New Data on Ephemeroptera, Plecoptera and Trichoptera from the Republic of Macedonia

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Abstract: As a result of field survey carried out in 2007-2014 at 18 sampling points at rivers of the Republic of Macedonia, new data on the distribution of four species of the order Ephemeroptera (Serratella ikonomovi, Ephemerella mucronata, Heptagenia longicauda and Caenis pseudorivulorum), two species of the order Plecoptera (Brachyptera beali beali and Taeniopteryx hubaulti) and one species of the order Trichoptera (Thremma anomalum) were collected. These data allow assessment of the conservation status of the studied species. This is the first record of the mayfly Caenis pseudorivulorum Keffermüller, 1960 in the Republic of Macedonia.

Key words: EPT, distribution pattern, conservation, Macedonia

Introduction

Freshwater ecosystems are of exceptional interest because they are among the most diverse habitats on earth. It is widely recognised that rapid globalisation has caused wide-spread degradation and disruption of natural systems, especially in the freshwater realm (Levêque et al. 2005). Declines in biodiversity are far greater in freshwaters (lakes, rivers and wetlands) than in the most affected terrestrial ecosystems (Dudgeon et al. 2006). According to the IUCN Red Lists of threatened species (IUCN 2015) and Abell et al. (2008), a quarter of the known worldwide freshwater species are listed as threatened or regionally extinct. Thus, the knowledge of the distribution and population status of the majority of aquatic species is urgently needed to understand and protect freshwater ecosystems worldwide (Mächler et al. 2014).

On the other hand, the present knowledge of freshwater diversity is still partial. According to a rough estimate by Balian et al. (2008), 60.4% of freshwater animal species are insects. Trichoptera, Plecoptera and Ephemeroptera (usually known as EPT taxa) represent 15%, 5% and 4%, respectively, of the total number of freshwater animal species (Balian et al. 2008). These organisms are essential elements in the benthic communities playing an important role in the nutrient cycling of materials and in trophic transfers (Ferro, Sites 2007). As EPT taxa are generally sensitive to environmental perturbations, they are widely used for ecological monitoring (Rosenberg, Resh 1993).

The vulnerability to variation in abiotic factors (pollution, habitat degradation, acidification, climate change, etc.) may lead to local or global extinction of many EPT species (Slavevska-Stamenkovic et al. 2011, Hershkovitz et al. 2015). In this regard, EPT species belong to the category of the most endangered aquatic insects (Hering et al. 2009, Petrović et al. 2014, 2015). However, globally there are only
11 (seven Extinct, two Vulnerable, one Endangered and one Critically Endangered) EPT taxa included in the IUCN Red Lists for threatened species (IUCN 2015). The larvae of EPT species, as well as of the other aquatic invertebrates are notoriously difficult to inventory because of their small size, often low population densities and patchy distribution (Mächer et al. 2014), which probably contributes to their low level of conservation.

Compared to Western and Central Europe (e.g., Graf et al. 2008, 2009; Buffagni et al. 2009), scarce information on the distribution and conservation status of EPT taxa from the Balkan Peninsula is available (Ibrahim et al. 2012, 2014, Tyufekchieva et al. 2013, Petrović et al. 2014, 2015). In the Republic of Macedonia, previous studies have been mainly focused on the taxonomy of EPT taxa. Ephemeroptera have been extensively examined by Ikonomov (1951, 1953, 1954 a, b, 1958, 1960, 1961 a, b, c, d, 1963 a, b, 1964, 1970) and, more recently, by Vidinova (1998), Smiljkov, Slavevska-Stamenkovic (2004) and Smiljkov et al. (2008).


Compared to mayflies and stoneflies, Trichoptera (caddisflies) is relatively insufficiently known insect order in Macedonia (Radovanović 1942, Botosaneanu 1960; Pavlovski 1991, Arsov 1991, Kuman 1997, Kuman, Malik 1999). Considerable progress has been made in recent years and new taxa were described (Oláh 2010, Oláh et al. 2011, 2013 a, b, Oláh, Kovács, 2013, 2014, Oláh et al. 2014, Vitecek et al. 2015).

Although historical data are of great importance, future changes in the composition of the EPT taxa in Macedonia will go undetected unless current distribution of existing species is well documented. Thus, the aim of this paper is to report new data on

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Fig. 1. Localities of the studied water bodies
some rare and endemic EPT taxa collected during the last years in the Republic of Macedonia, thus improving the knowledge on their geographic distribution and assisting to make a preliminary assessment of their conservation status.

Material and Methods

We present part of the results from the survey of 18 sampling points (Fig. 1) classified as: Site A - Bregalnica River (S1-S11); Site D - Mala Reka River (S12), Tresonechka River (S13), Rosochka River (S14), Portica (Lazaropolska) River (S15); Site B - Orevovechka River (S16-S17) and Site C - Lenishka River (S18). Data for the geographical coordinates, altitude, sampling period and ecoregion (according to Illies 1978) for each locality is presented in Table 1.

Table 1. Characteristics of the sampling sites

<table>
<thead>
<tr>
<th>Code</th>
<th>River/Locality</th>
<th>Altitude (m)</th>
<th>Longitude (°N)</th>
<th>Latitude (°E)</th>
<th>Ecoregion</th>
<th>Sampling period</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Dve Reki</td>
<td>1 300</td>
<td>41°43'37.5''</td>
<td>22°59'16.5''</td>
<td>7</td>
<td>October 2008-September 2009</td>
</tr>
<tr>
<td>S2</td>
<td>Ramna River</td>
<td>1 100</td>
<td>41°43'52.6''</td>
<td>22°56'56.3''</td>
<td>7</td>
<td>October 2008-September 2009</td>
</tr>
<tr>
<td>S3</td>
<td>upstream Berovo</td>
<td>856</td>
<td>41°41'59.8''</td>
<td>22°51'27.9''</td>
<td>7</td>
<td>October 2008-September 2009</td>
</tr>
<tr>
<td>S4</td>
<td>upstream Dechevo</td>
<td>601</td>
<td>41°56'32.5''</td>
<td>22°48'15.7''</td>
<td>7</td>
<td>October 2008-September 2009</td>
</tr>
<tr>
<td>S5</td>
<td>upstream Kalimanci dam</td>
<td>536</td>
<td>41°59'20.8''</td>
<td>22°39'16.9''</td>
<td>7</td>
<td>October 2008-September 2009</td>
</tr>
<tr>
<td>S6</td>
<td>downstream Kalimanci dam</td>
<td>420</td>
<td>41°58'03.6''</td>
<td>22°34'32.4''</td>
<td>7</td>
<td>October 2008-September 2009</td>
</tr>
<tr>
<td>S7</td>
<td>v. Teranci</td>
<td>317</td>
<td>41°51'45.4''</td>
<td>22°20'58.5''</td>
<td>7</td>
<td>October 2008-September 2009</td>
</tr>
<tr>
<td>S8</td>
<td>mouth of Zletovica River</td>
<td>296</td>
<td>41°51'32''</td>
<td>22°15'12''</td>
<td>7</td>
<td>October 2008-September 2009</td>
</tr>
<tr>
<td>S9</td>
<td>v. Dolni Balvan</td>
<td>282</td>
<td>41°48'21''</td>
<td>22°12'12''</td>
<td>7</td>
<td>October 2008-September 2009</td>
</tr>
<tr>
<td>S10</td>
<td>v. Sofilari</td>
<td>257</td>
<td>41°42'34''</td>
<td>22°8'12''</td>
<td>7</td>
<td>October 2008-September 2009</td>
</tr>
<tr>
<td>S11</td>
<td>mouth of Bregalnica to Vardar</td>
<td>154</td>
<td>41°36'24.344''</td>
<td>21°55'23.011''</td>
<td>7</td>
<td>October 2008-September 2009</td>
</tr>
<tr>
<td>S12</td>
<td>Mala Reka River</td>
<td>735</td>
<td>41°32'9.888''</td>
<td>20°38'25.987''</td>
<td>6</td>
<td>April 2011</td>
</tr>
<tr>
<td>S13</td>
<td>Tresonechka River</td>
<td>1150</td>
<td>41°34'2.03''</td>
<td>20°44'46.895''</td>
<td>6</td>
<td>April 2011</td>
</tr>
<tr>
<td>S14</td>
<td>Rosochka River</td>
<td>810</td>
<td>41°32'35.07''</td>
<td>20°40'22.729''</td>
<td>6</td>
<td>April 2011</td>
</tr>
<tr>
<td>S15</td>
<td>Portica (Lazaropolska) River</td>
<td>1170</td>
<td>41°31'28.85''</td>
<td>20°41'27.81''</td>
<td>6</td>
<td>April 2011</td>
</tr>
<tr>
<td>S16</td>
<td>downstream the local fishpond</td>
<td>860</td>
<td>41°23'48.32''</td>
<td>21°38'2.75''</td>
<td>6</td>
<td>March 2011, March 2012</td>
</tr>
<tr>
<td>S17</td>
<td>upstream entering Prilep Reservoir</td>
<td>740</td>
<td>41°23'1.971''</td>
<td>21°36'48.361''</td>
<td>6</td>
<td>March 2011, March 2012</td>
</tr>
<tr>
<td>S18</td>
<td>upstream course</td>
<td>1455</td>
<td>41°16'18.609''</td>
<td>20°33'13.628''</td>
<td>6</td>
<td>July 2014</td>
</tr>
</tbody>
</table>

The field survey was carried out between October 2007 and July 2014. Aquatic macroinvertebrates were collected with Surber sampler and hand-net with mesh size 500 μm, and in some cases (for coarse sand and silt substrata) an Ekman grab. Standard methodology for collection of bottom fauna (EN 28265:1994, EN 27828:1994, EN 9391:1995) was followed. EPT larvae specimens were separated from the other organisms, preserved in 80% ethanol and deposited in the Macedonian National Collection of Invertebrates (MNCI), Faculty for Natural Science and Mathematics, Skopje, R. Macedonia. The keys of Aubert (1959), Edigton, Hildrew (1981), Elliot et al. (1988), Hynes (1977), Waringer, Graf (1997, 2013), Wallace et al. (2003) and Zwick (2004) were used for identification of the EPT larvae. The systematic presentation follows Jong et al. (2014) and Bauerfeind, Soldan (2012).

Abbreviations of collectors: BR=Biljana Rimcheska, VS=Valentina Slavevska-Stamenković.

**Ephemera mucronata** (Bengtsson, 1909)


**Heptagenia longicauda** (Stephens, 1835)

**Material studied**: Bregalnica River, S11: 01.XI.2008: 7 la, leg. VS (MNCI).

**Caenis pseudorivulorum** Keffermüller, 1960


**Note**: New species for the fauna of the Republic of Macedonia.

**Plecoptera**

**Brachyptera beali beali** (Navás, 1924)


**Taeinipteryx hubaulti** Aubert, 1946

**Material studied**: Bregalnica River, S6: 24.XII.2007: 1 la, leg. VS (MNCI).

**Trichoptera**

**Thremma anomalum** McLachlan, 1876


**Discussion**

Our study shows that in Macedonia there are still unexplored areas concerning mayfly species. During the comprehensive survey of macroinvertebrate fauna from Bregalnica River, the presence of new and rare mayfly species was confirmed. Among them, *Caenis pseudorivulorum* Keffermüller, 1960 presents a Ponto-Caspian faunal element widespread all over Europe (Bauernfeind, Soldan 2012). Even though previously known from Bulgaria (Vidinova 2003), Greece (Bauernfeind 2003) and Serbia (Petrović et al. 2015), until now this species has not been reported from Macedonia. The finding of this species in the middle and lower part of Bregalnica River (from S5 to S11), confirms its affinity to the potamal of large rivers with gravel and sandy microhabitats (Buffagni 1997, 1999, 2003, Vidinova 2003). The records of *C. pseudorivulorum* in Macedonia contribute to the better knowledge of its distribution range on the Balkan Peninsula.

The mayfly *Serratella ikonomovi* (Puthz, 1971) was observed in the waters of several countries in Southern European, such as Bosnia and Herzegovina (Tanasević 1979), Serbia (Studemann et al. 1989, Simić, Simić, 2003, Savčić et al. 2010), Albania (Studemann et al. 1989), Greece (Studemann et al. 1989, Bauernfeind 2003), Italy (Buffagni et al. 2003) and Spain (López-Rodríguez et al., 2008), but never from Ecoregion 7 (Eastern Balkans). In the Republic of Macedonia, this species was previously reported from several streamlets from the western part (Ecoregion 6 - Hellenic Western Balkans) of the country (Ikonomov 1961, Studemann et al. 1989). In the current study, larvae of this rare species were found on stony substrate in the Upper Bregalnica River (S3; Fig. 1), which is the first finding of *S. ikonomovi* for the Ecoregion 7 (Illies 1978). Based on the fact that this Mediterranean faunistic element inhabits higher altitudes along the Bregalnica River (856 m a.s.l.), we presume that the region is under increasing influence of Mediterranean climate.

The rheophilic mayfly *Ephemera mucronata* (Bengtsson, 1909) is widespread in Europe (with the exception of the British Inlands and the Iberian Peninsula), oriental regions of the former USSR and North America (Belfiore et al. 1990, Bauernfeind, Soldan 2012). Concerning the Republic of Macedonia, scarce populations of the species were recorded by Ikonomov (1961) from three springs of the Baba and Osogovo Mountains. A field survey conducted on the upper course (S1 and S2; Figure 1) of Bregalnica River revealed that this rare mayfly inhabits Maleshevski Mountains too. These localities are the easternmost populations of *E. mucronata* in the Republic of Macedonia.

Another rare mayfly, *Heptagenia longicauda* Stephens 1835, is a well known species from the Western Palearctic (Bauernfeind, Soldan 2012).
Previously it was recorded by Ikonomov (1963a) from the middle and lower course of Vardar River. In the current study, few larvae of *H. longicauda* were collected from the stone bedrocks and submerged logs and plants at S11 (mouth of Bregalnica into Vardar River), although we expected it at locality S9 and S10 which also belong to the lower part of the river. Despite its eurivalue to the most of ecological factors (Macadam 2003), *H. longicauda* usually avoids places with α-mesosaprobic conditions (Vidinova, Russev 1997, Bauernfeind, Soldan 2012). Another reason for the restricted distribution of the heptageniid population in the lowland parts of many European rivers is the gravel extraction in the catchments, which alters the aquatic environment, and in many cases causes total loss of habitat (Macadam 2006). This could be a possible explanation for the extinction of *H. longicauda*, from the sampling point S9 (gravel extraction) and S10, one of the most polluted sites on the Bregalnica River (Slavevska-Stamenkovic, unpublished data).

The results of this study provide new data for the distribution of two rare Plecoptera species in the Republic of Macedonia: *Brachyptera beali beali* (Navás, 1924) and *Taeniopteryx hubaulti* Aubert, 1946. From a zoogeographical point of view, *B. beali beali* is a Balkan endemic stonefly (Graf et al. 2009) reported from Bosnia and Herzegovina (Murić et al. 2011), Greece (Aubert 1963, BerthélemY 1971, Zwick 1978) and Montenegro (Murányi 2008). According to Ikonomov (1983 b, 1986 b) and recently to Murányi et al. (2014) *B. beali beali* inhabits five springs in Southern Macedonia. Currently, Orevochevka River presents the northernmost point of its known distribution in the country.

The rheophilic stonefly *Taeniopteryx hubaulti* is an European species. According to Graf et al. (2009) it is known from Ecoregions 2 (Pyrenees), 4 (Alps), 5 (Dinaric Western Balkans), 6 (Hellenic Western Balkans), 7 (Eastern Balkans), 8 and 9 (Western and Central Highlands) and 10th (Carpathians). In Macedonia, the larvae of the stonefly *T. hubaulti* were previously reported only from the Brachinska River (Ikonomov 1974). In the current study its presence (a single larvae specimen) was recorded at site S6. Bregalnica River, after Kalimanci Dam is characterised with high current speed, colder water during the year, low fluctuation of temperature and high oxygen saturation which offers optimal conditions for its occurrence. Additionally, the restricted area and the fact that larvae were not collected during the last 50 years suggest that, if the species exists it is particularly rare; perhaps under higher risk of extinction, or that larvae occupy an unusual habitat which has not been sampled. Similar conservation status of the species was determined in the neighbouring countries Bulgaria and Serbia (Tyufekchieva et al. 2013, Petrović et al. 2014).

The caddisfly *Threuma anomalum* McLachlan, 1876 is a subendemic species for Balkan Peninsula, Carpathians and Caucasus (Graf et al. 2008, Živić et al. 2013). So far in Europe the species was known from Ecoregions 5, 6, 7, 10 and 24 (Oláh, Kovács 2013, Živić et al. 2013, Ibrahimî et al. 2014). Additionally, *T. anomalum* was found by Sipahiler (2007) from the Asian part of Turkey, which belongs to Ecoregion Y (Asia Minor).

In the Republic of Macedonia the adult stage of *T. anomalum* has been reported from Shar Planina Mountains (Kumanski 1997, Oláh, Kovács 2014) and Pelister (Radovanović 1942), and larvae were recorded from Podgorecka River, Jablanica Mts. (Radovanović 1942). In the current study limited numbers of specimens (11) of *T. anomalum* were found. Despite intensive research performed by Slavevska-Stamenkovic (unpublished data) on the Jablanica Mts, reported as area for protection (Biodiversity Strategy and Action Plan of the Republic of Macedonia, 2004), a single larvae specimen was registered (Lenishka River, S18). It should be stressed that the spring areas, upper courses of the streams and streamlets on this mountain are under higher anthropogenic pressure, and especially abstraction of water, which probably caused the disappearance of *T. anomalum*. The other ten larvae were found in Mawla Reka River (S12), Tresonecka River (S13), Lazaropolska River (S15) and Rosocka River (S14) that belong to the „Mavrovo“ National Park. Restricted distribution range in the country and scarce populations, especially in the Jablanica Mts., suggest that *T. anomalum* belongs to the group of threatened caddisfly species in the Republic of Macedonia. The similar population trend of this taxon is registered in some of our neighbouring countries. Namely, recent study in Western Serbia and Northern Montenegro has not recorded this species, in spite of its previous presence (Živić et al. 2013).

**Conclusion**

Our results highlight the importance of new surveys in the area in order to assess the overall biodiversity of this group of aquatic insects and to estimate population status or extinction rates of the EPT taxa according to IUCN criteria. Obtained data could be useful for selection the regions of high conservation values where effective protection measures should be applied.

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