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Determination of Ephemeroptera species diversity of Akçay Creek (Sakarya, Türkiye)

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ABSTRACT

The Marmara Region holds an important place in Türkiye's zoogeography and biodiversity, as the Macedonia-Thrace refuge, in which it is located, serves as an entranceway for European faunal elements to Anatolia. Although comprehensive studies have been conducted on the mayflies in some provinces of the Marmara Region, only four species have been reported from Sakarya province, which has many valuable aquatic habitats, and there is no detailed study.

This study, conducted in the Akçay Creek, aimed to address the deficiencies in the Marmara Region and provide more precise data on the Ephemeroptera fauna of the region. In this study, conducted in the Akçay Creek, 10 genera and 15 species belonging to five families were identified from the collected specimens. Thirteen of these species were reported for the first time from this area and are new records for Sakarya province.

Keywords: Mayflies, Nymph, Fauna, Marmara Region, Aquatic insects

Introduction

The order Ephemeroptera, one of the oldest and most primitive winged insect groups known, dates back to approximately 290 million years ago (late Carboniferous or Permian periods) (Edmunds & McCafferty, 1988; Brittain & Sartori, 2003). Unlike other insect groups, they have a winged stage called subimago before the adult stage. The order members, who spend most of their life cycle (99%) as nymphs in water, adapt to different habitats during this period, and morphological diversity occurs most frequently during this time (Barnard, 2011).

They are one of the important groups studied in zoogeographical studies as they are one of the oldest known insect groups, and due to factors that prevent their distribution, such as their nymphal stages being aquatic without exception, their ability to fly in adult stages, and their very short life span (Brittain, 1982; Kazancı, 2001; Ertorun & Tanatmış, 2004). Additionally, they are widely used as bioindicator organisms in studies assessing water quality (Barnard, 2011). Their sensitivity to organic pollution, presence in almost all freshwater systems, diverse feeding habits, ability to absorb toxic substances uniformly, and gradual and long-term response to environmental changes provide significant advantages in their use in studies on water quality (Landa & Soldan, 1995).

It is known that Ephemeroptera species, which can be found in almost all natural and clean waters, also constitute 10-25% of all macrozoobenthos in clean waters and make a significant contribution to secondary production in the food chain, especially in streams and stagnant waters (Brittain, 1982; Brittain & Sartori, 2003).

Since Ephemeroptera nymphs are highly sensitive to both long-term and short-term changes in the aquatic environment, they are often preferred as indicator organisms in various biotic indices, including the Chandler Biotic System (CBS), Biological Monitoring Working Party (BMWP), Trent Biotic Index (TBI), and Belgian Biotic Index (BBI), among others, for determining water quality. Some features of Ephemeroptera species make them suitable for use as bioindicators in determining water quality: Their long nymphal periods and spending this period in the aquatic environment, their nymphs being recognised taxonomically, being found in almost all aquatic ecosystems, reacting to changes in the environment gradually and for long periods, and having different feeding styles. (Alba-Tercedor et al., 1995; Kazancı et al., 1997; Landa & Soldan, 1995; Moog et al., 1997).

Many studies have been conducted to reveal the Ephemeroptera fauna of Türkiye and to determine the distribution of these species. To date, a total of 165 species (including four subspecies) belonging to 14 families and 33 genera of the Ephemeroptera order have been identified (Salur et al., 2016; Aydınlı & Ertorun, 2023).

Although studies have been conducted in the Marmara Region regarding the Ephemeroptera order, there are no studies covering the northeastern part of the region, where Kocaeli, Sakarya, and Yalova provinces are located (Salur et al., 2016). This region holds a critical position in zoogeographical terms, as it is situated on the Macedonia-Thrace line, which serves as the entrance and distribution route for Boreal European fauna elements into Anatolia.

The Akçay Creek, located in the Sapanca district of Sakarya Province, which is part of the Marmara Region, originates from the Eskiyayla region in the northwest of the Geyve district and merges with several small streams before flowing into the Sakarya River in the village of Adliye.

There is the Akçay Dam in the Eskiyayla region where the creek originates. In addition, there are trout farms, restaurants and marble processing facilities on the creek, especially around Adliye village, which is close to the Sakarya River (Baştürk, 2006; Baltacı & Aydın, 2016; Anonymous, 2018, 2023).

There is no detailed study on the Ephemeroptera order in Sakarya province, which contains important wetlands in the Marmara Region. To date, three studies have been conducted in this region, but only four species have been reported (Tanatmış, 1995; Taşdemir et al., 2008; Kazancı, 2013).

This study aims to collect samples of the Ephemeroptera order from Akçay Creek, located within the borders of Sakarya province, where the number of species that have not been studied extensively and have been identified within the provinces of the Marmara Region is relatively low, and to identify these species. At the same time, the identified species are intended to serve as a reference in future studies on biodiversity, biotic indices, and the determination and monitoring of water quality.

Materials and Methods

In this study, 308 larvae were collected and identified from six stations (Figure 1) on the Akçay Creek (Sakarya) in July, August, and September 2023, as well as in May 2024. During the field studies, sampling was conducted at each station from habitats with different ecological characteristics (stony or sandy ground structure, current velocity, presence or absence of aquatic vegetation, turbidity, etc.) (Figure 2).

The specimens were collected using a sieve (1mm mesh size), a water hand net, and forceps (leg. C. Gider). Samples were collected into bottles containing 70% ethyl alcohol, and data, including date, locality, elevation, and coordinates, were recorded (Table 1).

Based on their general body structures, the specimens were identified to the family and genus levels. Permanent slides were prepared by dissecting the mouthparts, forelegs, and gills to identify them to the species level. Slides and specimens were examined and identified using a Leica MZ12.5 stereomicroscope and a Leica DM LS2 light microscope. In the identification of the species, Grandi (1960), Müller-Liebenau (1969), Belfiore (1983), Malzacher (1984), Elliott et al. (1988), Harker (1989), Studemann et al. (1992), Kluge (1997), Bauernfeind (1995), Eiseler (2005), Bauernfeind & Soldán (2012) and Hrivniak et al. (2020) were used.

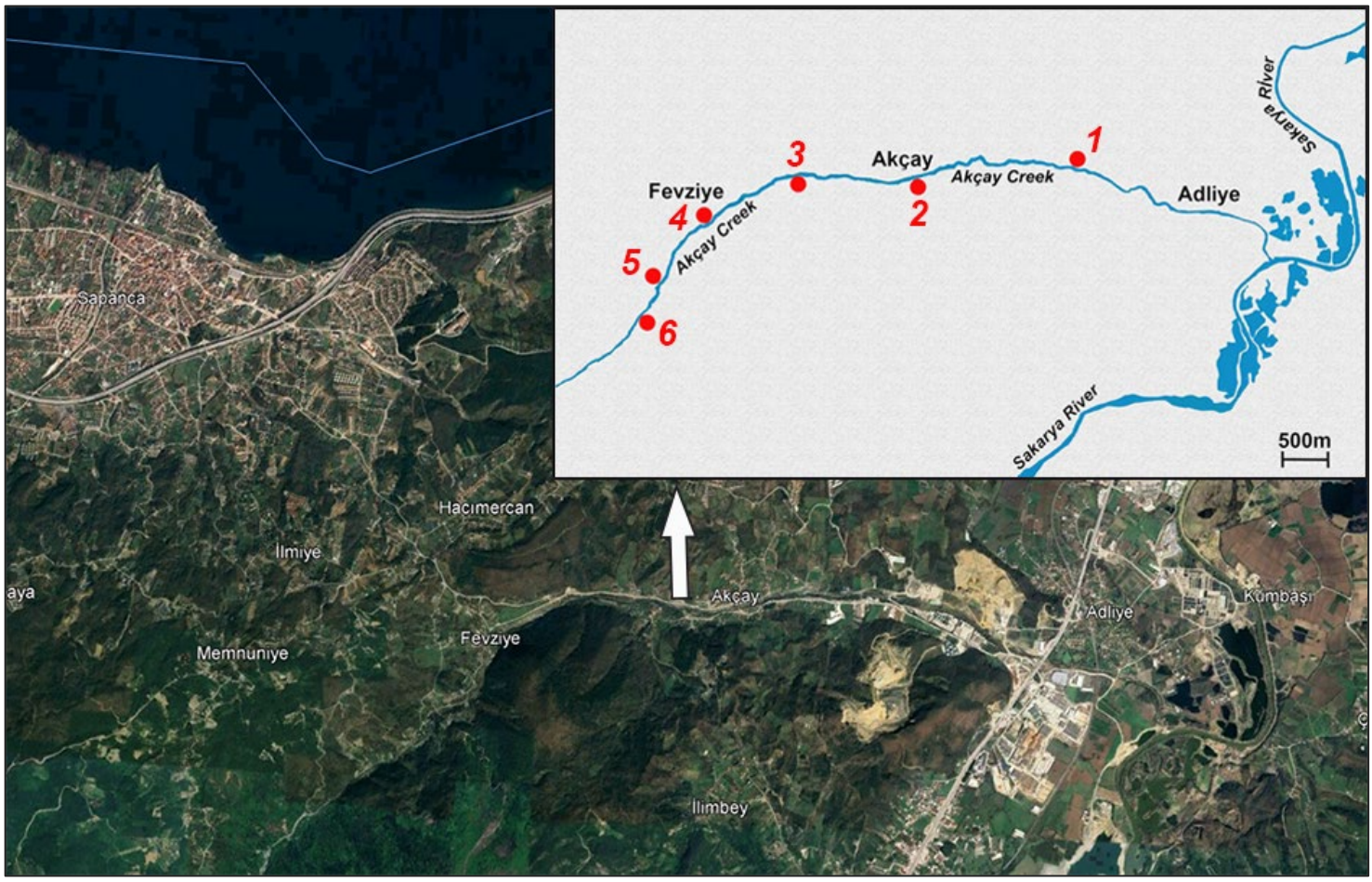

Figure 1. Map of the study area and location of sampling stations.

Figure 2. Photographs of sampling stations (st) (Photo: *C. Gider*).

Table 1. Information on the sampling stations.

Station	Station name	Coordinates (N, S)	Elevation (m)
1	Ahmediye	40°40'11.4", 30°20'21.9"	75
2	Akçay	40°40'05.7", 30°19'33.6"	106
3	Akçay-Fevziye yolu	40°40'06.0", 30°18'37.3"	144
4	Fevziye	40°39'46.7", 30°18'06.8"	173
5	Şükriye	40°39'17.9", 30°17'31.9"	224
6	Memnuniye	40°38'14.7", 30°16'29.3"	382

Results and Discussion

In this study, 308 specimens collected from 6 stations were examined, and 15 species belonging to 10 genera from 5 families were identified. The taxa list and sampling data for each species (date, number of individuals collected and station number, respectively) are given below:

Baetidae Leach, 1815

Baetis Leach, 1815

1. *Baetis (Baetis) buceratus* Eaton, 1870

   Material examined: 10.09.2023, 19 larvae (1); 10.09.2023, 1 larva (3).

2. *Baetis (Baetis) fuscatus* (Linnaeus, 1761)

   Material examined: 10.07.2023, 1 larva (1); 10.07.2023, 1 larva (4); 12.08.2023, 1 larva (3); 10.09.2023, 3 larvae (1); 10.09.2023, 4 larvae (3); 14.05.2024, 7 larvae (3); 14.05.2024, 1 larva (4).

3. *Baetis (Baetis) lutheri* Müller-Liebenau, 1967

   Material examined: 10.07.2023, 2 larvae (2); 10.07.2023, 1 larva (3); 12.08.2023, 1 larva (6); 10.09.2023, 2 larvae (1); 10.09.2023, 2 larvae (6); 14.05.2024, 5 larvae (3).

4. *Baetis (Baetis) vernus* Curtis, 1834

   Material examined: 12.08.2023, 1 larva (3); 10.09.2023, 7 larvae (1).

5. *Baetis (Rhodobaetis) rhodani* (Pictet, 1843)

   Material examined: 10.07.2023, 10 larvae (1); 10.07.2023, 15 larvae (2); 10.07.2023 13 larvae (3); 10.07.2023, 3 larvae (4); 10.07.2023, 1 larva (6); 12.08.2023, 28 larvae (3); 12.08.2023, 18 larvae (4); 12.08.2023, 6 larvae (5); 12.08.2023, 4 larvae (6); 10.09.2023, 3 larvae (1); 10.09.2023, 22 larvae (3); 10.09.2023, 1 larva (4); 10.09.2023, 8 larvae (5); 10.09.2023, 6 larvae (6); 14.05.2024, 20 larvae (3)

Procloeon Bengtsson, 1915

6. *Procloeon pennulatum* (Eaton, 1870)

   Material examined: 12.08.2023, 3 larvae (3); 10.09.2023, 7 larvae (3).

Cloeon Leach, 1815

7. *Cloeon dipterum* (Linnaeus, 1761)

   Material examined: 12.08.2023, 1 larva (2); 12.08.2023, 2 larvae (3).

Centroptilum Eaton, (1869).

8. *Centroptilum luteolum* (Müller, 1776)

   Material examined: 10.09.2023, 1 larva (3).

Heptageniidae Needham in Needham & Betten, 1901

Epeorus Eaton, 1881

9. *Epeorus (Caucasiron) znojkoi* (Tshernova, 1938)

   Material examined: 14.05.2024, 1 larva (3).

Electrogena Zurwerra & Tomka, 1985

10. *Electrogena affinis* (Eaton, 1886)

Material examined: 10.07.2023, 1 larva (4); 10.07.2023, 1 larva (5); 10.07.2023, 1 larva (6), 12.08.2023, 4 larvae (4), 12.08.2023, 3 larvae (6); 10.09.2023, 1 larva (5).

Leptophlebiidae (Banks, 1900).

Habrophlebia Eaton, 1881

11. *Habrophlebia lauta* McLachlan, 1884

Material examined: 10.07.2023, 7 larvae (4); 10.07.2023, 3 larvae (6).

Ephemerellidae Klapálek, 1909

Torleya Lestage, 1917

12. *Torleya major* (Klapálek, 1905)

Material examined: 14.05.2024, 1 larva (3).

Ephemerella Walsh, 1863

13. *Ephemerella (Serratella) ignita* (Poda, 1761)

Material examined: 10.07.2023, 1 larva (3).

Caenidae Newman, 1853

Caenis Stephens, 1835

14. *Caenis luctuosa* (Burmeister, 1839)

Material examined: 10.07.2023, 5 larvae (2); 12.08.2023, 6 larvae (2); 12.08.2023, 24 larvae (3).

15. *Caenis macrura* Stephens, 1836

Material examined: 12.08.2023, 9 larvae (1); 12.08.2023, 4 larvae (2); 12.08.2023, 2 larvae (4); 10.09.2023, 3 larvae (3).

To date, four species (*B. muticus, B. rhodani, C. dipterum, and Ephoron virgo*) have been reported from Sakarya Province (Salur et al., 2016). Thirteen of the 15 species identified in this study were reported for the first time from Sakarya province and are new records for this region (Table 2). When the distribution of species across sampling stations was examined, it was found that the first four stations had higher species diversity and a greater number of individuals collected than the others (Table 2). It is thought that since the ground at the fifth and sixth stations is covered with medium-to large-sized stones, the stream exhibits flood stream characteristics in these parts. Accordingly, the number of individuals and species diversity are low.

When the identified species were evaluated according to the sampling stations, it was determined that the pollution level increased as the Akçay Creek approached the Sakarya River. The presence of Heptageniidae species (which have low tolerance to pollution) and the higher species diversity in the third and sixth localities support this view. In addition, it is thought that the low species diversity in the first and second localities is related to the cumulative increase in waste from tourist hostels and trout farms along the Akçay Creek towards the first locality, as well as the presence of marble processing facilities in these localities.

Conclusion

Türkiye possesses a rich biodiversity potential due to its vast surface area, its regions exhibiting diverse ecological and geological characteristics, its availability of areas where faunal elements from different zoogeographic regions can spread, and its role as a gateway for species migrating from north to south and vice versa. The first study on the order Ephemeroptera in Türkiye was conducted by Ulmer in 1920. Until the 1980s, few studies by foreign researchers were available. In recent years, numerous new records and species have been identified, particularly in studies conducted by Turkish researchers, and the Ephemeroptera fauna of Türkiye is beginning to take shape. For all that, many areas remain to be researched, as Türkiye spans a large area. Studies have generally focused on large rivers and their basins, and the number of researchers working in this field is limited.

While studies have been conducted in the Marmara Region of Türkiye, there are no studies covering the northeastern part of the region, which includes Kocaeli, Sakarya, and Yalova provinces (Salur et al., 2016). The few studies conducted consist of samples collected from the Sakarya River. Considering that this region holds an important zoogeographical position due to its location on the Macedonia-Thrace line, which serves as the entry and distribution route for Boreal European fauna elements into Anatolia, it is expected that the study of other small streams and creeks in the region will also contribute to the fauna of Türkiye. In this context, this study, conducted in the Akçay Creek of the Sapanca district in Sakarya province, aimed to address these deficiencies in the Marmara Region and to provide more precise data on the Ephemeroptera fauna of the region.

Table 2. The number of individuals collected by species and station.

	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	Total
B. (B.) buceratus[*]	19	-	1	-	-	-	**20**
B. (B.) fuscatus[*]	4	-	12	2	-	-	**18**
B. (B.) lutheri[*]	2	2	6	-	-	3	**13**
B. (B.) vernus[*]	7	-	1	-	-	-	**8**
B. (R.) rhodani	13	15	83	22	14	11	**158**
P. pennulatum[*]	-	-	10	-	-	-	**10**
C. dipterum	-	1	2	-	-	-	**3**
C. luteolum[*]	-	-	1	-	-	-	**1**
E. (C.) znojkoi[*]	-	-	1	-	-	-	**1**
E. affinis[*]	-	-	-	5	2	4	**11**
H. lauta[*]	-	-	-	7		3	**10**
E. (S.) ignita[*]	-	-	1	-	-	-	**1**
T. major[*]	-	-	1	-	-	-	**1**
C. luctuosa[*]	-	11	24	-	-	-	**35**
C. macrura[*]	9	4	3	2	-	-	**18**
Total	**54**	**33**	**146**	**38**	**16**	**21**	**308**

[*] *Reported for the first time from Sakarya province*

Compliance with Ethical Standards

Conflict of interest: The author declares no actual, potential, or perceived conflict of interest for this article.

Ethics committee approval: Ethics committee approval is not required for this article.

Data availability: The data will be made available upon request from the author.

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Disclosure: -

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