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# FIRST RECORDS FOR BENTHIC MACROINVERTEBRATE FAUNA IN GÜZELDERE WATERFALL, TURKEY

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**ABSTRACT**. In this paper, the benthic macroinvertebrate fauna of the Güzeldere Stream and Waterfall were investigated. Samples were collected in October 2020 at 3 stations. A total of 41 taxa including Gastropoda, Oligochaeta (9 species), Ephemeroptera (7 species), Odonata, Coleoptera, Chironomidae (15 species), Simuliidae, Blephariceridae (2 species), Plecoptera (3 species), and Trichoptera (1 species) were identified in the area. The dominant taxon was Chironomidae at all three stations followed by Oligochaeta and Ephemeroptera, respectively. The second station had the highest individual numbers (195) and the highest species diversity (32). All of the identified taxa were the first records for the study area because there have been no studies conducted for the determination of the Güzeldere Stream and Waterfall.

## 1. INTRODUCTION

Benthic macroinvertebrates, one of the biotic components of aquatic ecosystems, are defined as organisms that are larger than 0.5 mm, live on the bottom of water bodies, can be seen with the naked eye, and have no internal skeletons [1,2]. Common inhabitants of lentic and lotic systems, benthic macroinvertebrates play a crucial role in the movement of energy through food webs [3]. The diversity of taxonomic groups that make up the benthic macroinvertebrate fauna is a crucial link in the energy flow from the deep compartment to the aquatic environment. This fact is related to their characteristics and ecological requirements, especially given that they are ubiquitous [4], sedentary, and have with a distribution that may be influenced by some physical or chemical disturbance [5,6], as well as by substrate characteristics [7]. Additionally, these invertebrates are a

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contemporary tool frequently used for monitoring freshwater aquatic ecosystems [8]. Compared to its rapidly changing physicochemical properties, benthic macroinvertebrates are the most prevalent faunal assemblages for bio-assessment and offer a more accurate assessment of long-term ecological changes in the quality of aquatic systems. They are helpful in determining temporal and spatial changes within an aquatic ecosystem due to their numerous life stages, sedentary lifestyle, and varying levels of susceptibility to environmental stressors [3].

Turkey has 25 freshwater basins including many water regions. One of these water regions is waterfalls, which are home to many aquatic benthic macroinvertebrates. Waterfalls are rocky biotopes with a rapid flow that have a unique geomorphic structure (stream channels and channel slopes typically erode to parent material). These biotopes typically reach heights of more than 1 m and flow vertically without obstruction [9]. Waterfalls are more prevalent in high elevation areas where the stream gradient is steeper and the river channels create discrete, sequential pools and waterfalls (or cascades and riffles) [10]. More than 66 waterfalls have been reported in the Turkish literature so far [11,12]. One of these waterfalls, Güzeldere Waterfall, located in Düzce Province, has a fall height of 130 m. This waterfall is among the highest waterfalls in Turkey [13].

In Turkey, there are many studies about the benthic macroinvertebrate fauna of lakes and rivers [e.g., 14-17] but there are no studies about the benthic fauna of waterfalls. The current study aimed to determine the benthic macroinvertebrate fauna of the Güzeldere Stream and Waterfall. In the area, there have been no studies about benthic macroinvertebrate fauna, although there are a few faunistic studies about the insect fauna in the area [18-20].

## 2. MATERIALS AND METHODS

The Güzeldere Stream and Waterfall are located in the province of Düzce in the Western Black Sea Basin. The waterfall was declared a nature park in July 2011. It covers an area of 22.76 ha. The 130-m-high waterfall is a multiple-drop waterfall [13].

In order to determine the macroinvertebrate fauna of the Güzeldere Stream and Waterfall, samples were taken from 3 stations in October 2020. The first station among the sampling areas was the area where the waterfall flows. The second and third stations are on the Güzeldere Stream.

Benthic macroinvertebrate samples were collected with a hand net and the sieved samples were fixed with 70% alcohol. Temperature, pH, and dissolved oxygen parameters were also measured *in situ*. After the benthic samples brought to the laboratory were sorted under a stereomicroscope, preparations were made for identification at the species level. For the identification of macroinvertebrate specimens at the species level, the identification keys of Schütt (1965), Zhadin (1965), Müller-Liebenau (1969), Bilgin (1980), Şahin (1984), Eliot et al. (1988), Harker (1989), Sauter (1992), Epler (1995), Cranston (1995), Nilsson (1996), Nilsson (1997), Glöer ve Meier-Brook (1998), Glöer (2002), Bouchard (2004), Eiseier (2005), Timm (2009), Bauernfeind and Soldán (2012), and Thorp and Rogers (2019) were used [21-39].

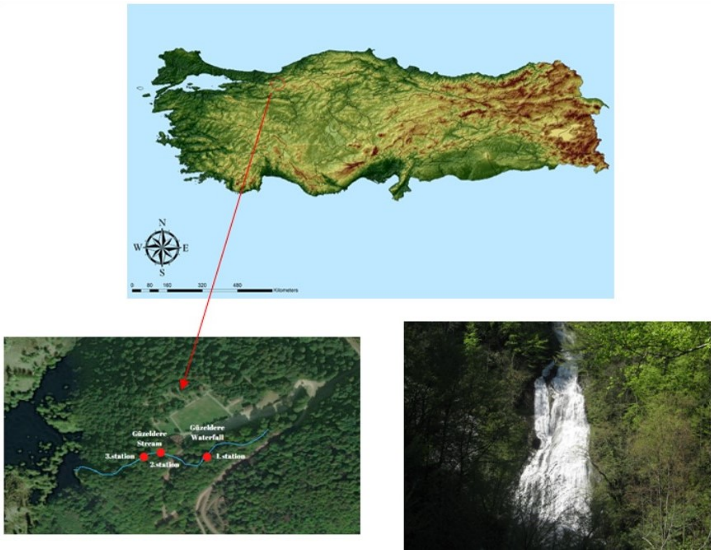


FIGURE 1. Geographical positions of sampling stations

## 3. RESULTS AND DISCUSSION

As a result of the examination of the samplings from three stations in the Güzeldere Stream and Waterfall in October 2020, 41 taxa were identified in the zoobenthic community structure. Table 1 shows the dominance values of these taxa and their distribution according to the stations, where it can be seen that the dominant macrozoobenthic taxon in the Güzeldere Stream and Waterfall was Chironomidae (31.25%, 42.56%, and 30.40% at stations 1, 2, and 3, respectively), followed by Oligochaeta and Ephemeroptera, respectively.

TABLE 1. Dominance values of macrozoobenthic taxa detected in the Güzeldere Stream and Waterfall and their distribution according to stations.

| | Güzeldere Waterfall | Güzeldere Stream | Güzeldere Stream | Mean |
|---|---|---|---|---|
| **Taxon/Sampling stations** | **1** | **2** | **3** | |
| **Gastropoda** | 1.14 | 4.10 | 8.80 | 4.68 |
| **Oligochaeta (in total)** | 29.55 | 29.74 | 32.00 | - |
| *Chaetogaster diastrophus* (Gruithuisen, 1828) | 2.84 | 3.08 | 3.20 | 3.04 |
| *Chaetogaster langi* Bretscher, 1896 | 2.84 | 0.00 | 1.60 | 1.48 |
| *Nais barbata* Müller, 1773 | 7.39 | 4.10 | 4.80 | 5.43 |
| *Nais bretscheri* Michaelsen, 1899 | 14.20 | 11.79 | 4.80 | 10.27 |
| *Nais pardalis* Piguet, 1906 | 0.00 | 4.62 | 9.60 | 4.74 |
| *Pristinella jenkinae* (Stephenson, 1931) | 0.00 | 2.56 | 3.20 | 1.92 |
| *Aulodrilus pigueti* Kowalewski, 1914 | 1.70 | 2.05 | 0.00 | 1.25 |
| *Potamothrix hammoniensis* (Michaelsen, 1901) | 0.00 | 1.54 | 1.60 | 1.05 |
| *Psammoryctides albicola* (Michaelsen, 1901) | 0.57 | 0.00 | 3.20 | 1.26 |
| **Ephemeroptera (in total)** | 11.93 | 10.77 | 12.80 | - |
| *Caenis luctuosa* (Burmeister, 1839) | 2.84 | 1.03 | 0.00 | 1.29 |
| *Caenis macrura* Stephens, 1836 | 3.98 | 0.00 | 1.60 | 1.86 |
| *Baetis vernus* Curtis, 1834 | 1.14 | 5.64 | 6.40 | 4.39 |
| *Baetis muticus* (Linnaeus, 1758) | 0.00 | 3.59 | 4.80 | 2.80 |
| *Electrogena lateralis* (Curtis, 1834) | 1.70 | 0.00 | 0.00 | 0.57 |
| *Ecdyonurus picteti* (Meyer-Dür, 1864) | 1.14 | 0.00 | 0.00 | 0.38 |
| *Epeorus* sp. | 1.14 | 0.51 | 0.00 | 0.55 |
| **Odonata** | 1.70 | 2.56 | 5.60 | 3.29 |

| | Güzeldere Waterfall | Güzeldere Stream | Güzeldere Stream | Mean |
|---|---|---|---|---|
| **Taxon/Sampling stations** | **1** | **2** | **3** | |
| **Coleoptera** | 1.14 | 2.56 | 1.60 | 1.77 |
| **Chironomidae (in total)** | 31.25 | 42.56 | 30.40 | - |
| *Macropelopia nebulosa* Meigen, 1804 | 2.27 | 7.18 | 7.20 | 5.55 |
| *Prodiamesa olivacea* Meigen, 1818 | 4.55 | 1.54 | 0.00 | 2.03 |
| *Psectrocladius calcaratus* Edwards, 1929 | 2.27 | 1.03 | 4.80 | 2.70 |
| *Cardiocladius capucinus* (Zetterstedt, 1850) | 0.00 | 2.56 | 0.00 | 0.85 |
| *Rheocricotopus fuscipes* Kieffer, 1909 | 0.00 | 3.08 | 3.20 | 2.09 |
| *Thienemanniella vittata* Edwards, 1924 | 3.98 | 2.56 | 0.80 | 2.45 |
| *Eukiefferiella claripennis* (Lundbeck, 1898) | 6.25 | 1.03 | 0.00 | 2.43 |
| *Eukiefferiella clypeata* Kieffer, 1923 | 3.41 | 1.03 | 3.20 | 2.54 |
| *Eukiefferiella ilkleyensis* Edwards, 1929 | 0.00 | 7.69 | 2.40 | 3.36 |
| *Metriocnemus cubitalis* (Kieffer, 1911) | 2.27 | 0.00 | 0.00 | 0.76 |
| *Paratrichocladius* sp. | 0.00 | 3.08 | 2.40 | 1.83 |
| *Paratrichocladius rufiventris* Meigen, 1830 | 1.14 | 3.08 | 0.00 | 1.40 |
| *Orthocladius (O.) thienemanni* (Kieffer & Thienemann, 1906) | 0.00 | 4.62 | 3.20 | 2.61 |
| *Chaetocladius piger* Goetghebuer, 1913 | 5.11 | 1.54 | 0.00 | 2.22 |
| *Cladotanytarsus mancus* Walker, 1856 | 0.00 | 2.56 | 3.20 | 1.92 |
| **Simuliidae** | 6.80 | 5.64 | 3.20 | 5.22 |
| **Blephariceridae** | | | | |
| *Blepharicera* sp. 1 | 4.55 | 0.00 | 0.00 | 1.52 |
| *Blepharicera* sp. 2 | 2.27 | 0.00 | 0.00 | 0.76 |
| **Plecoptera (in total)** | 4.55 | 0.51 | 4.00 | - |
| *Protonemura praecox* (Morton, 1894) | 1.14 | 0.51 | 2.40 | 1.35 |
| *Perla bipunctata* Pictet, 1833 | 2.27 | 0.00 | 1.60 | 1.29 |
| *Leuctra* sp. | 1.14 | 0.00 | 0.00 | 0.38 |
| **Trichoptera** | | | | |
| *Hydroptila occulta* (Eaton, 1873) | 5.11 | 1.54 | 1.60 | 2.75 |
| **Water parameters** | **Sampling stations** | | | |
| | **1** | **2** | **3** | |
| Temperature (°C) | 16.5 | 17 | 17 | - |
| pH | 6.8 | 6.9 | 6.8 | - |
| Dissolved oxygen (mg/L) | 12 | 11 | 9 | - |

The species with the highest abundance in the macrozoobenthic community were *Nais bretscheri* (10.27%), *Nais barbata* (5.43%), and *Nais pardalis* (4.74%) from Oligochaeta. The abundance of *Nais bretscheri* was particularly high at station 1, where the Güzeldere Waterfall flows from 130 m and forms a small pond. It is noteworthy that *Nais pardalis* was not found at this station, but was abundant in the second and third stations located on the stream. *N. bretscheri,* unlike the other two dominant *Nais* species, is typical of fast-flowing streams and prefers a sediment structure consisting mainly of hard material such as stones, sand, and gravel [37, 40]. It is known that *Nais barbata* and *Nais pardalis*, the other two dominant species, can also be found in fast-flowing waters, but their population densities increase in softer (mud + sand) sediments when compared to *N. bretscheri* [41]. The fact that this station has a harder sediment structure than the other two stations and the population abundance and dominance of the species in question support the literature information. All three Naidin species are widely distributed both in Turkey and around the world [42,43].

The genus *Aulodrilus* in the Tubificidae family is not very rich in terms of the number of species [42]. Defined as a cosmopolitan species [42], *Aulodrilus pigueti*, which was detected only in stations 1 and 2, was recorded for the first time in Turkey by Arslan and Şahin (2003) in the Upper Sakarya River System [44], The fact that these areas are high in dissolved oxygen (11–12 mg/L) and the water temperature is 16.5–17 °C (Table 1) supports the habitat preferences of the species. It has been detected in aquatic systems in different parts of Turkey, especially in high-altitude mountain streams and lakes, although in small numbers [43]. It is known that the species prefers cool waters with relatively high dissolved oxygen as its distribution area [40,44]. The stations where the species was detected were station 1, which was just below the waterfall, and station 2, which was the stream section.

The species with the highest abundance among Chironomidae individuals were Tanypodin *Macropelopia nebulosa* (5.55%), Orthocladiin *Eukiefferiella ilkleyensis* (3.36%) and *Psectrocladius calcaratus* (2.70%). As seen in Table 1, although two Tanypodin species were dominant in the Chironomidae fauna, it was seen that Orthocladiin individuals constituted the majority of the Chironomidae fauna. It was reported that Orthocladiin individuals are generally found in coarse sediments (stones, gravel), but their population densities can also increase in fine-grained and sandy substrates [45,46], their tolerance to organic pollution is lower than that of other chironomid members [47], they can also be found in fast flowing sections of rivers due to high oxygenation and in the littoral sections of lakes with a constant but high dissolved oxygen regime [48] and it has been reported that the population densities of *Orthocladius* and *Eukiefferiella* species in this group may increase and that they are distributed in gravelly, stony sediments, epirhitron and metarhitron areas of rivers [30,49]. The fact that the stations where Orthocladiin individuals were detected generally had cool waters, and flowing and hard substrate structure was in parallel with this information.

According to the average abundance values determined in the three stations in the study area, *Baetis vernus* (4.39%) and *Baetis muticus* (2.8%) were found to be the dominant species among the Ephemeroptera fauna, while *Ecdyonurus picteti* and *Electrogena lateralis* were found only at station 1, which was just below the waterfall. It is known that *Baetis vernus* nymphs are found in the rhitral and potamal parts of rivers, *Baetis muticus* nymphs are found in the krenal and rhitral parts of rivers, and both species generally prefer oligosaprobic, xenosaprobic and beta mesosaprobic areas [50]. This information is consistent with our results. It has been reported that *Ecdyonurus picteti* nymphs are found in sediments in rocky and stony places in fast-flowing areas from hyporhithron to hypocrenon sections of rivers, mostly oligosaprobic environments, but also xenosaprobic and beta-mesosaprobic environments [51]. The fact that this species was found among the stones at 1st station, which was the region where the waterfall flowed, supports the information in the literature.

The only other taxon detected in the study area is Blephariceridae members from the lower part of the waterfall, among the mosses and on the stones. It is known that the members of Blephariceridae (Table 1, *Blepharicera* sp. 1 and *Blepharicera* sp. 2), which can be identified up to the genus level, are the best-adapted Diptera group living in the waterfalls and cascades of mountain rivers, and are adapted to living in very fast flowing water thanks to their ventral discs [52]. Since blephariceridsprefer clean, cool, well-oxygenated river sections, the presence of members of this group in aquatic systems has been reported to be used as a positive bioindicator for water quality assessment [53]. Although detailed measurements to determine the water quality were not carried out in this study, the dissolved oxygen value measured in situ in the study area (12 mg/L at station 1 where the taxon was detected) indicates a water class I. The high abundance of both taxa (*Blepharicera* sp. 1 4.55% and *Blepharicera* sp. 2 2.27%) is consistent with this information. There are very few studies on the members of the family Blephariceridae in Turkey. In a study conducted by Koç and Zwick (2006), it was reported that *Blepharicera fasciata* (Westvood, 1842) is widespread in the Mediterranean region, from Portugal to Lebanon and Iran, and in Turkey except for arid regions, it has a wide distribution [54].

Shannon index (H'), Evenness, and Margalef index values were calculated for the taxa identified in the research area and given in Table 2. The highest number of individuals (195) and the highest species diversity (32) were found at station 2. The highest Shannon index value was found at station 2 (3.20), where the highest species diversity was detected. Shannon and Margalef index values and taxa numbers detected in the Güzeldere Stream and Waterfall were higher than expected, despite the fact that the study area was a small aquatic system. This suggests that this was due to the high diversity of microhabitats formed by stream and waterfall systems that can host different taxonomic groups.

TABLE 2. Index values of the stations according to the distribution and abundance of macrozoobenthic taxa detected in the Güzeldere Stream and Waterfall.

| | **Sampling stations** | | |
|---|---|---|---|
| **Indices** | **1** | **2** | **3** |
| Taxa number | 31 | 32 | 27 |
| Individuals | 174 | 195 | 125 |
| Shannon index (H’) | 3.17 | 3.20 | 3.13 |
| Evenness (e^H/S) | 0.77 | 0.79 | 0.85 |
| Margalef index | 5.82 | 5.69 | 5.39 |

## 4. CONCLUSIONS

As a result of the examination of the samplings from three stations in the Güzeldere Stream and Waterfall, 41 taxa were identified in the zoobenthic community structure. The macroinvertebrate fauna of waterfalls, which are usually composed of streams or rivers flowing more or less at a certain height, has been a subject of little interest in hydrobiological studies. However, in waterfall systems, the gradual and (or) sudden decrease in current velocity over short distances, the change in the river bed and sediment structure, the distribution and density of aquatic plants, and the change in water parameters provide different habitat opportunities for invertebrates with very different ecological preferences over short distances, which increases taxonomic diversity [55,56]. The results obtained in this study support this information. Since there are no previous studies to determine the macroinvertebrate fauna of the Güzeldere Stream and Waterfall, all of the taxa identified were the first records.

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