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ORIGINAL PAPER

Hirudinea (Annelida) species and their ecological preferences in some running waters and lakes

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Abstract The Hirudinea species were collected from various running waters and lakes in Turkey. The sampling sites were located on Yeşilırmak River, streams in Yedigöller National Park, Büyük Menderes River, Lake Beyşehir, Lake Işıklı, Karamuk Marsh and Karadut Spring of Acıgöl Lake. Recorded species were evaluated with physicochemical variables such as temperature, pH, dissolved oxygen, conductivity, nitrite nitrogen, nitrate nitrogen, ammonium nitrogen, orthophosphate phosphorus and substratum structure. In this study, eight Hirudinea species were determined. These are *Helobdella stagnalis*, *Erpobdella octoculata, Erpobdella testacea, Erpobdella vilnensis, Dina stschegolewi*, *Hirudo verbana, Limnatis nilotica*, *Haemopis sanguisuga*. The relationships between leech species and water quality variables were assessed with canonical correspondence analysis. The results show that leech species which are found in the present study are able to live in different saprobic levels in streams and trophic levels in lakes, but they usually prefer polluted environments. Knowledge of ecological characteristics of leech species must be improved to use them in water quality assessment much more effectively.

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Introduction

The class Hirudinea in phylum Annelida has a very wide ecological range; therefore, according to Neubert and Nesemann (1999), “they should not be used as major indicator organisms in biomonitoring of aquatic ecosystems”. Furthermore, their abundance is very low in running waters; hence, the evaluation of pollution level of running waters is not correct by using “only” leech species (Sládecek and Košel 1984). At the beginning of twentieth century, only few leech species were used as indicators of sabrobic conditions by Kolkwitz and Marsson (1902, 1909 cited in Sládecek and Košel 1984, p. 453). Grosser et al. (2001) constituted Hirudinea indication model via using indicator levels of species. Today, many leech species are used as indicator for survey of assessing moderately (Koperski 2005) or heavily polluted environments in biological assessment of freshwaters.

Leeches have special importance in ecological studies because they are hosts of some parasites (Koval’chuk and Chernaya 2003). They are invertebrate predators, and they are also an important component of the food chain in freshwater ecosystems (Sket and Trontelj 2008). Metcalfe et al. (1988) determined that bioaccumulation in Hirudinea is higher than in other benthic groups and also higher than in fish in industrially polluted running waters hence Hirudinea species can have a part to monitor organic contaminants. Macova et al. (2009) also carried out a study on polychlorinated biphenyl which accumulates in animal tissues and indicated that genus *Erpobdella* is a good sensor indicator of polychlorinated biphenyl contamination in rivers.

There are several factors affecting the distribution of leeches. Mann (1962) indicated that the availability of suitable hosts is the major factor for distribution and abundance of the blood-sucking species. The distribution of aquatic leeches also depends on the physical and the chemical characteristics of the water (Mann 1962). Availability of food organisms, substrate, depth of the water, water current, size and nature of the water body, hardness, pH and temperature of water, minimum concentration of dissolved oxygen, siltation, turbidity and salinity of the water are the most important factors affecting distribution of leeches (Sawyer 1974). Koval'chuk and Chernaya (2003) have studied in Middle Urals and determined that the size and the geographic location of the water body affect species and ecological diversity of leeches. Koperski (2006) tested whether type of environment, size of environment, geographical location, presence of fish predation, sampling season and level of eutrophication and degradation of aquatic ecosystems affect the distribution of leeches in Poland; he concluded that geographic regions, habitat size and collecting season do not affect the occurrence or the percentages of leeches.

While many leech species prefer beta-mesosaprobic and alpha-mesosaprobic environments, a few species live in oligosaprobic habitats. Neubert and Nesemann (1999) determined that Hirudinea can be used for longitudinal zonation of running waters; from epirhithron to the potamon diversity of leeches can increase. Hirudinea species are the constituents of benthic macroinvertebrate communities, and benthic macroinvertebrate communities are valuable tools for the evaluation of ecological quality of aquatic ecosystems (Rosenberg and Resh 1993). Composition and abundance of benthic macroinvertebrate fauna are used as biological quality elements for classification of ecological status of surface water in Water Framework Directive (WFD). Knowledge about Hirudinea species and their habitat preferences are inadequate for using them in biomonitoring studies with other components of benthic macroinvertebrates. In this process, determining ecological preferences of Hirudinea species is vital to apply WFD criteria. Hence, data of fauna, distribution, ecology and relationships with habitat quality of Hirudinea species in different regions should be collected and should be linked to ecological quality monitoring of aquatic ecosystems.

The aim of this study were to (1) contribute to the knowledge of Hirudinea species and biodiversity which inhabit in aquatic ecosystems of Turkey, (2) determine the relationships between some water quality variables and Hirudinea species found from some running waters (streams in Yedigöller National Park—June 2007 and June 2008, Yeşilırmak River—July 2008, Büyük Menderes River—1998–1999, Karadut Spring of Acıgöl—March 1993) and lakes (Lake Işıklı—August 1993, Karamuk Marsh—July 1997 and Lake Beyşehir—July 1995) and (3) provide usage of Hirudinea species which are components of benthic macroinvertebrate fauna in implementation of WFD criteria.

Materials and methods

The samples were collected from the streams in Yedigöller National Park in June 2007 and in June 2008, from Yesilırmak River in July 2008, from Büyük Menderes River monthly during 1998–1999 and from Karadut Spring of Acıgöl in March 1993. The lake samples were collected in Lake Işıklı in August 1993, Karamuk Marsh in July 1997 and Lake Beyşehir in July 1995. Leeches were collected by hand and by using an Ekman bottom sampler. The leeches were preserved in 80 % ethyl alcohol after they were kept in 20 % ethyl alcohol and were rinsed with water.

In Yeşilırmak River, Hirudinea species were found only in Yeşilırmak-1 (YI-1), Yeşilırmak-2 (YI-2), Yeşilırmak-3 (YI-3) and Yeşilırmak-13 (YI-13). In streams of Yedigöller National Park, 10 stations were sampled; Hirudinea species were found only in Yedigöller-2 (YG-2) and Yedigöller-10 (YG-10). In Büyük Menderes River, 17 stations were sampled; Hirudinea species were found in Büyük Menderes-2 (BM-2), Büyük Menderes-6 (BM-6), Büyük Menderes-8 (BM-8) and Büyük Menderes-12 (BM-12). Hirudinea species were also found in Karadut Spring of Lake Acıgöl (KS), Lake Işıklı (LI), Lake Beyşehir (LB) and Karamuk Marsh (KM). Temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), nitrate nitrogen (NO_3), nitrite nitrogen (NO_2), ammonium nitrogen (NH_4) and orthophosphate phosphorus (PO_4) were measured for all of the stations.

Temperature, pH, conductivity and dissolved oxygen (DO) were measured with YSI 556 multiprobe system; nitrite, nitrate, ammonium, orthophosphate were measured with Hach DR/890 Datalogging Colorimeter in Yeşilırmak River and streams in Yedigöller National Park. Spectrophotometer (Hach DR 2000), oxygen meter (Oxi 96/B set WTW), Ruttner water sampler (Hydrobios) were used in Büyük Menderes River, Lake Işıklı, Lake Beyşehir, Karamuk Marsh and Karadut Spring of Lake Acıgöl. Different references were used for physicochemical variables (Kazanci et al. 1996, 1998, 1999; Dügel 2001; Dügel and Kazanci 2004; Türkmen 2008). Leica Zoom 2000 stereo

Table 1 Geological characteristics which are required by WFD System A, physical and chemical characteristics of some running waters in Turkey

Variables	YI-1	YI-2	YI-3	YI-13	YG-2	YG-10	BM-2	BM-6	BM-8	BM-12	Karadut S.
Date	14.07.2008	15.07.2008	15.07.2008	25.07.2008	03.06.2007	03.06.2007	20.11.1998	07.09.1999	16.08.1999	14.07.1998	03.1993
Altitude (m) (System A)	407 (mid-altitude)	340 (mid-altitude)	280 (mid-altitude)	247 (mid-altitude)	900 (high altitude)	900 (high altitude)	26 (lowland)	855 (high altitude)	237 (mid-altitude)	802 (high altitude)	842 (–)
Catchment area (km^2) (System A)	38,000 (very large)	38,000 (very large)	38,000 (very large)	38,000 (very large)	20 (small)	20 (small)	24,873 (very large)	24,873 (very large)	24,873 (very large)	24,873 (very large)	–
Geology (System A)	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous	–
Temp (°C)	21.00	21.52	23.34	28.37	21.30	17.50	20.8	13.40	18.90	19.60	21.4
DO (mg/l)	8.15	3.11	6.71	6.12	7.27	6.98	7.31	9.55	6.02	7.20	3.7
pH	8.15	7.87	8.23	8.42	7.96	7.95	7.60	7.83	8.31	8.05	6.6
Conductivity[a] (mS/cm)	0.583	0.723	0.732	0.778	0.540	0.364	0.534	0.817	1.054	0.517	4.005
Orthophosphate phosphorus (mg/l)	0.222	0.378	0.391	0.388	0.550	0.080	0.207	0.071	0.918	0.030	0.000
Nitrate nitrogen (mg/l)	0.294	0.000	0.294	0.045	1.400	0.500	0.005	0.021	0.032	0.008	0.000
Nitrite nitrogen (mg/l)	0.030	0.073	0.081	0.039	1.524	0.018	0.021	0.051	1.047	0.005	0.000
Ammonium nitrogen (mg/l)	0.000	0.465	0.271	0.039	0.069	0.302	0.060	0.090	2.660	0.120	0.000
Substratum	60 % rock and stone, 30 % gravel, 10 % sand	80 % stone, 20 % sand	80 % stone, 20 % sand	20 % stone, 40 % gravel, 40 % sand	20 % gravel, 80 % sand	10 % stone, 50 % gravel, 40 % sand	40 % sand, 30 % stone, 30 % silt	50 % sand, 50 % silt	50 % sand, 50 % silt	60 % silt, 20 % sand, 20 % rock	80 % stone, 10 % sand, 10 % silt

[a] Values in 25°

Table 2 Geological characteristics which are required by WFD System A and physical characteristics of some lakes in Turkey

Variables	Lake Işıklı Summer period	Karamuk Marsh Summer period	Lake Beyşehir Summer period
Date	July 1993	July 1997	July 1995
Altitude (m) (System A)	814 (high)	1008 (high)	1121 (high)
Surface area (km^2) (System A)	64 (10–100 km^2)	37 (10–100 km^2)	656 (>100 km^2)
Mean depth (m) (System A)	7 (3–15 m)	1.5 (<3 m)	10 (3–15 m)
Geology (km^2) (System A)	Siliceous	Siliceous	Siliceous
Temperature (°C)	22.9	28	22
DO (mg/l)	6.3	6.9	5.4
pH	8.78	7.56	7.5
Conductivity[a] (mS/cm)	0.355	2.86	0.5
Orthophosphate phosphorus (mg/l)	0.000	0.0006	0.000
Nitrate nitrogen (mg/l)	0.000	0.000	0.011
Nitrite nitrogen (mg/l)	0.000	0.000	0.000
Ammonium nitrogen (mg/l)	0.300	0.085	0.045

[a] Values in 25 °C

microscope was used for the identification of species. Different keys were used for systematic analysis (Mann 1962; Bennike 1965; Elliot and Mann 1979; Neubert and Nesemann 1999).

Some physical characteristics of running waters (altitude, catchment area and geology) and lakes (altitude, mean depth, surface area and geology) were given according to Water Framework Directive System A (Council of European Communities 2000) (Tables 1 and 2).

Relationships between Hirudinea species and water quality variables were explored by canonical correspondence analysis (CCA; ter Braak 1988) (Fig. 1). Order of significance of environmental variables was found like with the given order: EC, NO_3-N, pH, NH_4-N, PO_4-P, DO, NO_2-N, temperature.

Results and discussion

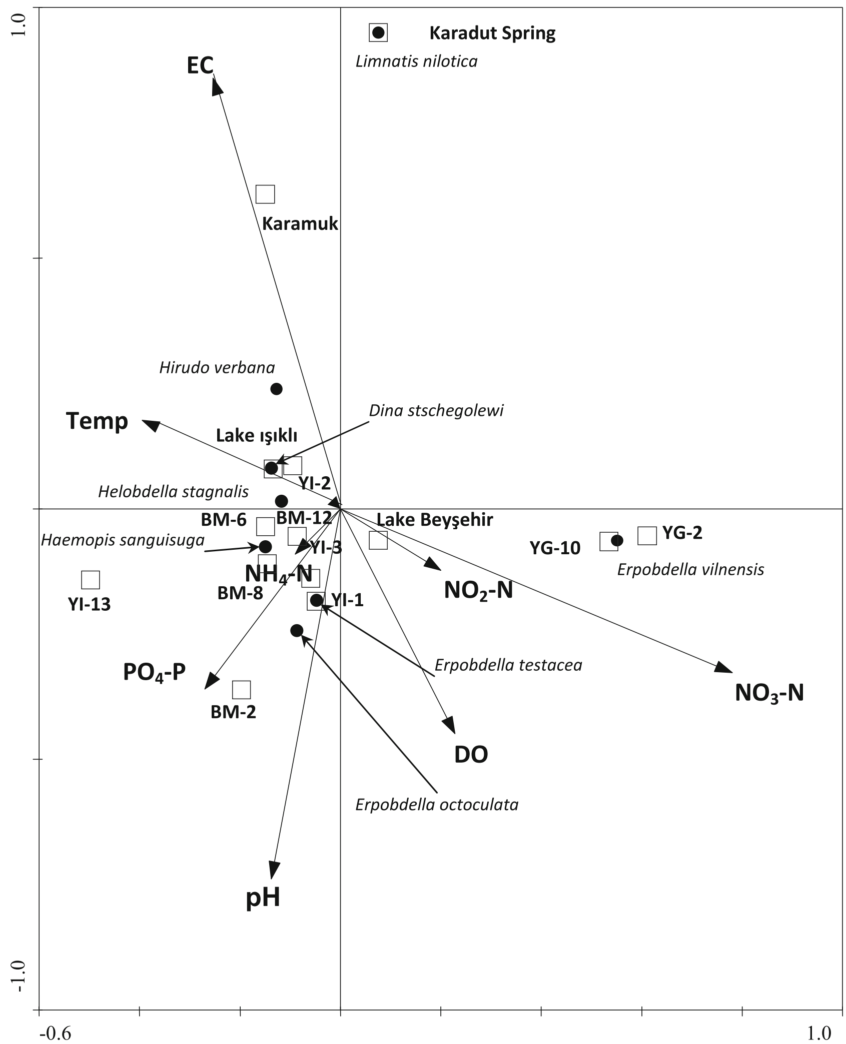
In this study, *Helobdella stagnalis* (Linnaeus 1758), *Erpobdella octoculata* (Linnaeus 1758), *Erpobdella testacea* (Savigny 1822), *Erpobdella vilnensis* (Liskiewicz 1925), *Haemopis sanguisuga* (Linnaeus 1758), *Hirudo verbana* Carena 1820, *Dina stschegolewi* (Lukin & Epshtein 1960), *Limnatis nilotica* (Savigny 1822) were determined in some running waters and lakes in Turkey. Ecological preferences of these leech species in the literature were given, and they were compared with the results of this study.

The species placed in quadrant A were positively correlated with temperature and electrical conductivity. Quadrant A includes *H. stagnalis, H. verbana* and *D. stschegolewi.*

Helobdella stagnalis is generally found in alpha-mesosaprobic environments, and it is occasionally found in beta-mesosaprobic and polysaprobic environments (Nesemann and Moog 1995), but there is a record which shows that it is able to live in all suitable habitats (Neubert and Nesemann 1999). Tavzes et al. (2006) reported *H. stagnalis* from the moderately polluted sites of urbanized small Glinščica stream, and Bubinas and Jagminienë (2002) found this species from slightly polluted Neris River. Kelly-Quinn et al. (2003) also found *H. stagnalis* in Caher River with high water quality and high ecological status. Agapow et al. (2006) recorded this species from Lubiatowskie Lakes in Poland with moderate and low water quality.

Helobdella stagnalis prefers hyporhithral, epipotamal, metapotamal and littoral zones and also prefers metarhithral and hypopotamal zones of running waters (Nesemann and Moog 1995). In this study, *H. stagnalis* was found in YI-1 (alpha-mesosaprobic), YI-2 (alpha-mesosaprobic), YI-3 (alpha-mesosaprobic), YI-13 (alpha-mesosaprobic), BM-6 (alpha-mesosaprobic), BM-12 (oligo/beta-mesosaprobic) and Lake Beyşehir (mesotrophic/eutrophic). YI-1, YI-2, YI-3 and YI-13 are placed in epipotamal zones of running waters where temperature values are higher. The substratum of YI-1 station consists of rock, stone, gravel and some sand, the substratum of YI-2 station contains stone and sand, the substratum of YI-3 station contains stone and sand, too, the substratum of YI-13 station includes mud and sand. Their altitudes are 407, 340, 280 and 247 m, respectively. BM-6 and BM-12 are placed in epirhithral and epipotamal zones of Büyük Menderes River, respectively. The bottom of BM-

Fig. 1 CCA diagram with selected water quality variables and leech species



6 station is muddy and sandy; the bottom of the BM-12 is muddy, but there are big rocks in this station. Altitudes of these stations are 855 and 802 m, respectively. Temperature varies along the length of the running waters (Hynes 1971), and the running waters in low altitude have high temperatures when compared to high altitude in the same valley. According to the CCA table, occurrence of *H. stagnalis* seems to be correlated with temperature and ammonium. Tillman and Barnes (1973) also reported that life cycle of *H. stagnalis* depends on temperature. Grosser et al. (2001) recorded that this species from alpha-mesosaprobic running waters in Germany. According to Mann (1955), *H. stagnalis* occurs most abundantly in hard, eutrophic lakes and ponds. The stations where *H. stagnalis* was found are generally in potamal zones of running waters in the present study, but there are some records showing that *H. stagnalis* is found in cold running waters of high mountainous regions (e.g., Grosser and Pešic 2006).

Hirudo verbana's ecological preferences are not known exactly because it has been confused with *Hirudo medicinalis* for years. *H. verbana* was considered as a variant of *H. medicinalis* (Kutschera 2007). The confusion about species of genus *Hirudo* arose from the fact that some authors did not take developments of leech's systematic into account (Utevsky et al. 2010). According to Utevsky et al. (2010), the species of genus *Hirudo* was exported from Turkey for medicinal request was thought to be *H. medicinalis*, but it was *H. verbana*. Most of the ecological information on medicinal leeches (*H. medicinalis*, *H. verbana* etc.) is based on laboratory studies, and there is only little information about them in their habitat (Elliot and Kutschera 2011). Kazanci et al. (2009) determined that *H. verbana* can live in alpha-mesosaprobic environments in running waters and in oligotrophic, mesotrophic, eutrophic and polytrophic lakes in Turkey.

Utevsky et al. (2010) reported that *H. verbana* prefers steppe region and specimens also prefer stagnant and shallow waters with submerged and emergent vegetation cover and they appear to tolerate arid conditions. In the present study, *H. verbana* was found in YI-2 (alpha-mesosaprobic), Lake Işıklı (oligotrophic–eutrophic) and Karamuk Marsh (mesotrophic–polytrophic). Lake Işıklı and Karamuk Marsh are located in steppe region; YI-2 is located near the steppe region, but it is near moist arboreal region.

The accurate distribution of *H. verbana* and its risk status are not known yet. Furthermore, there is not any legal protection for *H. verbana* in countries where they inhabit naturally (Elliot and Kutschera 2011). Although the conservation status still continues for *H. medicinalis* after they were separated from each other, any protective legislation has not been established for *H. verbana* (Trontelj et al. 2004). Ecological information about *H. medicinalis* and its closely-related species *H. verbana* in the wild is limited. The decline in suitable hosts in natural habitats threatens the population of these species. Number of small wetlands and shallow ponds has declined like the other European countries (Trontelj et al. 2004) and this scarcity affects the organisms which live naturally in these habitats. To conserve these species, knowledge about their natural habitats and ecological preferences of species is very important (Elliot and Kutschera 2011).

Dina stschegolewi is generally found in beta-mesosaprobic environments and is occasionally found in oligosaprobic environments (Nesemann and Moog 1995) and it is able to live in alpha-mesosaprobic environments (Kazanci et al. 2009). This species was found only in YI-2 (alpha-mesosaprobic) in this study.

Limnatis nilotica is placed in quadrant B. It was negatively correlated with pH, orthophosphate and ammonium while it was positively correlated with EC and temperature. This species inhabits in small stagnant or slow flowing running waters, lakes and springs (Neubert and Nesemann 1999). Bromley (1994) described the habitats of *L. nilotica* as springs, wells, water-troughs, small streams, ponds, ditches and reservoirs where mammals and/or frogs can be observed. *L. nilotica* is generally found in oligosaprobic environments and it is occasionally found in beta-mesosaprobic and xenosaprobic environments (Nesemann and Moog 1995). In this study, *L. nilotica* was found in Karadut Spring inflowing to Lake Acıgöl which has very high electrical conductivity with beta-mesosaprobic characteristics according to the criteria of Republic of Turkey Ministry of Environment and Forestry (2004). Karadut Spring of Lake Acıgöl's calcium concentration changed between 64.1 and 192.3 mg/l, magnesium concentration changed between 116.6 and 213.9 mg/l, sulfate concentration changed between 1.2 and 67.2 g/l and chloride concentration changed between 70.9 and 638.9 mg/l (Kazanci et al. 1998). This implied that *L. nilotica* can live in aquatic environment which has very high sulfate and chloride values (It was not possible to include these values in the CCA table because of sulfate and chloride values did not measure in all of the stations.) and high temperature values. High temperature values were observed in this site (between 19.8 and 23 °C). Nesemann and Förster (1997) also found *L. nilotica* from lentic and permanent environments with water temperature between 25 and 30 °C in wadis in Oman.

The species placed in quadrant C were positively correlated with pH, orthophosphate and ammonium. *E. octoculata, E. testacea, H. sanguisuga* placed in this quadrant. *E. octoculata* is generally found in alpha-mesosaprobic environments and it is also found in beta-mesosaprobic and polysaprobic environments (Nesemann and Moog 1995). According to Grosser et al. (2001), this species tolerate high concentrations of nitrite, nitrate, ammonium, phosphate and heavy metals and prefers beta-mesosaprobic, alpha-mesosaprobic and polysaprobic running waters. Aston and Brown (1975) obtained that *E. octoculata* population increased where domestic and industrial pollution was higher. This species was recorded from slightly polluted Neris River (Bubinas and Jagminienë 2002) and Lubiatowskie Lakes in Poland with moderate and low water qualities (Agapow et al. 2006). Tavzes et al. (2006) found *E. octoculata* in all of the moderately polluted sites of urbanized small stream (Glinščica stream). Koperski (2005) categorized *E. octoculata* as a negative bioindicator because of its high tolerance to pollutants. This species, which has a wide distribution in Palaearctic region, was found in YI-1 (alpha-mesosaprobic) and BM-2 (beta-mesosaprobic) in this study. YI station's altitude is 407 m, BM-2 station's altitude is 26 m. *E. octoculata* is able to live in different stream zones (Neubert and Nesemann 1999).

Erpobdella testacea is generally found in beta-mesosaprobic and alpha-mesosaprobic environments (Nesemann and Moog 1995). This species was found in alpha-mesosaprobic site YI-1 in this study. *E. testacea* prefers epipotamal, metapotamal and hypopotamal zones and bank habitat of running waters (Nesemann and Moog 1995). It was found in epipotamal zones of stream in this study. *E. testacea* was recorded in the moderately polluted site of urbanized small Glinščica stream (Tavzes et al. 2006) and in Lubiatowskie Lakes in Poland with moderate and low water qualities (Agapow et al. 2006) like *E. octoculata*.

Haemopis sanguisuga is generally found in beta-mesosaprobic and is occasionally found in alpha-mesosaprobic and oligosaprobic environments (Nesemann and Moog 1995). Grosser et al. (2001) reported this species from

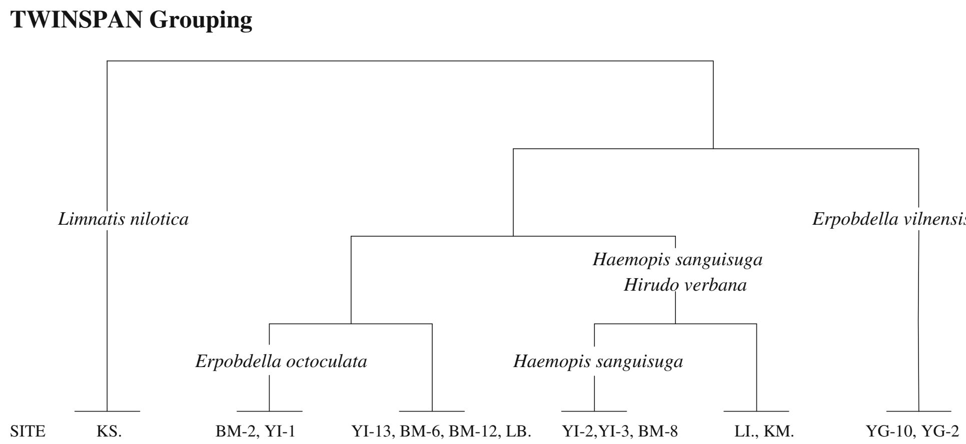


Fig. 2 TWINSPAN, *KS* Karadut Spring, *LB* Lake Beyşehir, *LI* Lake Işıklı, *KM* Karamuk Marsh

alpha-mesosaprobic running waters in Germany. In the present study, *H. sanguisuga* was found in YI-2 station (alpha-mesosaprobic), YI-3 (alpha-mesosaprobic) and BM-8 (polysaprobic). *H. sanguisuga* is able to live in all stream zones. YI-2 and YI-3 are placed in epipotamal zone of streams and BM-8 placed in metarhithral zone. Their altitudes are 340, 280 and 237 m, respectively. Zettler and Daunys (2007) recorded *E. octoculata, E. testacea and H. sanguisuga* in the eutrophic boreal lagoon of the Baltic Sea.

Erpobdella vilnensis placed in quadrant D was positively correlated with nitrate, nitrite, and dissolved oxygen but negatively correlated with temperature and electrical conductivity. Quadrant D includes only *E. vilnensis* which is tolerant to organic pollution and generally prefers beta-mesosaprobic environments and occasionally prefers oligosaprobic, alpha-mesosaprobic and poly-mesosaprobic environments (Nesemann and Moog 1995). Agapow and Piekarska (2000) give record of *E. vilnensis* as a characteristic species of mountain streams in Poland. It also lives in rhithral zones of running waters where dissolved oxygen is higher and water temperature is lower (Nesemann and Moog 1995; Jueg 2005). In this study, *E. vilnensis* was found in YG-2 and in YG-10 which were stations on the mountain streams in Yedigöller National Park. They were alpha-mesosaprobic and beta-mesosaprobic, respectively. YG-2 is placed in hyporhithral zone, and YG-10 is placed in metarhithral zone of the running waters. In YG-2, pebble's ratio was 20 %; mud and sand's ratio was 80 %. In YG-10, pebble's ratio was 50 %; stone's ratio was 10 %; sand's ratio was 40 %. YG-2's altitude is 900 m. YG-10's altitude is 950 m.

TWINSPAN grouping

Site Karadut Spring is located separately from the other sites by different physicochemical characteristics and by indicator species *L. nilotica* which were recorded only from this site (Table 3). Karadut Spring of Lake Acıgöl had very high sulfate and chloride concentrations (according to Kazancı et al, 1998 sulfate values changed between 1.2 and 67.2 g/l and chloride values changed between 70.9 and 638.9 mg/l).

Erpobdella octoculata was an indicator species of YI-1 and BM-2 which were moderately polluted according to orthophosphate phosphorus (0.222 and 0.207 mg/l, respectively) and nitrite nitrogen (0.030 and 0.021 mg/l, respectively) concentrations (Table 1).

Table 3 Hirudinea species which were found in study areas

Species	Basins
H. stagnalis	Yeşilırmak River Basin (YI-1, YI-2, YI-3, YI-13), Büyük Menderes River Basin (BM-6, BM-12), Lake Beyşehir
E. octoculata	Yeşilırmak River Basin (YI-1), Büyük Menderes River Basin (BM-2)
E. testacea	Yeşilırmak River Basin (YI-1)
E. vilnensis	Yedigöller National Park Basin (YG-2, YG-10)
H. sanguisuga	Yeşilırmak River Basin (YI-2, YI-3), Büyük Menderes River Basin (BM-8)
H. verbana	Yeşilırmak River Basin (YI-2), Lake Işıklı, Karamuk Marsh
D. stschegolewi	Yeşilırmak River Basin (YI-2),
L. nilotica	Karadut Spring

The influence of eight environmental variables on the distribution of eight leech species was assessed using CCA

YI-2, YI-3 and BM-8 were heavily polluted downstream sites of Yeşilırmak and Büyük Menderes Rivers and high orthophosphate phosphorus (0.378, 0.391 and 0.918 mg/l, respectively and nitrite nitrogen (0.073, 0.081 and 1.047 mg/l, respectively) concentrations were recorded at these sites (Table 1). *H. sanguisuga* was an indicator species for these polysaprobic sites in this study. Nesemann and Moog (1995) reported that *H. sanguisuga* is generally found in beta-mesosaprobic environments and is occasionally found in alpha-mesosaprobic and oligosaprobic environments Grosser et al. (2001) reported this species from alpha-mesosaprobic environments. According to the results of this study, this species was tolerant to heavy organic pollution.

Hirudo verbana and *Haemopis sanguisuga* were indicators of Karamuk Marsh and Lake Işıklı which had low orthophosphate phosphorus ($\sim$0 mg/l) and nitrite nitrogen (0 mg/l) concentrations (Table 2). These sites were in steppe region and covered by dense macropyhtic vegetation and *Hirudo verbana* prefers this type of lentic habitats (Utevsky et al. 2010).

Erpobdella vilnensis was an indicator species of YG-10 and YG-2 which were heavily polluted (YG-2 with 1.524 mg/l nitrite nitrogen) and moderately polluted (YG-10 with 0.018 mg/l nitrite nitrogen), respectively (Fig. 2). *E. vilnensis* is tolerant to organic pollution (Nesemann and Moog 1995).

Conclusion

The benthic macroinvertebrate community structures in running waters and lakes in Turkey are not very well known. Despite Hirudinea's importance as a component of benthic macroinvertebrate community, information about their relationships with habitat and water quality have been published scarcely. Some researchers carried out studies on Hirudinea but there are still more deficiencies in order to determine their ecological preferences in Turkey.

Ecological preferences of leech species were determined by using physicochemical variables such as temperature, pH, dissolved oxygen, conductivity, nitrate nitrogen, nitrite nitrogen, ammonium nitrogen, orthophosphate phosphorus and substratum structure.

In this study, some leech species and their ecological preferences were determined. According to the results of present study, *H. stagnalis* can live in oligo/beta-mesosaprobic environments in streams and mesotrophic and eutrophic conditions in lakes; *H. verbana* prefers alpha-mesosaprobic environments in streams; oligotrophic–eutrophic and mesosaprobic–polytrophic conditions in lakes; *D. stschegolewi* prefers alpha-mesosaprobic environments in streams; *L. nilotica* prefers beta-mesosaprobic environments in streams; *E. octoculata* prefers alpha-mesosaprobic and beta-mesosaprobic environments in streams; *E. testacea* prefers alpha-mesosaprobic environments; *H. sanguisuga* prefers alpha-mesosaprobic and polysaprobic environments; *E. vilnensis* prefers alpha-mesosaprobic and beta-mesosaprobic environments in streams.

Stream zonation preferences of leech species which live in streams of Turkey were found very close to the literature. In this study, it was determined that *H. stagnalis* prefers epirhithral and epipotamal zones, *H. verbana* prefers epipotamal zone, *D. stschegolewi* prefers epipotamal zone, *L. nilotica* prefers spring of streams, *E. octoculata* prefers potamal zone, *E. testacea* prefers epipotamal zone, *H. sanguisuga* prefers epipotamal and metarhithral zones, *E. vilnensis* prefers hyporhithral and metarhithral zones.

According to the results of this study, leech species are able to live in different types of saprobic levels in streams and trophic level in lakes, but they usually prefer polluted environments. Using Hirudinea in biomonitoring studies is currently difficult because of lack of systematic and ecological research on this group. In the future, knowledge about the diversity of Hirudinea fauna and utilization as biological indicators of water quality assessment in both lentic and lotic ecosystems are expected to increase significantly in Turkey. Leech species will be used more effectively in habitat quality studies and also they will be used in WFD studies.

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