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The horseflies fauna diversity (Diptera: Tabanidae) in the habitats along the Mura river in Međimurje, Croatia

Raznolikost faune obada (Diptera: Tabanidae) na staništima uz rijeku Muru u Međimurju, Hrvatska

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Abstract

From May to September 2022, in the habitats along the Mura River, 1295 horseflies were sampled, classified into two subfamilies, six genera, and 21 species. Seven new records of horseflies were recorded for the first time in the researched area. Newly recorded species are: *Tabanus bovinus*, *Tabanus cordiger*, *Tabanus sudeticus*, *Heptatoma pellucens*, *Haematopota italica*, *Haematopota scutellata*, *Haematopota subcylindrica*. The species *Haematopota pluvialis* is the most abundant species, accounting for 60.07% of all sampled horseflies. *Tabanus bromius* followed with 21.23%, while the other 19 horseflies account for 18.7%. 18 species of horseflies belonged to the boreal-Eurasian type of fauna, two belonged to the Mediterranean type of fauna, i.e. the southern European subtype, while one species belonged to the Afro-Eurasian-arid type of fauna. In the collected sample of horseflies, 33 males classified into 10 species were recorded, while all other collected horseflies were females (1262 specimens) classified into 20 species. The greatest similarity of the horseflies fauna was recorded between the localities Križovec and Goričan, 81.81%. 17 species of horseflies were sampled with a modified Manitoba trap (the so-called canopy trap), and 14 species were sampled with an oil or liquid trap. The largest number of horsefly specimens (59.07%) was sampled in the month of July, while the least horseflies were sampled in September (0.15%). The most abundant species, *Tabanus bromius* and *Haematopota pluvialis*, recorded their highest peaks of abundance in July. The longest flight period lasting five months (from May to September) was recorded only for *Haematopota pluvialis*. *Tabanus bromius* was represented in all 11 localities, while the species *Haematopota pluvialis* was represented in 10 localities, as well as the species *Chrysops viduatus*. Based on the earlier research conducted in 2011 and current research of the horseflies fauna along the Mura river in Međimurje, 22 taxa of horseflies (21 species and 1 subspecies) classified into six genera were identified.

***Keywords*:** Horseflies, Tabanidae, Diptera, Mura, Međimurje, Croatia

Sažetak

Na staništima uz rijeku Muru od svibnja do rujna 2022. godine uzorkovano je 1295 obada svrstanih u dvije potporodice, šest rodova i 21 vrstu. Sedam novih nalaza vrsta obada zabilježeno je za istraživano područje. Novozabilježene vrste su: *Tabanus bovinus*, *Tabanus cordiger*, *Tabanus sudeticus*, *Heptatoma pellucens*, *Haematopota italica*, *Haematopota scutellata*, *Haematopota subcylindrica*. Vrsta *Haematopota pluvialis* najbrojnija je uzorkovana vrsta te iznosi 60,07% od ukupno uzorkovanih obada. Slijedi vrsta *Tabanus bromius* s 21,23% uzorkovanih jedinki, dok ostalih 19 vrsta obada iznosi 18,7%. 18 vrsta obada pripada borealno-euroazijskom tipu faune, dvije vrste pripadaju mediteranskom tipu faune, odnosno južnoeuropskom podtipu, dok jedna vrsta pripada afro-euroazijsko-aridnom tipu faune. U skupljenom uzorku obada utvrđeno je 33 mužjaka svrstanih u 10 vrsta, dok su svi ostali skupljeni obadi ženke (1262 jedinke) svrstane u 20 vrsta. Najveća sličnost faune obada zabilježena je između lokaliteta Križovec i Goričan 81,81%. Modficiranom manitoba klopkom (tzv. canopy trap) uzorkovano je 17 vrsta obada, a uljnom ili tekućom klopkom 14 vrsta. Najveći broj jedinki obada (59,07%) uzorkovan je u sprnju, dok je najmanje obada uzorkovano u rujnu (0,15%). Najbrojnije vrste *Tabanus bromius* i *Haematopota pluvialis* najveću brojnost bilježe u mjesecu srpnju. Najduži letni period u trajanju od pet mjeseci od svibnja do rujna zabilježen je samo za vrstu *Haematopota pluvialis*. Vrsta *Tabanus bromius* zastupljena je na svih 11 lokaliteta, dok je vrsta *Haematopota pluvialis* zastupljena na 10 lokaliteta kao i vrsta *Chrysops viduatus*. Na osnovi ranije obavljenih istraživanja tijekom 2011. godine i sadašanjih istraživanja u fauni obada uz rijeku Muru u Međimurju utvrđene su 22 svojte obada (21 vrsta i 1 podvrsta) svrstane u šest rodova.

***Ključne riječi*:** obadi, Tabanidae, dvokrilci, Mura, Međimurje, Hrvatska

Introduction - *Uvod*

Horseflies (Tabanidae) appear in the adult stage in the spring and summer months in different terrestrial habitats. Males are nectar feeders, while females mainly suck the blood of various warm-blooded animals and thus can participate in the mechanical transmission of various pathogens (Chvála et al. 1972; Foil 1989). In Europe, from the point of view of veterinary and medical entomology, *Haematopota pluvialis* L.,1758 and *Tabanus bromius* L., 1758 are the most interesting species. They are mostly present from mid-May to mid-September. The species *Haematopota pluvialis* is a vector of the bacteria *Francisella tularensis*. However, some other species from the genera *Tabanus* and *Chrysops* are also potential vectors, given that this bacteria was isolated from natural populations of the above-mentioned genera (Baldacchino et al. 2014). The species *Tabanus bovinus* is a vector of the bacteria *Anaplasma marginale* (Hornok et al. 2008), while the mechanical transmission of the Equine infectious anemia virus (EIAV) recorded in Italy is attributed to different species of horseflies (Deliberato et al. 2019). Despite these findings, studies into the vector potential of horseflies in Europe is not common, but there are many more numerous studies into the diversity of horsefly fauna. By researching the fauna of the horseflies in the past twenty-five years, the number of horsefly species in the fauna of Croatia has increased by seven species, and now amounts to 78 taxa (species, subspecies) classified into 10 genera and two subfamilies (Krčmar et al. 2011). However, systematic study of the fauna of horseflies in the continental and even in the Mediterranean part of Croatia is quite rare, considering that foreign and domestic entomologists mostly collected horseflies

during their study trips, excursions, or as part of some projects where the research of the horseflies fauna was not highlighted as the primary goal of the implementation project tasks. For this reason, study into the diversity of the horseflies fauna in many areas of Croatia has been partially carried out or has been completely absent. And there are very few areas in Croatia where research on the diversity of the horseflies fauna has been repeated after several years with the aim of comparing changes in the diversity and qualitative and quantitative composition of the horseflies fauna. One such area is along the Mura River in Međimurje, where the initial surveys of the diversity of the horseflies fauna of the area were carried out in 2011. For this reason, through systematic research of the fauna of horseflies along the Mura River in Međimurje from mid-May to mid-September 2022, an effort was made to determine the recent horsefly fauna, then the qualitative and quantitative composition of the horsefly fauna in the habitats along the upper and lower flow of the Mura River, and to compare the current data on the fauna of horseflies with data from the previously conducted research on the fauna of horseflies along the Mura river, as well as the zoogeographic affiliation of the sampled species, and the seasonal dynamics of the sampled horseflies.

Materials and Methods - *Materijali i metode*

Sampling of horseflies along the Mura River in Međimurje was carried out at 11 localities in different types of habitats such as managed forests (Kotoriba, Goričan), along the edge of different agrobiocenoses (Sveta Marija, Hodošan, Donji Hrašćan), in wet meadows (Novakovec, Podturen, Mursko Središće), along the bank of the Mura river (Dekanovec, Miklavec), and in the gravel pit (Križovec). The horseflies were sampled with three types of traps, a modified Manitoba trap (the so-called canopy trap) according to Hribar et al. (1991), with an oil or liquid trap, and with a sticky trap. During the research, 33 traps were used for each horsefly's sampling, which took place continuously over five months (May, June, July, August and September) with two sampling days per month. The first horseflies sampling took place on May 24th and 25th, 2022, the second on June 20th and 21st, 2022, the third on July 12th and 13th, 2022, the fourth on August 17th and 18th, 2022, the fifth on 12th and 13th September 2022. At each horsefly sampling, 33 traps were placed: 11 modified Manitoba traps (so-called canopy traps), 11 oil or liquid traps, and 11 black sticky traps. Modified Manitoba traps (so-called canopy traps) in all samplings were baited with 2 ml of attractant 1-octen-3-ol (Sigma-Aldrich Chemie, GmbH, Steinheim, Germany), oil or liquid traps made from shiny black plastic sheets were filled with 0.5 to 1 cm of edible sunflower oil (Zvijezda, Zagreb, Croatia) and black plastic buckets with a volume of 12 l (sticky trap) were coated with glue for horseflies (RD Haaksbergen, Geesteren, The Netherlands). At each locality, three traps were placed 5 meters apart. Horsefly sampling started at 9 am and ended at 7 pm. Traps were visited twice a day in all localities and cleaned. The sampled horseflies were stored in plastic bottles with 96% ethanol solution. The identification of the sampled horseflies was performed using the following identification keys Chvála et al. (1972), and Krčmar et al. (2011). Species names were written according to the catalog of Palaearctic species of horseflies Chvála (1988), and zoogeographic affiliation according to Olsufjev (1977). All identified horseflies were stored in plastic bottles with 96% ethanol solution. The faunal similarity analysis of the horseflies sampled at 11 localities was performed using the Sørensen index of faunal similarity according to Durbešić (1988).

Results - *Rezultati*

In 11 localities along the Mura River, a total of 1295 horseflies were sampled, classified into two subfamilies, six genera, and 21 species (Table 1). The most numerous is the genus *Tabanus* with seven sampled species, followed by the genera *Chrysops*, *Hybomitra*, *Haematopota* each with four sampled species, and the genera *Therioplectes* and *Heptatoma* each with one sampled species (Table 1). Seven new records of horsefly species were recorded for the area along the Mura River in Međimurje (Table 1). Newly recorded species are: *Tabanus bovinus*, *Tabanus cordiger*, *Tabanus sudeticus*, *Heptatoma pellucens*, *Haematopota italica*, *Haematopota scutellata*, *Haematopota subcylindrica* (Table 1). The record of the species *Heptatoma pellucens* is also a new record of the genus of horseflies for the researched area since the genus *Heptatoma* is represented by only one species. The species *Haematopota pluvialis* is the most numerous sampled species, accounting to 60.07% of all sampled specimens of the horseflies (Table 2). *Tabanus bromius* followed with 21.23% of the sampled specimens, while the other 19 species of horseflies made up 18.7% of the collected specimens (Table 2). Of the 21 sampled horsefly species, 18 belonged to the boreal-Eurasian type of fauna (BE), two species belonged to the Mediterranean type of fauna (M), i.e. the southern European subtype (SE), while one species belonged to the Afro-Eurasian-arid type of fauna (AE), (Table 1). In the collected sample of horseflies, 33 males classified into 10 species were recorded, while all the rest were females, represented by 1262 specimens (Table 1). Only the species *Tabanus bovinus* was represented with one male specimen, while in the case of the species *Tabanus tergestinus*, more males than females were sampled (Table 1). The most abundantly sampled males belong to the species *Tabanus tergestinus* and *Tabanus bromius*, where in the sample of male specimens they amount to 36.36% and 27.27%, respectively (Table 1). 67 horseflies classified into 14 species were sampled with an oil or liquid trap (Table 2), while 1228 horseflies classified into 17 species were sampled with a modified Manitoba trap (the so-called canopy trap). The species *Therioplectes gigas*, *Tabanus bovinus*, *Tabanus cordiger* and *Heptatoma pellucens* were only sampled with oil or liquid traps (Table 2). Also, for the species *Tabanus tergestinus*, the oil trap proved to be much more successful in sampling than the modified Manitoba trap (the so-called canopy trap) (Table 2). However, for the first six most abundant species, the most effective sampling trap was the modified Manitoba trap (so-called canopy trap) (Table 2), and also for the other species that were sampled in both types of traps with the exception of *Tabanus tergestinus* (Table 2). The sticky traps did not collect any horseflies. *Tabanus bromius*, the second most abundant species of horseflies, was represented in all 11 localities, while the most abundant species *Haematopota pluvialis*, was represented in 10 localities along the Mura River, as well as the species *Chrysops viduatus* which was fifth in abundance (Tables 3 and 4). Species *Chrysops caecutiens*, *Chrysops relictus*, *Hybomitra solstitialis*, and *Tabanus maculicornis* were represented in seven localities (Tables 3 and 4). The species *Tabanus sudeticus* and *Tabanus tergestinus* were represented in five localities, while the species *Chrysops parallelogrammus*, *Hybomitra muehlfeldi* and *Tabanus autumnalis* were present in four localities (Tables 3 and 4). The species *Hybomitra ukrainica* and *Heptatoma pellucens* were recorded in three localities (Tables 3 and 4). The species *Therioplectes gigas*, *Haematopota scutellata* and *Haematopota subcylindrica* were recorded at two localities, and the species *Hybomitra bimaculata*, *Tabanus bovinus* and *Tabanus cordiger* were recorded at one locality (Tables 3 and 4). In the upper flow of the Mura River, 1117 horseflies were sampled (86.25% of all sampled horseflies). In this sample, the presence of 18 species was recorded (Table 3), while in the lower flow of the Mura River, 178 horseflies were sam-

pled, classified into 16 species (Table 4). The species *Therioplectes giga*s, *Tabanus bovinus* and *Tabanus cordiger* were not sampled at the localities in the upper Međimurje, while the species *Hybomitra bimaculata*, *Hybomitra ukrainica*, *Haematopota italica*, *Haematopota scutellata* and *Haematopota subcylindrica* were not sampled at localities in the lower Međimurje (Tables 3 and 4). Thirteen species of horseflies were recorded in both researched areas along the Mura river in the upper and lower Međimurje (Tables 3 and 4). The largest number of horseflies was collected in the Novakovec locality, 464, and they were collected in a wet meadow at the edge of a white willow forest with marsh bedstraw. Podturen followed with 254 collected horseflies that were also collected in a wet meadow along the banks of the Mura river overgrown with fragmented remnants of white willow and black poplar forest (Table 3). Abandoned gravel pit in Križovac followed by 125 collected horseflies, then localities along the banks of the Mura river: Miklavec with 123, Dekanovec with 79 collected horseflies, and wet meadow in Mursko Središće with 72 collected horseflies (Table 3). At the Goričan locality, in the managed black and white poplar forest, 68 horseflies were collected, while at the Kotoriba locality, 24 horseflies were collected at the edge of the managed poplar forest (Table 4). At the edge of the agrobiocenosis of the corn field at the Hodošan locality, 40 horseflies were collected, at the Sveta Marija locality 37, while the smallest number of horseflies (10) was collected at the Donji Hrašćan locality (Table 4). In the three localities with agrobiocenoses, 13 species of horseflies were recorded, while in the managed forests in the Goričan and Kotoriba localities, 12 species of horseflies were recorded (Table 4). 18 species of horseflies were recorded on wet meadows in the Novakovec, Podturen, and Mursko Središće localities (Table 3). 12 species of horseflies were recorded in two localities along the banks of the Mura river, while 11 species were sampled in the abandoned gravel pit in Križovac (Table 3). The greatest similarity of the horsefly fauna was recorded between the localities Križovec and Goričan (81.81%), then Novakovec and Goričan (76.92%), Križovec and Novakovec (76.92%), and Miklavec and Podturen (76.19%). The smallest similarity of the horseflies fauna was recorded between the localities of Sveta Marija and Donji Hrašćan, and Novakovec and Donji Hrašćan, and amounted to 33.33%. The most common structure of the compared populations of horseflies in these 11 localities ranged from 50% to 81.81%, which showed that the structure of horsefly fauna in the investigated localities was very similar. The largest number of horseflies (765) and species (15) were sampled in July, which was 59.07% of all sampled horseflies (Table 5). August followed with 235 sampled horseflies classified into 10 species and amounted to 18.14% (Table 5). In June, 200 horseflies were sampled and classified into 12 species. The sampled number of specimens amounted to 15.44% (Table 5). In May, 93 specimens of horseflies were collected and classified into 13 species. This sampled number of horseflies amounted to 7.18% (Table 5). The fewest horseflies were sampled in September, with only two specimens were classified into two species, and this amounted to 0.15% of the sampled horseflies (Table 5). Four species *Therioplectes gigas*, *Hybomitra bimaculata*, *Tabanus bovinus* and *Tabanus cordiger* were recorded only in May, and *Haematopota italica*, *Haematopota scutellata* only in July (Table 5). The species *Tabanus maculicornis* in May and June, while the species *Hybomitra muehlfeldi*, *Tabanus sudeticus*, *Tabanus tergestinus*, *Haematopota subcylindrica*, appeared in June and July. The species *Heptatoma pellucens* was recorded in August and September (Table 5). A three-month-long flight period during the summer months of June, July, and August had been established for the species *Chrysops parallelogrammus* and *Tabanus sudeticus*. The flight period lasting four months, May, June, July, August was established for the following species: *Chrysops caecutiens*, *Chrysops relictus*, *Chrysops viduatus*, *Hybomitra*

solstitialis, and *Tabanus bromius*. Only the species *Haematopota pluvialis* has the longest flight period lasting five months from May to September (Table 5). The two most abundant species *Tabanus bromius* and *Haematopota pluvialis*, recorded their highest peak of abundance in July (Table 5). Also, species *Chrysops viduatus*, *Hybomitra muehlfeldi*, *Hybomitra solstitialis* and *Tabanus sudeticus* that are represented in the sample with more than 10 specimens are the most abundant in July (Table 5). In June, the highest peaks of abundance were recorded for the species *Chrysops caecutiens*, *Tabanus maculicornis* and *Tabanus tergestinus* (Table 5). Of all the recorded species, only *Chrysops relictus* and *Heptatoma pellucens* showed the highest abundance in August (Table 5).

Table 1 List of the fauna of horseflies (Tabanidae) along the Mura river in Međimurje in 2022, new species records (*) and zoogeographic affiliation of the sampled species

Tablica 1. Popis faune obada (Tabanidae) uz rijeku Muru u Međimurju 2022., novi nalazi vrsta (*) i zoogeografska pripadnost uzorkovanih vrsta.

Species *Vrsta*	No. speciemns and sex *Br. primjeraka i spol*	%	Zoogeographical group *Zoogeografska grupa*
*Haematopota pluvialis (*L., 1758)	778♀	60,07	BE
Tabanus bromius (L., 1758)	266♀, 9♂	21,23	BE
Chrysops relictus (Meigen, 1820)	47♀	3,62	BE
Hybomitra solstitialis (Meigen, 1820) nec (Lyneborg, 1959)	40♀, 2♂	3,24	BE
Chrysops viduatus (Fabricius, 1794)	27♀, 3♂	2,31	BE
Hybomitra muehlfeldi (Brauer *in* Brauer and Bergenstamm, 1880)	21♀, 1♂	1,69	BE
Tabanus tergestinus (Egger, 1859)	8♀, 12♂	1,54	SE (M)
*Chrysops caecutiens (*L., 1758)	17♀, 1♂	1,38	BE
Tabanus maculicornis (Zetterstedt, 1842)	13♀	1,00	BE
**Tabanus sudeticus* (Zeller, 1842)	9♀, 1♂	0,77	BE
Chrysops parallelogrammus (Zeller, 1842)	9♀	0,69	BE
**Haematopota scutellata* (Olsufjev, Moucha et Chvála, 1964)	7♀	0,54	BE
**Heptatoma pellucens* (Fabricius, 1776)	3♀, 2♂	0,38	BE
Tabanus autumnalis (L., 1761)	4♀	0,30	BE
**Haematopota italica* (Meigen, 1804)	4♀	0,30	BE
Hybomitra ukrainica (Olsufjev, 1952)	3♀	0,23	AE
**Haematopota subcylindrica* (Pandellé, 1883)	3♀	0,23	BE
Therioplectes gigas (Herbst, 1787)	1♀, 1♂	0,15	SE (M)
Hybomitra bimaculata (Macquart, 1826)	1♀	0,07	BE
**Tabanus bovinus* (L., 1758)	1♂	0,07	BE
**Tabanus cordiger* (Meigen, 1820)	1♀	0,07	BE
∑21	1262♀, 33♂		3

Table 2 Effectiveness of traps in sampling of horseflies along the Mura River in Međimurje in 2022

Tablica 2. Učinkovitost lovki u uzorkovanju obada uz rijeku Muru u Međimurju 2022.

Species / Traps *Vrsta / Lovka*	Modified Manitoba trap (the so-called canopy trap) *Modificirana Manitoba lovka*	Oil or liquid trap *Uljna ili tekuća lovka*
Haematopota pluvialis	778	0
Tabanus bromius	249	26
Chrysops relictus	45	2
Hybomitra solstitialis	39	3
Chrysops viduatus	27	3
Hybomitra muehlfeldi	21	1
Tabanus tergestinus	4	16
Chrysops caecutiens	17	1
Tabanus maculicornis	10	3
Tabanus sudeticus	8	2
Chrysops parallelogrammus	9	0
Haematopota scutellata	7	0
Heptatoma pellucens	0	5
Tabanus autumnalis	3	1
Haematopota italica	4	0
Hybomitra ukrainica	3	0
Haematopota subcylindrica	3	0
Therioplectes gigas	0	2
Hybomitra bimaculata	1	0
Tabanus bovinus	0	1
Tabanus cordiger	0	1
∑21	1228	67

Table 3 Qualitative and quantitative composition of the horseflies fauna (Tabanidae) sampled in 2022 at localities in the upper flow of the Mura River in Međimurje

Tablica 3. Kvalitativni i kvantitativni sastav faune obada (Tabanidae) uzorkovanih 2022. godine na lokalitetima u gornjem toku rijeke Mure u Međimurju.

Species/Locality *Vrsta/Lokalitet*	Mursko Središće	Križovec	Miklavec	Podturen	Novakovec	Dekanovec
Chrysops caecutiens	1	-	1	4	4	-
Chrysops parallelogrammus	-	-	-	1	6	1
Chrysops relictus	9	11	-	6	13	6
Chrysops viduatus	2	1	6	7	4	1
Hybomitra bimaculata	1	-	-	-	-	-
Hybomitra muehlfeldi	-	-	4	16	-	-
Hybomitra solstitialis	-	5	12	19	2	1
Hybomitra ukrainica	-	1	1	1	-	-
Tabanus autumnalis	1	1	-	-	1	-
Tabanus bromius	2	36	25	72	51	23
Tabanus maculicornis	1	3	1	1	2	-
Tabanus sudeticus	-	3	-	-	3	1
Tabanus tergestinus	-	1	-	-	1	-
Heptatoma pellucens	-	1	-	-	3	-
Haematopota italica	-	-	-	1	3	-
Haematopota pluvialis	55	62	71	124	365	46
Haematopota scutellata	-	-	2	-	5	-
Haematopota subcylindrica	-	-	-	2	1	-
∑18	72	125	123	254	464	79

Table 4 Qualitative and quantitative composition of the horseflies fauna (Tabanidae) sampled in 2022, at localities in the lower flow of the Mura River in Međimurje.

Tablica 4. Kvalitativni i kvantitativni sastav faune obada (Tabanidae) uzorkovanih 2022. godine na lokalitetima u donjem toku rijeke Mure u Međimurju.

Species/Locality *Vrsta/Lokalitet*	Donji Hrašćan	Hodošan	Goričan	Sveta Marija	Kotoriba
Chrysops caecutiens	-	1	1	-	6
Chrysops parallelogrammus	-	-	-	-	1
Chrysops relictus	-	-	1	1	-
Chrysops viduatus	1	1	4	-	3
Therioplectes gigas	-	1	-	1	-
Hybomitra muehlfeldi	-	1	-	1	-
Hybomitra solstitialis	-	2	1	-	-
Tabanus autumnalis	-	-	1	-	-
Tabanus bovinus	-	-	1	-	-
Tabanus bromius	8	24	13	17	4
Tabanus cordiger	-	-	-	1	-
Tabanus maculicornis	-	-	4	1	-
Tabanus sudeticus	-	1	1	-	1
Tabanus tergestinus	-	-	9	7	2
Heptatoma pellucens	-	-	-	1	-
Haematopota pluvialis	1	9	31	7	7
∑16	10	40	67	37	24

Table 5 Seasonal dynamics of horseflies on habitats along the Mura River in Međimurje in 2022.

Tablica 5. Sezonska dinamika obada na staništima uz rijeku Muru u Međimurju u 2022. godini.

Species / Month *Vrsta/Mjesec*	May *Svibanj*	June *Lipanj*	July *Srpanj*	August *Kolovoz*	September *Rujan*	Σ
Haematopota pluvialis	8	90	526	153	1	778
Tabanus bromius	63	56	130	26	-	275
Chrysops relictus	1	6	1	39	-	47
Hybomitra solstitialis	2	2	34	4	-	42
Chrysops viduatus	2	7	17	4	-	30
Hybomitra muehlfeldi	-	3	19	-	-	22
Tabanus tergestinus	-	13	7	-	-	20
Chrysops caecutiens	3	10	3	2	-	18
Tabanus maculicornis	6	7	-	-	-	13
Tabanus sudeticus	-	2	7	1	-	10
Chrysops parallelogrammus	-	3	5	1	-	9
Haematopota scutellata	-	-	7	-	-	7
Heptatoma pellucens	-	-	-	4	1	5
Tabanus autumnalis	1	-	2	1	-	4
Haematopota italica	-	-	4	-	-	4
Hybomitra ukrainica	2	-	1	-	-	3
Haematopota subcylindrica	-	1	2	-	-	3
Therioplectes gigas	2	-	-	-	-	2
Hybomitra bimaculata	1	-	-	-	-	1
Tabanus bovinus	1	-	-	-	-	1
Tabanus cordiger	1	-	-	-	-	1
∑21	93	200	765	235	2	1295

Discussion - *Rasprava*

In the previously conducted study of the horseflies fauna during 2011 in the same time period (from May to September), at 10 localities along the Mura River in the upper and lower flow of the Mura River in Međimurje, 989 horseflies were sampled and classified into two subfamilies, five genera, 14 species and one subspecies (Pintarić 2012). In the present research in the same area, 1295 specimens of horseflies classified into two subfamilies, six genera, and 21 species were sampled. In 2022, only the presence of the subspecies *Hybomitra nitidifrons confiformis* Chvála et Moucha, 1971 was not confirmed in this study of the horseflies fauna, compared to earlier studies. Subspecies *Hybomitra nitidifrons confiformis* was collected in May 2011 at the locality of Goričan (Pintarić 2012). The zoogeographic affiliation of the now and previously recorded species is the same. A shift in the number of horseflies was recorded in comparison to earlier studies. The month with the highest number of collected horseflies was July, while in an earlier study it was recorded in June (Pintarić 2012). Also, data on seasonal dynamics of the most abundant species, *Haematopota pluvialis* and *Tabanus bromius*, were different in comparison with earlier studies. The peak of abundance for these most abundant species during this study was recorded in July, while according to Pintarić (2012) it was in June. The third most abundant species, *Chrysops relictus*, had the highest abundance during this year in August, while in earlier studies it was recorded in July (Pintarić 2012). During 2022, the greatest diversity of species was determined in July (15 species). The same number of taxa (14 species and one subspecies) in 2011 was recorded in May (Pintarić 2012). The data on the similarity of the horseflies fauna in studied localities also differ, the highest percentage of similarity of horseflies fauna in this year's study was 81.81%, and the lowest was 33.33%. In research conducted in 2011, the highest percentage was 88.89%, and the lowest was 37.5% (Pintarić 2012). When comparing the horseflies fauna along the Mura River with other areas in Croatia where similar research had been carried out, the number of identified species of horseflies does not significantly differ from the number of identified species in the habitats along the Mura River in Međimurje. The same number of horsefly species and the order of the two most abundant species recorded in this study along the Mura River was the same as 20 years ago in the Monjoroš forest area on the right bank of the Danube River. In the flooded belt of the Monjoroš forest, 21 species of horseflies were sampled in 2001 and 2002, and the most abundant species were *Haematopota pluvialis* and *Tabanus bromius* (Krčmar 2004). In the area of the Kopački rit Nature Park, 26 species of horseflies were recorded (Krčmar 2014). The same number of species were recorded in the pasture in Petrijevci along the Karašica river (Krčmar and Matsumura 1996). In Kopački rit Nature Park in 2004, the most abundant species of horseflies were the species *Tabanus bromius* (Krčmar 2005), while in the pasture in Petrijevci along the bank of Karašica river, in a study conducted in 1993, the species *Tabanus bromius* and *Haematopota pluvialis* were the second and third most abundant species with the highest abundance in July (Krčmar 2005). Also, these data on the seasonal dynamics of the species *Tabanus bromius* and *Haematopota pluvialis* are identical to the data on the seasonal dynamics of these two species during 2022 in the area along the Mura River in Međimurje. In the Spačvan Basin, 24 species of horseflies were identified, of which the species *Haematopota pluvialis* recorded the highest abundance in July (Krčmar et al. 2002). This overlap coincided with the results of the seasonal dynamics of this species in this research conducted along the Mura River in Međimurje. In the area of Gorski Kotar, 28 species of horseflies were recorded (Krčmar et al. 2008), while in the area of the Lonjsko Polje Nature Park, 20 species of

horseflies were recorded (Krčmar and Leclercq 1999). In both areas, *Tabanus bromius* is the most abundant species. In the habitats along the Mura River in Međimurje, *Tabanus bromius* was the second most abundant species in 2022. When comparing the qualitative composition of the fauna of horseflies along the Mura river in Međimurje with other areas in continental Croatia, it was evident that the differences in the number of species were not large. The differences were only present in the qualitative composition of the sampled species. In most of the mentioned areas, the species *Haematopta pluvialis* and *Tabanus bromius* belonged to the most numerous sampled horseflies, as it was also determined during this study of the diversity of the horseflies fauna along the Mura River in Međimurje. The methods used in horseflies' samplings were quite selective. With the modified Manitoba trap (the so-called canopy trap) with the addition of the attractant 1-octen-3-ol, the most horseflies were sampled (Table 2). All sampled specimens were females, that is, those that were searching for a blood meal. The blood meal is needed by the majority of female of horseflies as a source of energy in the process of egg maturation (Inaoka 1992). The oil or liquid trap was the second most effective in the sampling of horseflies, with this type of trap both male and female horseflies were sampled. Recently, it was discovered that horseflies belonged to a group of polarotactic insects, meaning that males and females of horseflies are attracted to this type of trap by horizontally polarized light (Horváth et al. 2008; Egri et al. 2012; Kriska et al. 2009). Namely, with this optical cue, they can detect water surfaces since both sexes use water (Horváth et al. 2014). The black sticky trap was not successful in sampling of horseflies. This type of trap with reflected linearly polarized light exclusively attracted blood-seeking females of horseflies (Egri et al. 2013). The reason why this type of trap was ineffective is that the traps were placed in the complete shade of trees. The traps were attached to branches that were at a different height from the ground surface. The negative influence of shade or complete shade on the effectiveness of traps in horseflies samplings was also recorded in a study by Otartics et al. (2019), while on sunlit meadows, a black sticky trap is very effective in samplings of horseflies (Krčmar 2021).

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