

New data on Odonata fauna of the Drava River basin

Nove spoznaje o fauni vretenaca porječja rijeke Drave

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Abstract

Odonata are amphibious insects widely used as bioindicators of freshwater ecosystems' health. Their assemblages at lotic and lentic habitats in the area of the Drava River basin are still not completely known. Therefore, we surveyed Odonata fauna at two Drava River oxbows and the Drava River lower reaches in Croatia and Hungary. We recorded a total of 21 species. Although most of them were generalists, we also documented two species of conservation concern: *Sympetrum fonscolombii* and *Ophiogomphus cecilia*. During the fieldwork, we also observed some of the anthropogenic impacts present at studied habitats, such as plastic waste disposal, and removal of riparian vegetation, including the removal of individual trees for purposes of fishing. With this study, we increased our knowledge about Odonata fauna of the Drava River basin. Our data can be used for future monitoring of the recorded species and their habitats.

Keywords: Drava River, oxbow, dragonflies, damselflies, species composition, anthropogenic impact

Sažetak

Vretenca su amfibijski red kukaca koji se diljem svijeta koriste kao bioindikatori zdravlja slatkovodnih ekosustava. Sastav njihovih zajednica na lotičkim i lentičkim staništima porječja rijeke Drave još uvijek nije u potpunosti istražen. Stoga, inventarizirali smo faunu vretenaca dvaju rukavaca rijeke Drave i rijeku Dravu u području njezina donjeg toka na teritoriju Hrvatske i Mađarske. Zabilježili smo ukupno 21 vrstu, od čega je većina njih generalista. No, zabilježili smo i dvije vrste od konzervacijskog značaja: *Sympetrum fonscolombii* i *Ophiogomphus cecilia*. Tijekom terenskog rada na istraživanim staništima uočili smo i neke antropogene utjecaje, poput odlaganja plastičnog otpada, te uklanjanja obalne vegetacije, uključujući i sječju pojedinih stabala u svrhu izrade postaja za lov ribe. Ovo istraživanje doprinosi boljem poznavanju faune vretenaca porječja rijeke Drave te se prikupljeni podaci mogu koristiti za buduće praćenje stanja populacija zabilježenih vrsta i njihovih staništa.

Ključne riječi: rijeka Drava, rukavac, vretenca, sastav vrsta, antropogeni utjecaj

Introduction - *Uvod*

Predatory insects Odonata represent an important link between the aquatic and terrestrial habitats due to their aquatic nymphal and terrestrial adult life stage (Askew 2004, Corbet and Brooks 2008). Approximately 6400 extant species occur on Earth (Schorr et al. 2022), of which 143 are so far recorded in Europe (Kalkman et al. 2008). Some species are confined to lotic habitats, such as streams and rivers, while others prefer lentic ones, such as ponds, oxbows, and lakes (Dijkstra and Lewington 2006). This is mainly due to the species' requirements for habitat morphological and physicochemical parameters, such as the concentration of dissolved oxygen, water velocity, microhabitat composition, food availability, and presence of predators (Corbet and Brooks 2008, Vidaković Maoduš et al. 2022, Vilenica 2017, Vilenica 2020a, b). Also, one of the key characteristics of Odonata habitats is the presence and structure of aquatic and riparian vegetation, which provides microhabitats for the resting of adults, copulation, oviposition, nymphal survival, etc. (Askew 2004; Dijkstra and Lewington 2006; Vilenica and Mihaljević 2022). Due to such specific requirements of a particular species for habitat conditions, these insects are widely used as bioindicators of freshwater ecosystems' health (Golfieri et al. 2016). Nevertheless, the increased anthropogenic pressures on freshwater habitats worldwide, combined with climate change, will most probably result in a decline in the conservation status of many Odonata species in the near future (Kalkman et al. 2008). Therefore, faunistic studies represent a very important basis for future monitoring of species distribution and their population sizes.

Previous research on Odonata in the habitats within the Drava River basin in Croatia was mainly focused on the anthropogenically altered sections of the river and have recorded a total of 11 Odonata species (Vilenica and Mihaljević 2022). On the other hand, Móra and Csabai (2019) provided a detailed overview of aquatic macroinvertebrate fauna research in the Drava River basin area in Hungary, where 53 Odonata species were recorded. Here, it is important to mention the high species richness of riverine species of the Gomphidae family (*Gomphus flavipes* (Charpentier, 1825), *Gomphus vulgatissimus* (Linnaeus, 1758), *Onychogomphus forcipatus* (Linnaeus, 1758), *Ophiogomphus cecilia* (Fourcroy, 1785)), which are generally very sensitive to water pollution and are decisive indicators of good water quality in the Drava River. Therefore, they play a very important role in current and future conservation measures in the area of the Drava River's lower reaches (Móra and Csabai 2019; Vilenica and Mihaljević 2022). It is also important to mention some of the species prefer old river channels and oxbows rich in wetland vegetation, that are also of national or international conservation importance, such as *Leucorrhinia caudalis* (Charpentier, 1840), *Leucorrhinia pectoralis* (Charpentier, 1825), *Epithea bimaculata* (Charpentier, 1825) and *Erythromma najas* Hansemann, 1823 (Kalkman et al. 2010; Móra and Csabai 2019; Vilenica and Mihaljević 2022). Despite the existence of previous research, the main goal of this study was to increase our knowledge about the Odonata fauna of lotic and lentic habitats in the area of the Drava River's lower reaches and to detect the existing anthropogenic pressures and their potential impact on the recorded species.

Materials and Methods - Materijali i metode

The study area is located in the climate zone Cfb, characterized by a moderately warm humid climate with a hot summer (the mean air temperature of the hottest month is below 22 °C) (Köppen climate division, Šegota and Filipčić 2003). The average annual air temperature is 11 °C and the average amount of precipitation is 800 mm (Zaninović et al. 2008).

The survey encompassed a total of ten study sites in the Drava River basin (in the area of the river's lower reaches), including sites on the two Drava River oxbows as well as the sites along the left and right banks of the Drava River in the vicinity of those oxbows (Table 1, Figures 1, 2). One of the oxbows is located in Croatia, in Ferdinandovac village, along the right banks of the Drava River. The other one, the Heresznye oxbow stretches across Croatian (60% of its length) and Hungarian (40% of its length) territory and is located along the left banks of the Drava River.

The Odonata survey was conducted on four occasions, in June and August 2021 (11 and 23 June, 14 and 24 August). Surveys were conducted during a period of approximately 45 - 90 minutes (depending on the study site). Species flying or perching within five meters of the surveyed route were counted (high abundances of damselflies were estimated immediately). Central areas of the Drava River and the Heresznye oxbow were surveyed from the boat. Odonata fauna was investigated during sunny weather between 10 a.m. and 6 p.m. Species were predominantly recorded visually and identified by eye or using close-focusing binoculars, while some species were caught using an entomological net (e.g., those from the genus *Sympetrum*), identified in the field and released.

Table 1 Study sites included in the survey of the Drava River's Odonata

Tablica 1. Lokacije istraživanja faune vretenaca porječja rijeke Drave.

Study site number <i>Broj lokacije istraživanja</i>	Study site description <i>Opis lokacije istraživanja</i>	Date <i>Datum</i>	Coordinates <i>Koordinate</i>
1	Transect through the centre of the Heresznye oxbow, Hungary	11.06.2021.	46°02'32", 17°15'55"; 46°02'48", 17°15'40"
2	Pond next to the Heresznye oxbow, Hungary	11.06.2021.	46°02'52", 17°15'43"
3	Transect along the left Drava River bank, Croatia	11.06.2021.	46°02'53", 17°15'25"
4	Transect along the right Drava River bank, Ferdinandovac, Croatia	11.06.2021., 24.08.2021.	46°03'02", 17°15'07"; 46°03'24", 17°15'12"
5	Transect through the Heresznye oxbow, at the border of the Croatian and Hungarian territory	23.06.2021., 14.08.2021.	46°02'53", 17°15'37"
6	Transect along the banks of the Heresznye oxbow and meadows along the left bank of the Drava River, Hungary	23.06.2021., 14.08.2021.	46°02'44", 17°15'50"; 46°02'19", 17°15'58"
7	Transect along the centre of the Drava River (between the Brodić and entrance to the Heresznye oxbow)	24.08.2021.	46°01'20", 17°15'42"; 46°03'11", 17°15'20"
8	Northern section of the Heresznye oxbow, Croatia	24.08.2021.	46°03'01", 17°15'24"
9	Right banks of the Drava River, Brodić, Croatia	24.08.2021.	46°01'20", 17°15'42"
10	Ferdinandovac oxbow, located next to the right bank of the Drava River, Croatia	24.08.2021.	46°03'25", 17°15'16"

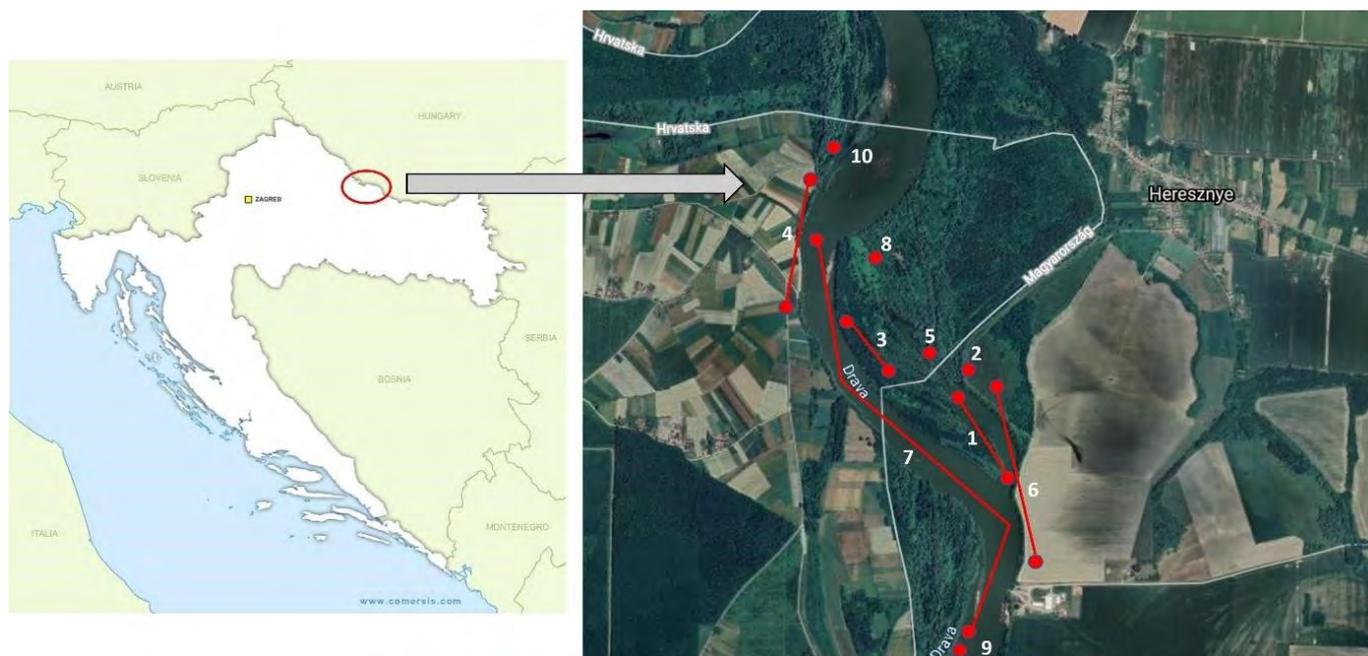


Figure 1 Study area position with the map of the study sites (study site numbers correspond to those in Table 1).
Slika 1. Položaj područja istraživanja s kartom lokacija istraživanja (brojevi lokacija istraživanja odgovaraju onima u Tablici 1).



Figure 2 Study sites included in the Odonata survey at habitats around the Drava River's lower reaches (study site numbers correspond to those in Table 1).
Slika 2. Lokacije istraživanja faune vretenaca na staništima oko donjeg toka rijeke Drave (brojevi lokacija istraživanja odgovaraju onima u Tablici 1).

Results and Discussion - *Rezultati i rasprava*

A total of 21 Odonata species was recorded at ten study sites within the surveyed area of the Drava River's lower reaches (Table 2, Figure 3). This represents 31% of the Croatian and 32% of the Hungarian Odonata fauna (Belančić et al. 2008, Müller et al. 2006), as well as 40% of the Odonata fauna previously recorded for the Drava River lower reaches area (Móra and Csabai 2019, Vilenica and Mihaljević 2022). Most probably, this is not the final species list that can be expected in this area. Many authors have already emphasized the necessity of combining various sampling methods (i.e. sampling of nymphs, exuviae, and adults) in order to obtain the complete Odonata fauna of a particular habitat (Vilenica et al. 2020a, b). Therefore, we recommend including the sampling of nymphs (if possible) and exuviae in future studies. Moreover, the results of this survey could have been negatively affected by non-optimal weather and hydrological conditions during the study season (spring and summer 2021). Namely, the spring period was extremely humid, with large amounts of precipitation, which is why the water level of the Drava River and both oxbows was high, and the terrain was often very difficult to access. On the other hand, the summer period was characterized by several heat waves, with high air temperatures (above 35°C), which possibly resulted in the lower activity of species during some of the fieldwork sessions. Nevertheless, the results of our study increase our knowledge about the Odonata fauna of the Drava River basin, particularly of its lower reaches region. The obtained data can be used for future monitoring of species and their habitats.

Most of the species recorded with this survey were generalists and common in freshwater habitats in the area of the Drava River's lower reaches, both in Croatia and Hungary (Dijkstra and Lewington 2006; Móra and Csabai 2019; Vilenica and Mihaljević 2022). The most numerous and/or the most frequently recorded species were *Orthemtrum albistylum* (Figure 3a) and *Sympetrum sanguineum* (Figure 3b) from the suborder Anisoptera, and *Platycnemis pennipes* (Figure 3c) and *Calopteryx splendens* among the representatives of the suborder Zygoptera. *Orthemtrum albistylum* prefers sunny standing water habitats (ponds, lakes, oxbows) (Dijkstra and Lewington 2006), but it was also recorded in the lentic habitats with little or no aquatic vegetation (Vilenica et al. 2011, 2020a). *Sympetrum sanguineum* prefers sunny lentic habitats with well-developed riparian vegetation (Dijkstra and Lewington 2006), and it is possible that most of the recorded individuals originate from the Ferdinandovac oxbow (study site 10) or from some other sunny oxbow with well-developed vegetation located in the vicinity of our study sites. *Calopteryx splendens* and *Platycnemis pennipes* are species that prefer sunny streams and rivers, but it is also possible to find them in well-oxygenated lentic habitats (Dijkstra and Lewington 2006; Vilenica et al. 2020a).

The highest number of species, 17, was observed at sites located along the Heresznye oxbow (study sites 1, 2, 5, 6, 8), followed by the Drava River transects (study sites 3, 4, 7, 9), and the oxbow in Ferdinandovac (study site 10), where a total of 12 and nine species was observed, respectively (Table 2). This could be related to the sampling effort, but also to some extent to habitat characteristics. Amongst the key environmental variables for habitat selection of adult Odonata is the structure of aquatic and riparian vegetation (Askew 2004; Corbet and Brooks 2008), as it is important for e.g. mating, oviposition, resting, but it also provides nymphs a shelter for hiding from predators or for lurking for their own prey (Corbet and Brooks 2008; Perron et al. 2021; Vilenica et al. 2022). Even though we observed rather high Odonata species richness at the Heresznye oxbow, optimal vegetation conditions were not observed, which may indi-

cate that some of the recorded species do not complete their life cycle at this habitat but visit it in search of food. The oxbow was in large part surrounded by forest and characterized by rich riparian vegetation, nevertheless, optimal structure or even the presence of aquatic vegetation at most of the oxbow was not observed (Figure 2). Instead, akal (gravel) mixed with argylal (silt, clay) were dominant substrates in the northern part of the oxbow (study site 8), while argylal and xylal (dead plant parts) dominated in its southern sections (study sites 1, 5, 6). Moreover, the northern section was in the shade of a dense forest, which resulted in a lower number of recorded species. Nevertheless, there we recorded some species characteristic for shaded forested habitats, such as *Aeshna cyanea*, and *Calopteryx virgo* (Dijkstra and Lewington 2006). Due to the aforementioned habitat characteristics, at this oxbow, we have not recorded species preferring sunny standing water habitats with rich aquatic and riparian vegetation, such as *Aeshna affinis* (Vander Linden, 1820), *Aeshna isocetes* (Müller, 1767), *Epi-theca bimaculata*, *Leucorrhinia pectoralis*, which were some of the species recorded at the oxbows around the lower reaches of the Drava River during previous research (Móra and Csabai 2019). The other investigated oxbow, the Ferdinandovac oxbow has very well-developed aquatic and riparian vegetation (Figure 2), which makes it a more suitable habitat for a higher number of lentic species (Dijkstra and Lewington 2006). However, lower species richness detected there compared to the Heresznye oxbow is most probably due to the lower sampling effort and very difficult accessibility to the Ferdinandovac oxbow, as it was surrounded by dense trees and bushes. Moreover, in data interpretation, one must have in mind that adult dragonflies (Anisoptera) have very high dispersal ability, and in search for food or favourable habitat for mating and oviposition, they can fly far from the habitat from which they emerged (Corbet and Brooks 2008). Therefore, it is possible that some of the riverine species that were recorded around the oxbows, such as *Onychogomphus forcipactus*, *Ophiogomphus cecilia* and *Gomphus vulgatissimus* (Dijkstra and Lewington 2006), most likely came there from the Drava River. Moreover, some of the typical lentic species, such as *Anax imperator*, *Libellula depressa* or *Sympetrum sanguineum*, that were recorded along the Drava River transects, most probably originate from some of the lentic habitats nearby, such as the Ferdinandovac oxbow (Dijkstra and Lewington 2006).

It is important to mention species of conservation concern, such as *Sympetrum fonscolombii*, a species that inhabits warm and shallow ponds, sometimes without vegetation, where nymphs live in a muddy substrate or on aquatic vegetation (Dijkstra and Lewington 2006). In this survey, it was recorded at the northern part of the Heresznye oxbow (study site 8) and at the Ferdinandovac oxbow (study site 10). As only one individual was observed at the Heresznye oxbow, it is possible that it arrived from the Ferdinandovac oxbow or from some other lentic habitat in the vicinity. At the Croatian Red List of Odonata, this species is listed as near threatened (NT) due to the anthropogenic threats present at its habitats (Belančić et al. 2008). *Ophiogomphus cecilia*, a species that preferably inhabits larger lowland rivers with a sandy substrate (Dijkstra and Lewington 2006) is listed as a vulnerable (VU) species in Croatia due to its restricted distribution in the continental part of the country (Belančić et al. 2008). This species is also of international conservation concern: it is listed in Appendices II and IV of Habitat's Directive (Kalkman et al. 2010). The species was recorded in small abundance, and it is possible that all recorded individuals originate from the Drava River population, as adult individuals of this species are able to migrate long distances (Askew 2004).

During this survey, we have observed several anthropogenic impacts at visited habitats, such as plastic waste disposal (mainly plastic packaging, Figure 4 a, b) and small-scale deforestation (i.e. removal of the individual trees mainly from the riparian zone of the Drava River) (Figure 4c). At this point, those impacts should not have a significant influence on Odonata species. Along the left bank of the Drava River, we observed farms and agricultural land, which could negatively influence the water quality of aquatic habitats nearby and could have a negative impact on their Odonata assemblages (e.g. Vilenica and Mihaljević 2022). Many recent studies already showed a sensitivity of Odonata to water pollution (e.g. Vilenica et al. 2020a, b). At certain segments along the left and right banks of the Drava River, we observed fishing stations (Figure 4c). During their creation, the riparian vegetation was removed, which might have a negative impact on some riverine species that require vegetation for emergence, such as *Ophiogomphus cecilia* (Farkas et al. 2012). Nevertheless, considering that large sections along both banks of the Drava River are also unaffected by such actions, it is highly possible that those modifications do not pose an immediate threat to the species.

Table 2 Odonata species recorded at ten study sites in the Drava River basin in Croatia and Hungary (study site numbers correspond to those in Table 1). Legend: m = male, f = female

Tablica 2. Vrste vretenaca zabilježene na deset lokacija istraživanja u slivu rijeke Drave u Hrvatskoj i Mađarskoj (brojevi lokacija istraživanja odgovaraju onima u Tablici 1). Legenda: m = mužjak, f = ženka.

Date/Study site/Species Datum/lokacija istraživanja/vrsta	1	2	3	4	5	6	7	8	9	10		
<i>Calopteryx splendens</i> (Harris, 1780)	~20 m, f	~50 m, f	~100 m, f	~50 m, f	~20 m, f	7 m, 4 f	~20 m, f	3 m	2 f	7 m, 4 f	~30 m, f	~20 m, f
<i>Calopteryx virgo</i> Linnaeus, 1758											~3 m, 4 f	
<i>Coenagrion puella</i> (Linnaeus, 1758)		~20 m, f		~50 m, f		~100 m, f						
<i>Erythromma lindenii</i> Selys, 1840												~20 m, f
<i>Erythromma viridulum</i> Charpentier, 1840												~20 m, f
<i>Ischnura elegans</i> (Vander Linden, 1820)				~20 m, f		~20 m, f	6 m	5 m	3 m			~20 m, f
<i>Platycnemis pennipes</i> (Pallas, 1771)		~50 m, f	~400 m, f	~400 m, f	~100 m, f	~500 m, f	~400 m, f	~200 m, f	~200 m, f		~20 m, f	~100 m, f
<i>Aeshna cyanea</i> Müller, 1764						1 m					2 m	
<i>Anax imperator</i> (Leach 1815)					1 m							1 m
<i>Gomphus vulgatissimus</i> (Linnaeus, 1758)	2 m		1 f	1 f	1 m		1 m	1 f	1 m			
<i>Onychogomphus forcipatus</i> (Linnaeus, 1758)	3					3		1	3 m, 1 f			
<i>Ophiogomphus cecilia</i> (Charpentier, 1840)						2						1 f
<i>Cordulia aenea</i> (Linnaeus, 1758)					1 m	3			2 f			
<i>Crocothemis erythraea</i> Brullé, 1832					2 f							
<i>Libellula fulva</i> Müller, 1764	1 m											
<i>Libellula depressa</i> Linnaeus, 1758				1 m								2 m
<i>Orthetrum albistylum</i> Selys, 1848			3 m	1 f		8 m, 1 f	~30 m, f	4 m, 2 f	2 f			
<i>Orthetrum cancellatum</i> Linnaeus, 1758			1 f			7 m, 2 f	2 f					1 m
<i>Sympetrum fonscolombii</i> (Selys, 1840)										1 m		6 m
<i>Sympetrum sanguineum</i> Müller, 1764					2 m	~20 m, 1 f	1 m	3 m		2 m, 1 f	1 m	~30 m, f
<i>Sympetrum striolatum</i> Charpentier, 1840					1 m							2 m



Figure 3 Some of the Odonata species recorded in the study area located at habitats around the Drava River lower reaches in Croatia and Hungary: a) *Orthetrum albistylum* (adult male), b) *Sympetrum sanguineum* (adult male), c) *Platycnemis pennipes* (adult male and female in copulation).

Slika 3. Neke od vrsta vretenaca zabilježenih u području istraživanja koje se nalaze na staništima oko donjeg toka rijeke Drave u Hrvatskoj i Mađarskoj: a) *Orthetrum albistylum* (odrasli mužjak), b) *Sympetrum sanguineum* (odrasli mužjak), c) *Platycnemis pennipes* (odrasli mužjak i ženka u kopulaciji).



Figure 4 Anthropogenic impacts observed in the study area located within the Drava River basin in Croatia and Hungary: a), b) plastic waste disposal, c) removal of individual trees from the riparian zone of the Drava River as part of the construction activities of fishing stations.

Slika 4. Antropogeni utjecaji uočeni na području istraživanja koje se nalazi u slivu rijeke Drave u Hrvatskoj i Mađarskoj: a), b) odlaganje plastičnog otpada, c) uklanjanje pojedinačnih stabala iz obalnog pojasa rijeke Drave u sklopu izgradnje ribarskih postaja.

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