Caddisflies of regulated and unregulated stretches of the lower Hron River (The Danube Basin, Slovakia)

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Abstract

This study presents initial results of the research focusing on the assessment of changes in a macroinvertebrate assemblage after 20 years of operation of a small hydropower plant situated in the lower Hron River. Its aim was to provide faunistic data on Trichoptera obtained between the spring of 2019 and the summer of 2020 in the river stretches between the villages of Psiare and Jur nad Hronom. This part of the river includes seminatural stretches that alternate with those modified by the embankment, weirs, and dams; the main part of the investigated area is affected by the small hydropower plant in the village of Turá. Altogether, 46 caddisfly species were collected by different sampling methods and identified during the present study, including several rare species, such as Ceraclea riparia *(Albarda, 1874),* Leptocerus interruptus *(Fabricius, 1775),* Oecetis tripunctata *(Fabricius, 1793), and* Orthotrichia angustella *(McLachlan, 1865). Further spreading of* Adicella syriaca *(Ulmer, 1907) in Slovakia was documented as well. The caddisfly fauna of the lower Hron River has been subjected to several studies in the past and all available data are compared and briefly discussed.*

Keywords

Trichoptera, faunistics, Pannonian ecoregion, epipotamal, small hydropower plant

Introduction

Aquatic insects of the Hron River have been the subject of several studies in recent decades. Krno (2007) examined the longitudinal zonation and anthropogenic impact on ecological metrics of stonefly assemblages. The longitudinal zonation of chironomids was studied by Bitušík et al. (2006), and that of blackflies by Illéšová et al. (2008). Similarly, Čiliak et al. (2014) analysed the environmental factors that affect the distribution of caddisfly assemblages in the longitudinal profile of the river. Tributaries of the upper Hron River were also studied, and data on the structure of the caddisfly and mayfly community were provided by Novikmec (2005) and Svitok (2006).

In the past, the river had been severely impacted by urban sewage and industrial wastewaters (Krno 2007). Due to the improvement in water quality in the 90s, as well as the absence of large damming constructions (Bitušík et al., 2006), the river became a reference model for zonation of unbound Carpathian rivers in the study

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by Čiliak et al. (2014). Since that period, construction of hydropower plants along the entire river course became common.

It has been well-documented that the presence of dams and weirs causes a decrease in the biodiversity of macroinvertebrates, as well as changes in species composition (Spence & Hynes, 1971; Munn & Brusven, 1991). These invoked changes may be more significant than those caused by climate change (Graf, 1999). The main processes caused by dams can be categorised as biogeochemical changes via disruption of water and sediment transport, water temperature alteration, as well as disruption in transport of organisms and nutrients (Poff & Hart, 2002). Along with the influence of industrial areas and land use, it can be concluded that the river is affected by the so-called ´urban stream syndrome´ (Meyer et al., 2005; Walsh et al., 2005).

The most intensively investigated part of the river is probably its lower stretch in the vicinity of the village of Turá due to the damming by the small hydropower plant (SHP), Turá, in 2000. To assess the impact of the construction and operation of the SHP, an extensive study was done (Lisický, 2003). The detailed results of the study on mayflies and stoneflies were presented by Krno (2005). Krno (2006) subsequently published data on caddisflies and alderflies which included a review of all previous caddisfly records from that river stretch (cf. Dudich, 1958; Novák & Obr, 1966; Elexová, 1998). The aim of this paper is to present new data as well as contribute to the current knowledge of the caddisfly fauna of the Hron River.

Material and methods

The Hron River, with its length of 279.5 km, is the second longest river in Slovakia and a left tributary of the Danube River. The river's catchment is 5,465 km^2 (Škoda et al., 2005).

Caddisfly adults were swept from the riparian vegetation at several sites alongside the stretch of the lower Hron River between the villages of Psiare and Jur nad Hronom (Figure 1). This part of the river was chosen for investigation of the effect of the SHP, Turá, since several previous studies had been conducted there. On one occasion, an LED UV light was used to attract caddisflies at the riverbank in the village of Kalná nad Hronom. Collected caddisfly adults were preserved in 75 % ethanol and identified according to Malicky (2004). Although this study was primarily focused on caddisfly adults, we also used larval material to extend the species spectrum and distributional data. Benthic samples were collected by the kicking method (Frost et al., 1971), preserved in 4 % solution of formaldehyde, and sorted in the laboratory. Caddis larvae were identified according to Waringer & Graf (2011) and Waringer et al. (2017).

Site description

S1 – Village of Psiare (cadastral part of the Hronský Beňadik village) (177 m a.s.l.), 48°19'32"N 18°33'01"E, (DFS 7677c), visited on 2.vii.2019, 14.v.2020, 25.viii.2020. The site could be characterised as unregulated, wadable stretch with rapid current. The river bottom consisted mainly of macrolithal, supplemented with large boulders (megalithal). Psammal and gravel were also present. The riparian vegetation was well-preserved (also at all study sites).

S2 – Village of Kalná nad Hronom (157 m a.s.l.), 48°12'00"N 18°31'23"E, (DFS 7777c), visited on 24.viii.2020. All material captured by UV-light attracting. The site was situated in an urbanised area below the reservoir of a small hydropower plant in the original river channel.

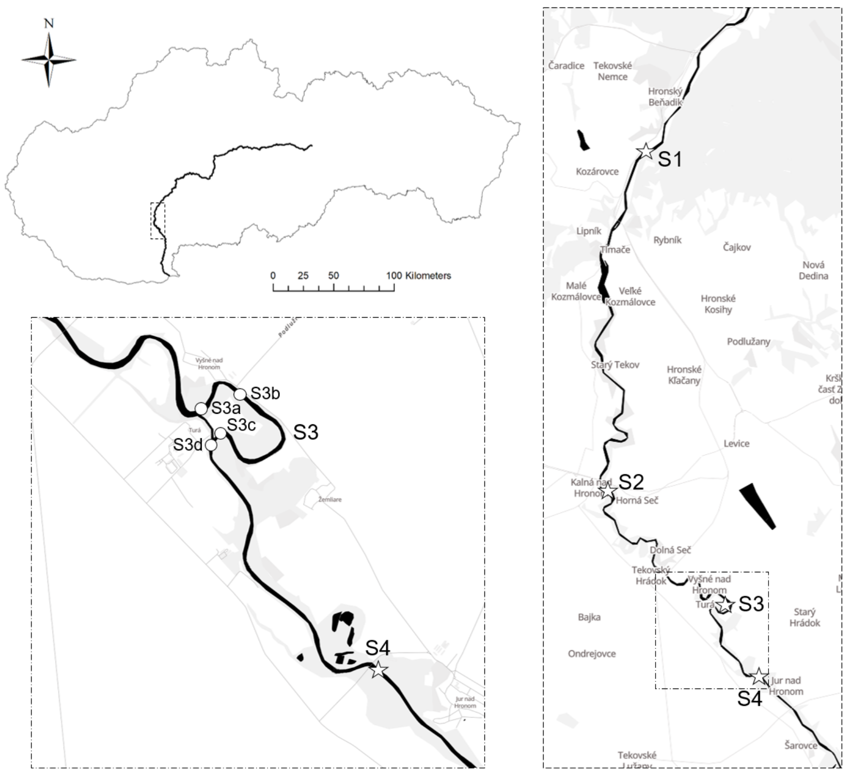

Figure 1. Map of investigated sites at the Hron River

S3 – Meander at the village of Turá, visited on 6.vi.2019, 2.vii.2019, 14.v.2020, 24.viii.2020. In this case, four sites were merged because of their relative vicinity; thus, the distances were negligible for winged adults. All four sites (within an altitude range of 154 – 145 m a.s.l., DFS 7877b) belonged to the meander at the village of Turá and were affected by a small hydropower plant, as well as further regulation (fragmentation by weirs). The first collecting site S3a, 48°09'32"N 18°35'03"E, was situated in the beginning of the meander below the main dam that created the reservoir upstream. The second collecting site S3b, 48°09'32"N 18°35'35"E, and the third collecting site S3c, 48°09'08"N 18°35'29"E, lied upstream of the second weir with slow water current. The fourth collecting site S3d, 48°09'13"N 18°35'07"E, was situated below the confluence of the main channel and the derivation channel and below the third weir. By merging the four sites into S3, the results became more coherent; however, it also means that the sampling effort at S3 was more extensive than at S1, S2, and S4. The stretch within the meander was the richest in macrophytes when compared to all other sites and contained diverse habitats with different flow conditions and substrate structure.

S4 – Village of Jur nad Hronom (140 m a.s.l.), 48°07'44"N 18°36'50"E, (DFS 7877d), visited on 6.vi.2019, 2.vii.2019, 14.v.2020, 24.viii.2020. This was the lowermost site, unregulated, with relatively good natural conditions. The site was typical of the presence of riffles, more rapid current, and gravel was the dominant substrate; macrolithal and psammal were present as well.

Results and discussion

Altogether, 46 species of Trichoptera were identified from all samples containing over 3,000 adults and larvae (Table 1). Most species were found as adults; however, several species (*Rhyacophila nubila*, *Polycentropus flavomaculatus*, *Hydropsyche bulbifera*, *Brachycentrus subnubilus*, *Anabolia furcata*, *Allogamus auricollis*, *Lepidostoma hirtum*, *Athripsodes albifrons*, and *Oecetis ochracea*) were recorded exclusively in the larval stage. If the relative abundance of adults is compared, the most abundant species was *Psychomyia pusilla* with 539 individuals, which represented 25 % of all individuals. The second was *Agapetus laniger* with 186 individuals (8.6 %). In addition, females of the *Hydroptila sparsa* Species Group, which represents several species, were quite numerous (32.85 %) in the sample from the light trap. All other species were less than 70 specimens; the most abundant of them were Leptoceridae, such as *Athripsodes cinereus* (3.1 %), *Adicella syriaca* (3 %), and *Setodes punctatus* (2.32 %). From the Hydropsychidae family, the most abundant were *Hydropsyche angustipennis* (2.46 %) and *Cheumatopsyche lepida* (2.18 %).

The faunistic data are summarised in Table 1 and consequently compared to the previous studies that focused on caddisflies from the Hron River in Table 2.

From the faunistic point of view, several rare species of Slovak Trichoptera fauna were recorded:

Ceraclea riparia has so far only been known from the Váh river basin in Slovakia according to two historical records: Pazsiczky (1914) reported the species from Trenčín (Trencsén) (middle stretch of the Váh River) and Mayer (1937) found it in the Rajčanka River above Rajec (left tributary of Váh in NW Slovakia). In Hungary, the species is sparsely distributed in the Danube River and its tributaries; however, it is still quite rare (Nógrádi & Uherkovich, 2002). It is also considered to be extinct in the Czech Republic (Chvojka & Komzák, 2017). In many Western European countries, it is denoted as endangered or even likely to be extinct, possibly because of anthropogenic impacts (pollution, regulation) in lowland rivers or specific habitat preferences (macrolithal) (Urbanič et al., 2003).

Leptocerus interruptus was collected on the Slovak side of the Danube River by Mayer (1935) and Krno et al. (2018). It is quite rare in neighbouring countries as well, and was completely absent in the Czech Republic, Austria, and Hungary for decades until its recent rediscovery (Chvojka et al., 2016; Graf et al., 2017; Kiss, 2012; Nógrádi & Uherkovich, 2002). This species may have a high indicatory value, even as an umbrella species in lowland rivers because of its ecological requirements (Buczyńska et al., 2016).

Additionally, *Oecetis tripunctata* is found among significant records as well, since its distribution in Slovakia is still insufficiently known. Records exist from the lower stretch of the Váh River (Pazsiczky, 1914; Navara et al., 2020a) and an unverified finding of larva from foothills of the Malé Karpaty Mts. (Pomichal, 1979). At present, the species occurs locally in the lower Morava River basin (left tributary of the Danube River) in the Czech Republic (Komzák & Chvojka, 2018). It is quite rare in the western part of Hungary, while more findings are known from the Tisa River basin (Nógrádi & Uherkovich, 2002).

Another rare record is that of *Orthotrichia angustella*. This species is known from SW Slovakia on the basis of a single record (Pomichal, 1979). In Hungary, the species became known in 1986 (Nógrádi 1986) and proved to be frequent in artificial water courses of Central Transdanubia; however, it may probably prefer unpolluted, highly-oxygenated waters (Nógrádi, 2001). In the Czech Republic, the species is considered absent in Bohemia (Chvojka & Komzák, 2017), though it was recorded for the first time quite recently in the Dyje River in Morava (Komzák & Kroča, 2018). Recently, it was also found in Austria for the first time (Graf et al., 2017).

We also documented further spreading of *Adicella syriaca* in Slovakia. This species is currently known from the Danube, Váh and Hron rivers (Navara et al., 2020b). In the Hron River, a new record of the species was made at the village of Psiare (S1) in 2020, approximately 25 km upstream from the only recorded site at the village of Turá (S3) in 2019. Therefore, it is quite possible that the species has expanded its distribution area.

Although the caddisfly fauna of the lower Hron River was the subject of several studies in the past (e.g., Dudich, 1958; Elexová, 1998; Krno, 2006; Čiliak et al., 2014), we have increased the knowledge of Trichoptera species distribution considerably. Krno (2006) found 23 species during his study and summarised previously published data, listing 32 species altogether (Table 2). In his study, records of *Limnephilus binotatus* and *Leptocerus tineiformis*, which are not recorded in the current research, originated from the side arms of the lower Hron. These habitats were not investigated in our work. Nevertheless, additional 22 species were identified during recent research and altogether, 55 taxa are presently known from the lower Hron River. A higher number of species compared to the previous studies (Table 2) was recorded due to the diverse sampling methods, which focused primarily on caddisfly adults. The importance of adult collections in obtaining relevant faunistic information is generally known (e.g., Malicky, 2014). These methods enabled us to acquire comprehensive information on the caddisfly fauna of the lower Hron River. The limnological studies (Elexová, 1998; Čiliak et al., 2014) that had been carried out there dealt with benthic samples exclusively, and thus the presence of larvae of micro-caddisflies (Hydroptilidae) and several Leptoceridae appeared to be underestimated. Regarding the larval records, larvae of *Agapetus laniger* were not found during previous limnological investigations, although this species was numerous in our samples and recently proved to be rather abundant in the Váh and Hron rivers (Navara et al., 2019; Navara et al., 2020a).

In comparison to the Váh River´s lower stretch (Navara et al., 2020a), the caddisfly fauna of the Hron River´s lower stretch was notably richer with 46 species as compared to 27 species from the corresponding stretch of the lower Váh (the town of Piešťany and downstream sites). The higher species diversity of the Hron could be explained by more favourable hydromorphological conditions of the stream channel and a lack of large impoundments, derivation channels, and large urban areas. More stable flow conditions could be an important factor as well, when compared to the Váh River where the fluctuations in discharge were notable. The fluctuations can negatively impact the macroinvertebrate fauna (Álvarez-Troncoso et al., 2015). Likewise, riparian vegetation and macrophytes richness appeared to be more preserved in the investigated stretch of the Hron River than in the Váh River. These may also be factors that positively affect the biodiversity of aquatic macroinvertebrates (Tokeshi & Pinder, 1985; Carpenter & Lodge, 1986; Rios & Bailey, 2006).

We can assume that this river stretch may serve as a refugium of rare species that are sensitive to anthropogenically induced changes. In any case, the high diversity and presence of rare and possible umbrella species in the lower Hron signifies the need of protection and preservation of natural conditions as much as possible, and this corresponds highly to the recommendations by Lisický (2003) upon his revitalisation survey. The importance of the river habitat and its preservation was further confirmed by the occurrence of a population of the Common kingfisher (*Alcedo atthis*) (Ambruš & Bulánková, 2005).

Further detailed research focusing on the fauna and environmental conditions of the main Danube tributaries in the Danube Lowland is still necessary for assessment of overall biodiversity.

Table 1. Species list of the examined sites of the Hron River

Species/site	S1	S2	S3	S4
Rhyacophila cf. *nubila* (Zetterstedt, 1840)	3L			
Agapetus laniger (Pictet, 1834)	37L	4f	4L, 2m	23L, 7m, 4f
	126m, 42f			
Hydroptila angulata Mosely, 1922			3m	
Hydroptila forcipata (Eaton, 1873)	31m, 9f	2f	1m, 2f	1m
Hydroptila lotensis Mosely, 1930	14m	2m	18m	8m
Hydroptila sparsa Curtis, 1834	1m	1m	18m	1m
Hydroptila sparsa gr. females	4f	667f	33f	4f
Hydroptila vectis Curtis, 1834			3m	
Ithytrichia lamellaris Eaton, 1873	2m, 2f		2f	
Orthotrichia angustella (McLachlan, 1865)		1f	5m, 2f	1m

Orthotrichia costalis (Curtis, 1834)		1f	3m, 2f	
Cheumatopsyche lepida (Pictet, 1834)	14L, 8m, 1f	5m, 2f	47L, 8m, 3f	212L, 13m, 2f
Hydropsyche angustipennis (Curtis, 1834)	2m		49m, 2f	
Hydropsyche bulbifera McLachlan, 1878	1L		2L	
Hydropsyche contubernalis McLachlan, 1865	4L		7L, 1m	2m
Hydropsyche exocellata Dufour, 1841	1L	12m	4L, 19m	2L, 3m
Hydropsyche incognita Pitsch, 1993	1m		1L	
Hydropsyche modesta Navás, 1925	1m			
Hydropsyche spp.	13f	11f	13L, 11f	15f
Cyrnus trimaculatus (Curtis, 1834)			2m, 1f	
Neureclipsis bimaculata (Linnaeus, 1758)			1L, 7m, 5f	
Polycentropus flavomaculatus (Pictet, 1834)			1L	
Lype phaeopa (Stephens, 1836)			12m, 1f	
Psychomyia pusilla (Fabricius, 1781)	18L 84m, 32f	13m, 148f	7L, 142m, 56f	75L, 36m, 26f
Ecnomus tenellus (Rambur, 1842)		7m, 12f	1L, 3m, 1f	
Brachycentrus subnubilus Curtis, 1834	425L		9L	52L
Anabolia furcata Brauer, 1857			2L	
Limnephilus flavicornis (Fabricius, 1787)			1m	
Limnephilus lunatus Curtis, 1834			1f	1m
Allogamus auricollis (Pictet, 1834)	1L			
Stenophylax permistus McLachlan, 1895			1m	
Goera pillosa (Fabricius, 1775)	11m, 1f			
Lepidostoma hirtum (Fabricius, 1775)	1L			
Adicella syriaca Ulmer, 1907	8m, 3f		1L, 36m, 19f	
Athripsodes albifrons (Linnaeus, 1758)			2L	
Athripsodes cinereus (Curtis, 1834)	4m, 5f		3L, 34m, 21f	
Ceraclea annulicornis (Stephens, 1836)			1f	1m
Ceraclea dissimilis (Stephens, 1836)			1m	
Ceraclea riparia (Albarda, 1874)				1L, 1m, 1f
Leptocerus interruptus (Fabricius, 1775)			1f	
Mystacides azurea (Linnaeus, 1761)	2m, 2f		13m, 3f	1m
Mystacides longicornis (Linnaeus, 1758)			1m	1f
Mystacides nigra (Linnaeus, 1758)			34m, 5f	

Oecetis lacustris (Pictet, 1834)		1f	
Oecetis notata (Rambur, 1842)		1m, 3f	3L, 1m, 1f
Oecetis ochracea (Curtis, 1825)		2L	2L
Oecetis tripunctata (Fabricius, 1793)		3m, 1f	1m
Setodes punctatus (Fabricius, 1793)	15m, 12f	5m, 5f	5L, 11m, 2f

Explanations: m - male, f - female, L - larva
Site: S1 – Psiare (177 m), S2 – Kalná and Hronom (157 m), S3 – Turá (145 – 154 m), S4 – Jur and Hronom (140 m)

Table 2. Comparison of recorded species from the current study to previous studies

Species presence/study	Krno (2006)*	Čiliak et al. (2014)×	Current study 2019-2020
Rhyacophila cf. *nubila* (Zetterstedt, 1840)	+		+
Rhyacophila s. str.		+	
Agapetus laniger (Pictet, 1834)			+
Hydroptila angulata Mosely, 1922			+
Hydroptila forcipata (Eaton, 1873)			+
Hydroptila lotensis Mosely, 1930			+
Hydroptila sparsa Curtis, 1834	+		+
Hydroptila vectis Curtis, 1834			+
Hydroptila sp.	+		
Ithytrichia lamellaris Eaton, 1873	+		+
Orthotrichia angustella (McLachlan, 1865)			+
Orthotrichia costalis (Curtis, 1834)			+
Cheumatopsyche lepida (Pictet, 1834)			+
Hydropsyche angustipennis (Curtis, 1834)	+		+
Hydropsyche bulbifera McLachlan, 1878	+	+	+
Hydropsyche bulgaromanorum Malicky, 1977	+		
Hydropsyche contubernalis McLachlan, 1865	+	+	+
Hydropsyche exocellata Dufour, 1841	+	+	+
Hydropsyche incognita Pitsch, 1993	+	+	+
Hydropsyche modesta Navás, 1925	+	+	+
Cyrnus trimaculatus (Curtis, 1834)	+		+
Neureclipsis bimaculata (Linnaeus, 1758)			+
Polycentropus flavomaculatus (Pictet, 1834)	+	+	+
Lype phaeopa (Stephens, 1836)			+

Psychomyia pusilla (Fabricius, 1781)	+	+	+
Tinodes sp.		+	
Ecnomus tenellus (Rambur, 1842)	+		+
Brachycentrus subnubilus Curtis, 1834	+	+	+
Anabolia furcata Brauer, 1857	+		+
Limnephilus binotatus Curtis, 1834	+		
Limnephilus flavicornis (Fabricius, 1787)	+		+
Limnephilus lunatus Curtis, 1834			+
Allogamus auricollis (Pictet, 1834)			+
Stenophylax permistus McLachlan, 1895			+
Goera pillosa (Fabricius, 1775)	+		+
Silo pallipes (Fabricius, 1781)	+		
Lepidostoma hirtum (Fabricius, 1775)			+
Adicella syriaca Ulmer, 1907			+
Athripsodes aterrimus (Stephens, 1836)	+		
Athripsodes albifrons (Linnaeus, 1758)			+
Athripsodes bilineatus (Linnaeus, 1758)	+		
Athripsodes cinereus (Curtis, 1834)	+	+	+
Ceraclea annulicornis (Stephens, 1836)	+		+
Ceraclea dissimilis (Stephens, 1836)	+		+
Ceraclea riparia (Albarda, 1874)			+
Leptocerus interruptus (Fabricius, 1775)			+
Leptocerus tineiformis Curtis, 1834	+		
Mystacides azurea (Linnaeus, 1761)	+		+
Mystacides longicornis (Linnaeus, 1758)	+		+
Mystacides nigra (Linnaeus, 1758)	+		+
Oecetis furva (Rambur, 1842)	+		
Oecetis lacustris (Pictet, 1834)			+
Oecetis notata (Rambur, 1842)			+
Oecetis ochracea (Curtis, 1825)			+
Oecetis tripunctata (Fabricius, 1793)			+
Setodes punctatus (Fabricius, 1793)	+		+
Triaenodes bicolor (Curtis, 1834)	+		
Total number of taxa	33	11	46

* - Including studies reviewed in the paper, i.e., Dudich (1958), Novák & Obr (1966), Elexová (1998); studies included adult sampling as well.

ˣ - Only sites from the lower Hron were considered (i.e., Kalná n. Hronom, Jur n. Hronom, Bíňa, Kamenica n. Hronom); the study was aimed exclusively at larval sampling.

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