-	8	-	-	-	-	-	-	8	2	0.5%
Psectrotanypus varius (Fabricius, 1787)	-	2	-	-	-	-	2	-	-	-	-	2	1	0.2%
Rheotanytarsus sp.	-	6	-	-	6	-	-	-	-	-	-	6	1	0.2%
Robackia demeijerei (Kruseman, 1933)	-	2	-	-	-	2	-	-	-	2	-	-	1	0.2%
Smittia sp.	-	2	-	4	2	-	4	-	-	4	-	2	1	0.2%
Stictochironomus sp.	254	14	-	-	44	82	92	50	174	80	-	14	67	16%
Tanypus punctipennis Meigen, 1818	44	2	-	-	4	16	20	6	40	4	-	2	11	2.6%
Tanytarsus gregarius Kieffer, 1909	14	36	-	2	34	2	12	4	15	4	2	32	13	3.1%
Tanytarsus sp.	-	10	-	-	10	-	-	-	-	-	-	10	2	0.5%
Thienemannimyia geijskesi (Goetghebuer, 1834)	-	23	-	-	23	-	-	-	-	-	-	23	5	1.3%
Virgotanytarsus sp.	22	-	-	2	-	12	12	-	22	-	2	-	6	1.4%
Total number of individuals	873	434	4	372	433	640	400	210	699	176	413	394	421	
Number of taxa	35	36	1	20	37	25	28	21	33	18	23	35	57	
Shannon H'	2.57	2.98	0.00	1.93	3.02	2.44	2.50	2.49	2.58	1.96	2.15	2.98		

Procladius (*Holotanypus*) sp., was found on station 3. which receives sewage water from a paper factory and has a substratum with only mud and brownish-black colour of water. Since this species has some morphological adaptations that serve to enhance the absorption and transportation of the dissolved oxygen from the water-sediment interphase (Juarez-Flores and Ibanez-Aguirre, 2003), it may tolerate the low oxygen level of the water.

The most abundant taxa in average were *Stictochironomus* sp., *Procladius* (*Holotanypus*) sp., *Chironomus anthracinus*, and *Camptochironomus tentans*, comprising 16%, 9.7%, 8.6%, and 8.6% of the total specimens, respectively (Table 1). Furthermore, *Stictochironomus* sp. is the most abundant species in station 1. followed by *Chironomus anthracinus*, *Procladius* (*Holotanypus*) sp., and *Cladotanytarsus mancus*, respectively (Table 1). *Procladius* (*Holotanypus*) sp. is the most abundant species in station 2. while *Camptochironomus tentans* is the most abundant species in station 4. (Table 1).

It was found that the abundance of chironomid larvae was very high on station 1. (total number of individuals is 873 per m^2) while station 3. was found to be the poorest (total number of individuals is 4 per m^2) (Table 1). According to Shannon diversity index, station 2. was determined to have the highest diversity while station 3. was the least diverse (Table 1).

Remarkable seasonal changes were also detected in the distribution of chironomid larvae (Table 1). The greatest individual numbers were observed in summer whereas they decreased during winter. The most diverse season was spring when alltogether 37 taxa occurred (Table 1).

Results of the Bray-Curtis similarity index show that stations 1. and 2. are the most similar (33% similarity) whereas stations 3. and 4. are the most different from each other (0% similarity) in terms of compositions of larval Chironomidae species. Results of the Bray-Curtis similarity index also showed that the composition of the larvae in seasons spring and winter were the most similar (53% similarity) whereas summer and winter were the most different from each other (23% similarity) (Table 2).

Table-2. Bray-Curtis similarity index results of stations and seasons for larval chironomid specimens (both in terms of number of species and number of individuals).

Proportions of the Similarities for sampling stations

	2nd station	3rd station	4th station
1st station	33,8 %	0,9 %	17,6 %
2nd station	*	1,8 %	10,9 %
3rd station	*	*	0 %

Proportions of the similarities for sampling seasons

	Summer	Autmn	Winter
Spring	26,1 %	36,9 %	52,9 %
Summer	*	48,5 %	23,5 %
Autmn	*	*	41,9 %

It was observed that the substratum type with mud-detritus is the most preferred for chironomid larvae whereas only mud is the least preferred substratum type. Shannon index has also supported these results (Table 1). Furthermore, only five species (*Cricotopus fuscus*, *Monopelopia tenuicalcar*, *Paratanytarsus lauterborni*, *Paratendipes*

Table 3. Physicochemical conditions of Sazlidere Stream during the investigatigation (D.O.: dissolved oxygen; BOD5: Biological Oxygen demand; COD: Chemical Oxygen demand; WT: water temperature; st.:station).

	Conductivity (μS cm^{-1})	pH	D.O. (mg L^{-1})	BOD5 (mg L^{-1})	COD (mg L^{-1})	Ca^{+2} (mg L^{-1})	Mg^{+2} (mg L^{-1})	Cl^{-1} (mg L^{-1})	$NO_3^{-1}N$ (mg L^{-1})	$NO_2^{-1}N$ (mg L^{-1})	PO_4^{-3} (mg L^{-1})	Cr^{+6} (μg L^{-1})	WT (°C)
Sep.	362	6.0	1.9	0.8	604	129	18	117	33	0.2	0.05	0.37	21
Oct.	282	6.8	2.7	1.4	500	133	34	179	31	0.7	0.15	1.08	13
Nov.	260	7.0	3.0	1.6	495	121	29	200	5	0.2	0.10	0.35	13
Dec.	122	7.5	5.5	2.9	581	109	25	115	6	0.3	0.14	0.46	8
Jan.	207	7.6	8.8	3.4	882	99	32	159	16	0.5	0.11	0.99	3
Mar.	162	7.4	11.4	5.4	140	94	33	132	19	0.2	0.08	0.15	5
Apr.	218	7.2	6.9	3.4	95	78	36	138	13	0.1	0.02	0.01	14
May	332	7.0	2.7	1.3	112	86	14	121	7	0.2	0.04	0.05	20
Jun.	477	6.7	2.7	1.3	365	70	13	130	9	0.2	0.06	0.15	19
Jul.	505	6.7	2.3	1.6	1958	105	21	270	17	0.8	0.16	1.33	26
Aug.	494	6.8	1.8	0.9	922	85	18	203	9	0.3	0.07	0.03	27
1st st.	208	6.8	5.9	1.5	215	78	25	123	15	0.07	0.02	0.03	13
2nd st.	312	7.2	5.9	3.4	191	70	23	168	10	0.13	0.03	0.08	14.5
3rd st.	421	7.0	3.2	2.2	1923	162	28	219	27	0.98	0.22	1.53	18.5
4th st.	303	6.9	3.8	1.9	327	93	21	132	9	0.25	0.07	0.33	16

nubilus, *Paratrissocladius rufiventris*) were found in sandy substratum; and only two species (*Chironomus riparius*, *Potthastia gaedii*) in sand/mud substratum. A total of 15 species inhabited mud/detritus substratum and only one species (*Robackia demeijerei*) was found in mud substratum (Table 1).

The physicochemical parameters that were measured during this study are summarized in Table 3. In Sazlidere Stream BOD, PO_4^{-3} and water temperature were found at first quality level whereas COD, NO_2^{-1}-N, Cr^{+6} were found at fourth quality (SKKY, 2004). Chloride and pH were found of second quality level while dissolved oxygen and NO_3^{-1}-N were between second and fourth quality levels (SKKY, 2004). Calcium, Magnesium and conductivity were at normal levels.

Spearman rank correlation was used for stations separately because each stations were considerably different from each other in the composition of the larvae. Results showed that pH, DO, BOD, and water temperature influence the abundance of larval chironomid fauna in station 3. ($r= +0.61$, $r= +0.66$, $r= +0.62$, and $r= –0.67$ at $p<0.05$, respectively). Significant positive correlations were also found between the number of chironomid larvae and some chemical variables (COD and NO_2-N) at station 4. ($r=+0.66$, $r=+0.70$ at $p<0.05$, respectively) whereas significant negative correlations were found between the number of the larvae and pH, DO, and BOD at station 1. ($r= –0.60$, $r= –0.63$ at $p<0.05$, and $r= –0.75$ at $p<0.01$, respectively). The correlations between the number of larvae and the other parameters were determined not significant statistically.

If this study is compared to that performed by Kirgiz and Guher (1992) in Sazlidere Stream, the difference is that they considered all the Chironomidae larvae as a single group. They collected 515 Chironomidae larvae per m^2 in the average of total chironomid fauna, but they did not carry out the taxonomic identification of the chironomid larvae. An average individual number of 421 larvae per m^2 which was found during present study showed a certain decrease in larval chironomids in Sazlidere between the years 1992 and 1996.

Waste water of settlements, industrial factories and agricultural areas around the stream, which can effect qualitative and quantitative distributions of the larvae, are potential danger for the stream and the other water sources which are fed by Sazlidere. Consequently, it can be suggested that limnological studies must be performed periodically in Sazlidere to predict the future of the stream and its aquatic fauna.

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