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# DISTRIBUTION OF SPHAERIIDAE (MOLLUSCA: BIVALVIA) IN RELATION TO ENVIRONMENTAL VARIABLES IN NORTHWESTERN BASIN STREAMS IN TÜRKİYE

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## Abstract
In this study, Sphaeriidae family was investigated in some freshwater systems of northwestern basin streams of Türkiye such as Karamenderes, Sarıçay, Mıhlı and Tuzla with respect to environmental variables. A standard multi-habitat sampling technique was applied to these streams at pre-selected stations using kick-net and surber-net. In addition, some water quality parameters such as temperature, pH, dissolved oxygen, conductivity, Oxidation Reduction Potential (ORP) were measured in situ using a multimeter probe. The taxa of Sphaeriidae were identified and counted in the laboratory under stereo microscope. The identified taxa were as follows, *Musculium lacustre*, *Pisidium casertanum*, *P. nitidum*, *P. subtruncatum* and *P. sogdianum*. Three of these species, namely *P. casertanum*, *P. subtruncatum*, *P. nitidum*, were widely distributed in the study area, while the rest were found in narrow ranges, especially *P. sogdianum*, which was found only in the Tuzla stream. The individual numbers of species in some streams were subjected to multidimensional scaling using SPSS 21.0. According to the multi-dimensional scaling (MDS), most of the water quality parameters influenced the distribution of most of the species. Water conductivity is the least effective parameter among the measured parameters, additionally *P. casertanum* and *P. sogdianum* showed distribution independent of water quality parameters.

**Keywords:** Water quality, Streams, Northwestern Basin, Bivalvia, Multi-dimesional scaling

## Introduction

Sphaeriidae are freshwater bivalve molluscs, known as pill clams because of their small size, that represent a large and diverse freshwater molluscan radiation with a current cosmopolitan distribution in all types of lotic and lentic habitats (Korniushin and Glaubrecht, 2006). They are formed by two symmetrical valves, which are hinged at the umbo, and a dorsal ligament. Because of having hermaphroditic mode of reproduction, they keep its' juveniles in the sac during brooding process (Zhadin, 1952, Korniushin and Glaubrecht, 2006). Bivalves feed by filtering water or taking food from the water-silt interface (pedal feeding) (Shumway et al., 1985). Thus, they play an active role in the flow of nutrients in freshwaters. Sphaeriidae, often used as a water quality indicator in large rivers, are also absent from the area, although water quality has improved (Delong et al., 2023).

In Türkiye, some papers on freshwater macroinvertebrates have been published and some of the Sphaeriidae common in Turkish freshwaters such as *P. casertanum*, *P. subtruncatum*, *P. annandalei* (*P. sogdianum*), *P. nitidum*, *Musculium lacustre* have been mentioned. Thus, due to the scientific publication is quantitatively very scarce on the Sphaeriidae, more research is needed. In this study, we aimed to show the distribution of Sphaeriidae in relation to water quality.

## Material and Method

Sampling was carried out in the streams of Sarıçay, Karamenderes, Tuzla and Mıhlı in three periods such as spring (between 21th March and 13rd of April), summer ((between 1 and 2 of August), and autumn (12 and 13 of September) (Figure 1, Table 1). In sampling, multi-habitat-sampling method (net area: 0.0625 m2, 0.5 mm mesh size; ISO 10870:2012) used in the sampling of benthic assemblages of the macroinvertebrates was applied for each stations at a distance of 100 m towards the upper stream against the flow direction for each microhabitat types such as muddy, sandy, gravelly and detrital deposits by dredging twenty subsamples within a total sampling area of 1.25 m2.

The number of individuals per square meter was calculated using the formula: (Su x Sr) x (Uc x n / Sa), where Su is the unit area sampled, Sr is the number of sampling replicates, Uc is the unit coefficient (1 used as square meter), n is the number of individuals counted, and Sa is the area sampled. During sampling, some water quality parameters such as temperature, pH, dissolved oxygen, conductivity and ORP were measured in situ using a multimeter probe (HI98194). Samples were taken to the Laboratory of Marine Science and Limnology (Water Quality Laboratory) of Çanakkale Onsekiz Mart University and washed several times under tap water using a 0.5 µm sieve. Sorted samples were collected in vials containing 80% alcohol for taxonomic identification under stereomicroscopes (Olympus SD30). Glöer (2015) was used for the taxonomic identification of Sphaeriidae.

All stations chosen from each stream on the streams of Sarıçay, Karamenderes, Tuzla and Mıhlı.

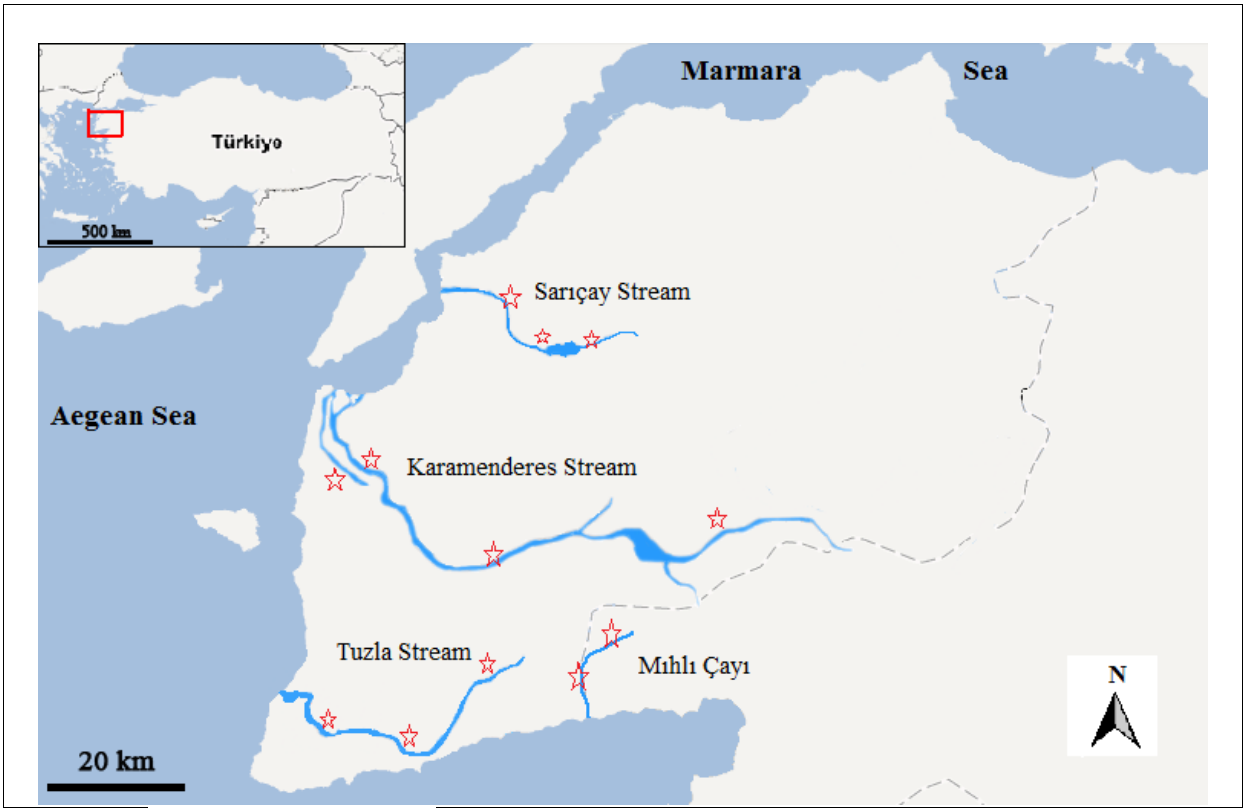


**Figure 1.** Map of the study area.

**Table 1.** Sampling stations with coordinates of the study area.

| | | |
|---|---|---|
| Sarıçay Stream | 1 Troya Bridge | 40° 8' 41.6686" K<br>26° 25' 13.5167" D |
| | 2 Kurşunlu Village | 40° 7' 46.9385" K<br>26° 30' 38.8161" D |
| | 3 Serçiler Village | 40° 3' 23.3777" K<br>26° 35' 37.3781" D |
| Kamanederes Stream | 1 Pınarbaşı Kırkgözler Spring | 39° 53' 10.3408" K<br>26° 15' 29.4571" D |
| | 2 Köprübaşı Bridge | 39° 49' 55.6911" K<br>26° 19' 37.2675" D |
| | 3 Ahmetçeli Village | 39° 48' 33.1627" K<br>26° 31' 10.8738" D |
| | 4 Üzümlü Village | 39° 47' 14.1684" K<br>26° 40' 42.8925" D |
| Tuzla Stream | 1 Tuzla Village | 39° 33' 28.4185" K<br>26° 9' 33.5001" D |
| | 2 Behram Bridge | 39° 29' 55.1153" K<br>26° 19' 56.3476" D |
| | 3 Ayvacık District | 39° 35' 52.206" K<br>26° 26' 59.4328" D |
| Mıhlı Stream | 1 Mıhlı Stream | 39° 33' 25.9171" K<br>26° 39' 25.3358" D |
| | 2 Narlı Village | 39° 34' 32.4931 K<br>26° 39' 8.4186" D |

**Results and Discussion**

According to the data, five species of Sphaeriidae were identified, such as *P. casertanum, P. nitidum, P. sogdianum, P. subtruncatum* and *M. lacustre*. Majority of these species were widespread in the study area, except for *P. sogdianum* which was sampled only in two streams in the study area, Tuzla and Karamenderes streams. The species showed a continuous distribution in the stations of Tuzla Stream (Table 2). During the course of the study, there is no specimen of sphaeriids at the sampling stations of Mıhlı Stream. These sampling stations were fluent clearly and their bottom were mainly stony, the reason why sphaeriid species on this area. According to Dillon (2000), Lopez and Holopainen (1987) have suggested that although larger sphaeriids quite probably do ingest and assimilate algae and/or detritus, the smaller *Pisidium* may feed exclusively on bacteria. Thus, scarcity of organic debris in the stations of Mıhlı Stream does not support the Sphaeriidae life.

**Table 1**. Distribution of Shpaeriidae in the study area.

| Species/Stations | Sarıçay Stream | | | Karamenderes Stream | | | | Tuzla Stream | | | Mıhlı Stream | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 |
| *Pisidium casertanum* | + | - | - | + | + | + | - | + | - | - | - | - |
| *P. nitidum* | + | - | - | - | + | - | - | + | - | + | - | - |
| *P. subtruncatum* | + | - | - | - | + | + | - | + | - | + | - | - |
| *P. sogdianum* | - | - | - | - | + | - | - | + | + | + | - | - |
| *Musculium lacustre* | - | + | - | - | - | - | - | + | - | - | - | - |

According to the data of environmental variables especially in temperature, there was a seasonal fluctuation (Table 2). Although, the most of the water quality parameters were higher water quality class (WQC-I, II), some of the parameters showed lower quality according to the regulations of inland waters classification criteria of Türkiye (Anonymous, 2012). Biological Oxygen Demand ($BOD_5$) and COD have been used as an indication of the water pollution based on wastewater discharge in surface waters (Sawyer and McCarty, 1978).

During the study period, the highest levels of $BOD_5$ and COD were recorded at the Sarıçay Stream (Table 3), most probably due to local domestic effluents along the settlement area and high salinity at the estuarine zone. The highest level of concentration of $NO_3^-$ was measured at the Kocabaş Stream (3.78 – 8.20 $mgL^{-1}$), thus the stream can be classified as highly polluted (IV) for this parameter according to WQCR of Türkiye.

**Table 3.** Water quality parameters measured of the streams.

| | | DO | EC | pH | Sal | Temp | $BOD_5$ | COD | $NO_3$ | $PO_4$ | Turb |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SARIÇAY | **AUTUMN** | 7.68 | 11348.7 | 7.37 | 8.94 | 12.7 | 6.58 | 43.21 | 3.66 | 0.57 | 0.95 |
| | **WINTER** | 11.91 | 5072.9 | 7.22 | 4.52 | 9.2 | 8.21 | 51.08 | 1.47 | 0.86 | 16 |
| | **SPRING** | 9.72 | 10521.3 | 7.17 | 8.31 | 13.8 | 2.55 | 38.00 | 2.87 | 1.02 | 2.67 |
| | **SUMMER** | 5.91 | 461.1 | 7.75 | 6.87 | 23 | 1.27 | 21.17 | 1.43 | 0.03 | 3 |
| KOCABAŞ | **AUTUMN** | 8.02 | 713.2 | 7.39 | 0.47 | 11.9 | 2.44 | 19.28 | 3.39 | 0.96 | 6.25 |
| | **WINTER** | 13.28 | 269.1 | 7.14 | 5.89 | 7.6 | 0.37 | 14.94 | 8.20 | 1.12 | 67.50 |
| | **SPRING** | 9.69 | 602.2 | 6.98 | 0.33 | 18.8 | 3.84 | 16.14 | 3.33 | 1.28 | 10 |
| | **SUMMER** | 9.53 | 615.6 | 7.58 | 1.98 | 26.3 | 1.50 | 15.79 | 3.78 | 3.13 | 12.75 |
| KMENDERES | **AUTUMN** | 8.01 | 3174.7 | 7.79 | 2.23 | 14.3 | 6.91 | 41.53 | 1.15 | 1.00 | 8.67 |
| | **WINTER** | 12.53 | 359.9 | 7.49 | 0.27 | 7.6 | 1.57 | 8.95 | 3.33 | 0.52 | 14.75 |
| | **SPRING** | 9.87 | 416.9 | 6.80 | 0.24 | 17.2 | 2.80 | 15.10 | 1.13 | 10.70 | 9.25 |
| | **SUMMER** | 9.45 | 653.1 | 7.77 | 0.33 | 23.7 | 1.10 | 9.02 | 1.15 | 0.20 | 8.08 |
| TUZLA | **AUTUMN** | 12.79 | 435.3 | 8.26 | 0.27 | 13. 8 | 6.45 | 61.53 | 6.06 | 0.47 | 37.25 |
| | **WINTER** | 12.71 | 291.3 | 7.35 | 0.20 | 9.3 | 0.80 | 13.1 | 1.65 | 0.67 | 27.25 |
| | **SPRING** | 15.56 | 531.4 | 7.76 | 0.27 | 22.9 | 1.14 | 11.3 | 7.85 | 0.06 | 1.5 |
| | **SUMMER** | 10.49 | 321.4 | 7.56 | 0.19 | 25.9 | 0.7 | 8.53 | 0.52 | 0.47 | 4.2 |

According to the results of the MDS, conductivity has no effect on the distribution of Sphaeriidae species and is independent of other water quality parameters, due to impaired seawater exchange in the estuaries of the streams where no mussels were distributed.

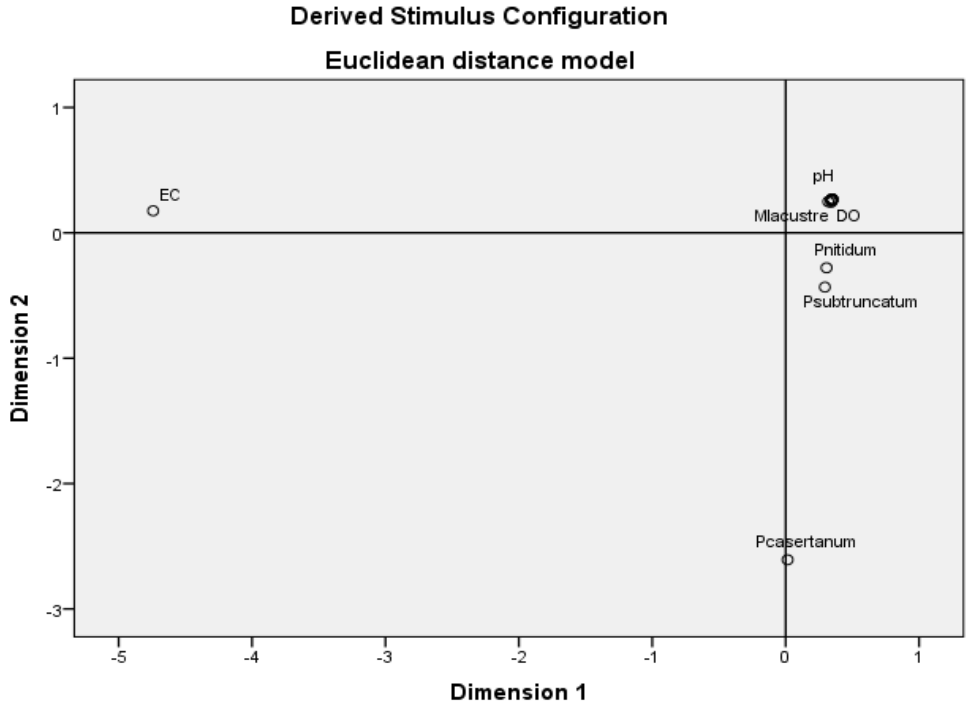


**Figure 2.** MDS plot belong to the stations of Sarıçay Stream.

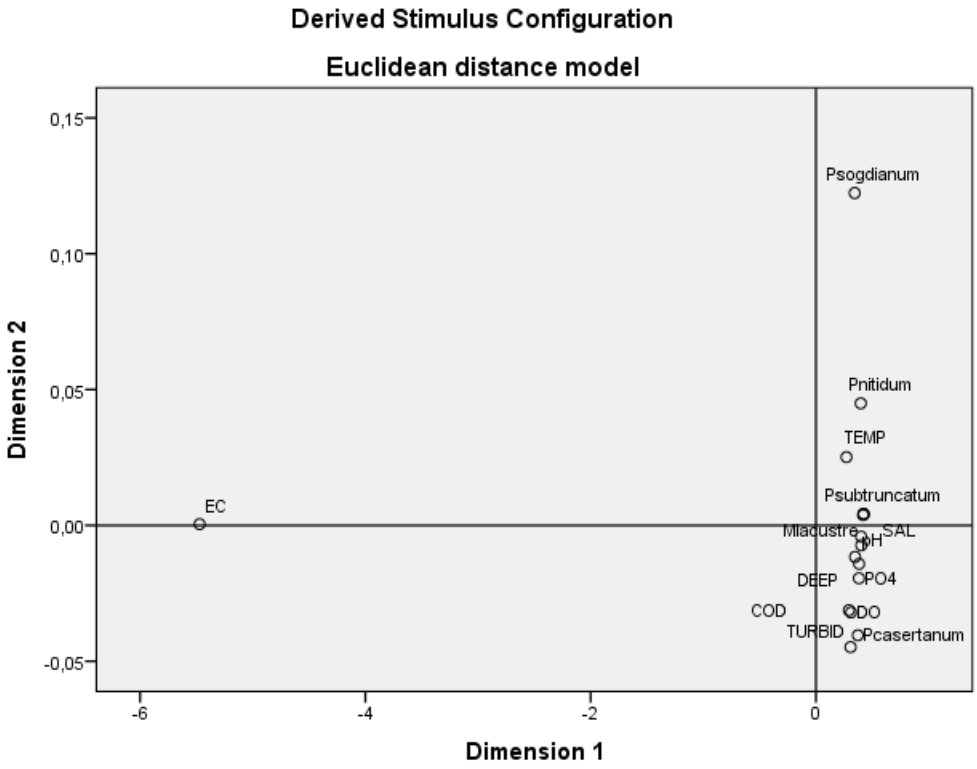


**Figure 3.** MDS plot belong to the stations of Karamenderes Stream.

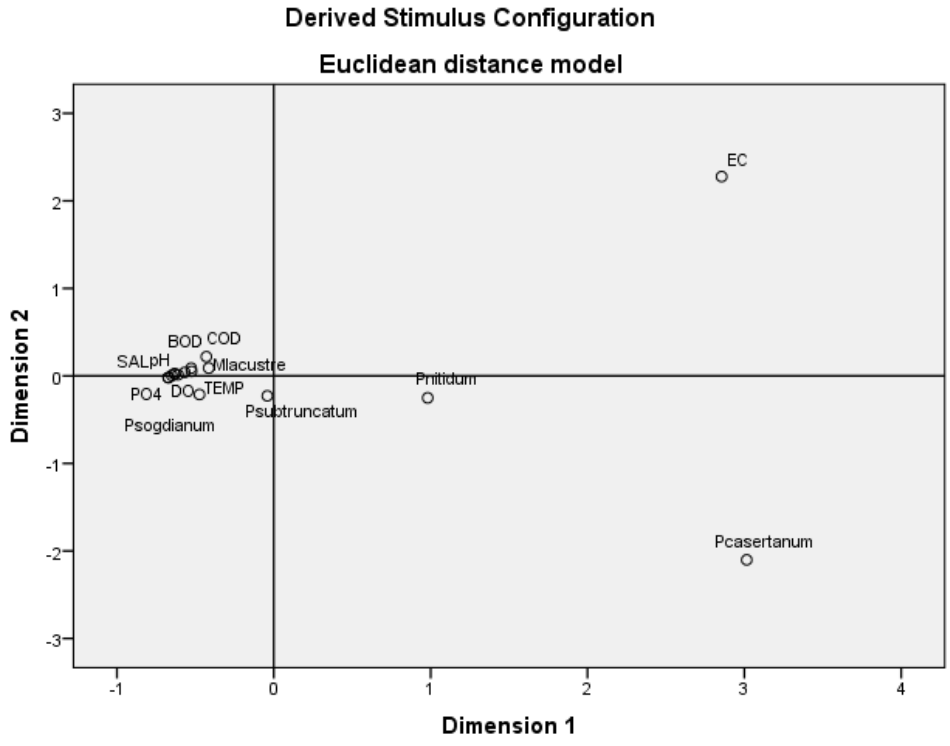


**Figure 4.** MDS plot belong to the stations of Tuzla Stream.

## Discussion

*Pisidium casertanum* was on distant places from the rest of species and the majority of the water qualities in Sarıçay and Tuzla Streams, while *P. sogdianum* separated in Karamenderes Stream. The fact that these two species are far from the majority of water quality parameters is probably due to the fact that they are represented by a large number of individuals in different habitats. On the other hand, the density of other species such as *P. nitidum*, P. subtruncatum, *M. lacustre*, and in some circumstances *P. sogdianum* in the habitats represented by most of the water quality parameters indicates that there are populations compatible with these parameters.

*Pisidium casertanum* (Poli, 1791) with the synonym name *Euglesa casertana*, is one of the most widespread species of freshwater bivalve molluscs in the world. It is known from the Palearctic and Nearctic regions in the world, thus considered as a cosmopolitan species (Subba Rao, 1989, Ramakrishna and Dey, 2007). The species is widespread throughout Europe, from Scandinavia to the Mediterranean countries as well as Türkiye and Syria (Ustaoğlu et al., 2001; Gürelli and Özbek, 2012; Şereflişan et al., 2007; Van Damme and Kebapçı, 2009). The other pill clams i.e. *P. subtruncatum, P. nitidum* and *M. lacustre* are also widespread in Holarctic region. These species of Sphaeriidae, especially *M. lacustre*, tend to live in slightly organic polluted conditions (Killeen et al., 2017; Seddon and Van Damme, 2017; Seddon et al., 2017). In the MDS plots, the overlap of the *M. lacustre* population with most of the water quality parameters indicates that it is a pollution tolerant species.

On the other hand, *P. sogdianum* unlike the other species that were recorded in the study area, is of mainly Asian distribution pattern as being Israel to Southeast Asia and India (Subba Rao, 1989; Nesemann et al., 2001. Besides, there are some occurrences in Mediterranean parts of southeastern Europe, including Sicily, southern Italy and Greece (Zeissler, 1971) and Türkiye (Ustaoğlu et al., 2001). This species is widely distributed from unpolluted oligosaprobic zones to betamesosaprobic organically polluted zones, thus it is the most useful indicator species for water quality assessment (Nesemann and Sharma, 2005). Uninterrupted distribution pattern of this species in the Tuzla Stream region can be attributed to the water quality conditions and pristine character of the ecosystem as indicated in an earlier data by Odabaşı (2011).

## Conclusion

In conclusion, the detection of several species of Sphaeriidae is indicative of the biodiversity of the streams of the Biga Peninsula. The distribution model of the taxa also demonstrates their biological indicator value. According to our data, these bivalves can be used in bio-monitoring studies both for the region and nationwide. For Sphaeriidae taxa to be an effective indicator in biological monitoring studies, population density at a sampling site and water quality parameters that are indicators of pollution (such as $BOD_5$, COD, $NO_3$, $PO_4$, and DO) should be evaluated together. As can be seen in Figure 3, *P. subtruncatum, M. lacustre, P. casertanum* can be considered as indicators for $PO_4$ and $BOD_5$ parameters in Karamenderes Stream, while *P. subtruncatum, M. lacustre,* and *P. sogdianum* can be considered as indicators for $NO_3$ and $BOD_5$ in Tuzla stream based on their population densities and water quality parameters.

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## Ethical approval

Not applicable, due to this study involving aquatic invertebrates.

**Informed consent**
Not available.

**Data availability statement**
The authors declare that data can be provided by corresponding author upon reasonable request.

**Conflicts of interest**
There is no conflict of interests for publishing this study.
The corresponding author is responsible on behalf of all authors' declaration.

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**Contribution of authors**
Author 1: Project administration, Conceptualization, Formal analysis, Writing original draft, and Funding acquisition.
Author 2: Investigation, Field study, and Data curation,
Author 3:, Resources, Methodology, Software, Visualization, Review, Editing.
"All authors have read and agreed to the published version of the manuscript."

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