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Research of breeding sites capacity for oviposition of floodwater mosquitoes in the flooded area of Danube and Drava rivers in Croatia

Istraživanje kapaciteta staništa za ovipoziciju jaja poplavnih komaraca na poplavnom prostoru Dunava i Drave, Hrvatska

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Abstract

Floodwater mosquitoes lay their eggs on dry ground where water will eventually flood the area. By flooding the area and submerging the eggs of floodwater mosquitoes, the development of larvae begins. For a gravid female mosquito, the most important thing is choosing the place where to lay eggs. As part of this research, which was conducted in April and May 2022, soil and leaf samples were taken on an area of 50 x 50 cm from different altitudes in the area of Dunavac near Ilok (Danube) and Halašovo near Osijek (Drava) in order to determine at which altitude, the largest number of eggs are laid. Collected soil was submerged in the laboratory for the purpose of further mosquito development. Part of the larvae was preserved in alcohol, and part of larvae was left to develop into adults, after which species determination was carried out. A large difference was found in the potential of breeding sites in the floodplain of the Drava and Danube, and the number of collected eggs ranged from 0 to 66 per sample. The number of individuals sampled in the Danube area was 53, and in the Drava area 133. The individuals sampled in the researched areas were determined as *Aedes vexans* and *Aedes sticticus*. A large difference in oviposition was found in the floodplain of the Danube, while in the floodplain of the Drava, this level is significantly higher.

Keywords: mosquito eggs, oviposition, floodwater mosquitoes, inundation of Danube and Drava rivers, breeding site capacity

Sažetak

Poplavni komarci jaja polažu na suho tlo tamo gdje će u određenom trenutku voda poplaviti područje. Plavljenjem područja i potapanjem jaja poplavnih komaraca započinje razvoj ličinki. Za gravidnu ženku komarca najvažniji je odabir mesta na koje će položiti jaja. U okviru ovog istraživanja, koje je provedeno u travnju i svibnju 2022. godine, uzeti su uzorci zemlje i lišća na površini 50 x 50 cm s različitim nadmorskim visinama na području Dunavca kod Iloka (Danav) i Halaševa kod Osijeka (Drava) da bi utvrdili na kojoj je nadmorskoj visini položen najveći broj jaja. Prikupljena je zemlja u laboratoriju potopljena vodom u svrhu praćenja razvoja komaraca. Dio ličinki sačuvan je u alkoholu, a dio ličinki ostavljen je da se razvije do odraslih jedinki nakon

čega je provedena determinacija do vrste. Utvrđena je velika razlika u potencijalu legla na poplavnom području Drave i Dunava, a broj sakupljenih jaja kretao se od 0 do 66 po uzorku. Broj uzorkovanih jedinki na području Dunava iznosio je 53, a na području Drave 133. Uzorkovane jedinke na istraživanim područjima determinirane su kao vrste *Aedes vexans* i *Aedes sticticus*. Utvrđena je velika razlika u ovipoziciji na istraživanim područjima i to na poplavnom prostoru Dunava evidentirano je manje komaraca nego na poplavnom prostoru Drave.

Ključne riječi: jaja komaraca, ovipozicija, poplavni komarci, poplavni prostor Dunava i Drave, kapacitet staništa

Introduction - *Uvod*

After ingestion of a blood meal, adult mosquito females usually lay between 50 and 500 eggs to a suitable breeding site, which can be pools of melted snow, floodplains, canals, tree-holes, and small water bodies (Becker et al. 2010). In lowland Croatia the most numerous are floodwater mosquitoes such as *Aedes vexans* (Meigen, 1830) or *Aedes sticticus* (Meigen 1838) which develop in huge numbers along the lowland rivers (Merdić and Lovaković, 2004).

Areas for developing floodwater mosquitoes are characterized by temporary water flow caused by fluctuating river levels after snowmelt (in spring) or heavy rains (early and mid-summer), while late summer and winter periods are usually periods of low water levels (Merdić et al. 2020).

Floodwater mosquitoes such as *Ae. vexans* lay single eggs to the moist soil of their breeding places, which are going to be flooded when the water level rises (Barr and Azawi 1958) to ensure that the sensitive, and still unprotected freshly laid eggs do not dry out (Gillett 1955). Sufficient flooding is necessary to complete development. It is important that the water body have a low number of mosquito predators. An oviposition site is never in low-lying area with an almost permanent water flow, which can float away eggs, and generally, this kind of water body has a high number of natural predators. Another problem can be flooded areas with a very short period of water flow because they have an unsuitable wet and dry sequence. Also, these areas dry rapidly after a flood so the freshly laid eggs are at risk of desiccation (Becker et al. 2010).

It is not yet known how mosquitoes select the optimal oviposition place. Preferred egg-laying sites of the floodwater mosquitoes usually are areas of silty soil and dense vegetation. Floodwater mosquitoes are likely able to recognize the soil in floodplains, which consists of a high percentage of clay and a low percentage of humus or organic materials. It is also speculated that those areas produce pheromone-like odors from previously laid eggs or from particular associations of plants that indicate a specific moisture level in the soil, which the female mosquitoes recognize (Becker et al. 2010).

The optimal conditions for floodwater mosquito larvae development occur between April and September with a diapause during autumn, and early spring (Merdić et al. 2020; Telford 1963).

Two factors are important for egg hatching. First is the level of the oxygen when larval hatching is triggered by a decline of dissolved oxygen as a consequence of several factors like microbial-induced. The second abiotic factor is suitable adequate water temperature (Schäfer and Lundström 2006; Horsfall and Fowler 1961). However, not all larvae hatch uniformly and this so-called "hatching in installments" ensures the

survival of populations in case initial larval populations are killed by drying of breeding sites. The larval development is temperature-dependent and can be completed within very short time frames. In addition, floodwater mosquito species are known for egg mass-production and long-range adult dispersal.

A big challenge for female mosquitoes is where to lay eggs. Every year water level (flood) is different and a small difference in altitude can be significant for mosquito survival. The aim of this paper is to compare two breeding sites of floodwater mosquitoes (one in Danube River inundation and one in the Drava River) and assess which habitat and altitude are more suitable for egg laying of floodwater mosquitoes.

Materials and Methods - Materijali i metode

The research was conducted in the surrounding of the town of Ilok, at the shores of the Danube River, and in inundation area of the Drava River in the surrounding of the city of Osijek (Figure 1). This research was done before the regular spring flooding of lowland rivers. In both areas on uneven ground, a secluded place with developed vegetation (ass. *Populetum nigro-albae*) and high index of humidity (according to vegetation characteristics) near the water bodies was selected. In the Danube area six samples from six localities, on different altitudes with approximately 0,5 m difference starting from 75masl, were selected and sampled on April 9th, 2022. In the Drava area four localities on different altitudes with approximately 0,5 m difference starting from 84masl were selected and sampled on May 2nd, 2022.



Figure 1 Researched area. Yellow circle – flooded area on the Drava river in surroundings of the Osijek city; Blue circle – flooded area on the Danube River in surroundings of the town of Ilok

Slika 1. Istraživano područje. Žuta kružnica - poplavno područje na rijeci Dravi nedaleko od Osijeka; plava kružnica - poplavno područje na rijeci Dunav nedaleko Iloka

Method used for this research was the flooding method (Silver 2008), which implies taking standardized soil surface samples, so the number of eggs per surface unit can be counted. A metal frame (50x50) is used to take a soil sample. The sample of soil which consisted of 2-3 cm of surface soil and all dry leafage was put into big plastic containers (40x50x80 cm), labeled, and transported to the laboratory. In laboratory, the container was filled up with approximately 10 l of water and kept for eight days at an average temperature of 24°C to let the eggs hatch. Every two days, the containers were checked in to watch the progress of hatching the larvae, and the biofilm that appeared on the surface of the water, which may impede the correct development of the larvae, was removed. After hatching, without feeding, the larvae were allowed to develop until 4 instars then were removed from the container. Part of larvae was mounted on slides for determination and parts were removed in the insect cage to finish development to the adult stage. Adult mosquitoes were killed by cigarette smoke and mounted on entomological pins. Determination was done by using keys Becker et al. 2010 and Gutsevich et al. 1974. To calculate the population size estimate, we took the average number of eggs for the entire researched areas.

Results - Rezultati

On both locations in all samples a total of 186 mosquitoes were hatched and determined. A much higher number of mosquito eggs, in total 133, were noted in the Drava area, and 53 mosquitoes were noted in locations in the Danube area (Figure 2). As we had a different number of samples from two areas of research, we calculated the average number per sample per area. The average number in the Drava area is 33,25 mosquitoes per sample and in Danube area 10,60 mosquitoes.

All sampling sites were at different altitudes. The difference between sites is approximately 0.5 m. The number of eggs differs from location to location depending on altitude. The highest number of eggs (59), was noted in the Drava area at the highest altitude approximately 86masl. No mosquitoes were noted at the lowest altitude in the Danube area (Table 1).

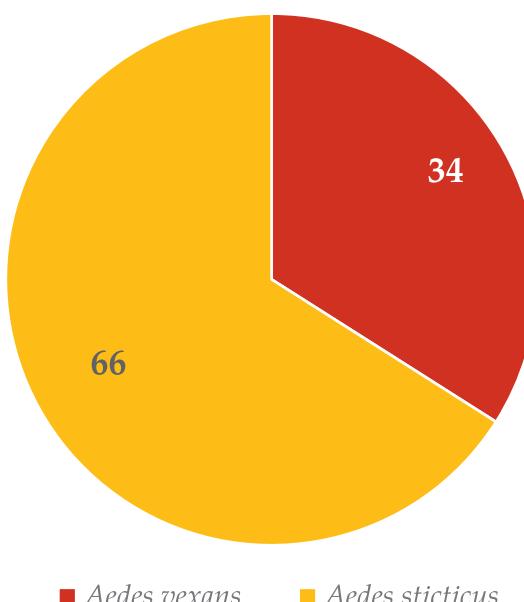


Figure 2 Composition of mosquito species from samples from the Danube area

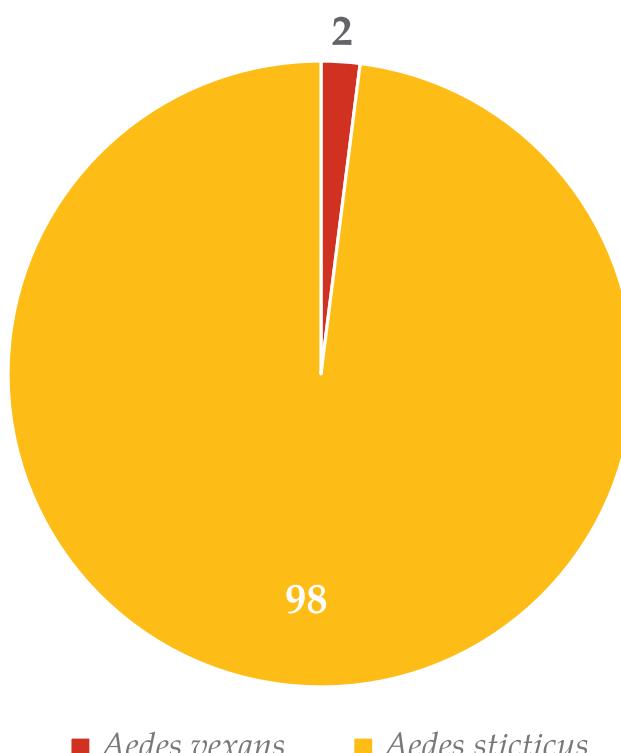
Slika 2. Sastav vrsta komaraca iz uzoraka s područja Dunava

Table 1 Noted number of mosquitoes in different altitudes**Tablica 1.** Broj komaraca po postajama s različitim nadmorskim visinama

Area Područje	Sampling date Datum uzimanja uzorka	Location Lokacija	Coordinates Koordinate	Altitude, masl Nadmorska visina, m	Number of mosquitoes Broj komaraca
Danube / Dunav	9.04.2022.	1	45°13'39" N 19°21'50" E	75	0
Danube / Dunav	9.04.2022.	2	45°13'40" N 19°21'48" E	75,5	9
Danube / Dunav	9.04.2022.	3	45°13'42" N 19°21'46" E	76	7
Danube / Dunav	9.04.2022.	4	45°13'44" N 19°21'49" E	76,5	2
Danube / Dunav	9.04.2022.	5	45°13'43" N 19°22'11" E	74	25
Danube / Dunav	9.04.2022.	6	45°13'35" N 19°22'39" E	77	10
Drava	2.05.2022.	1	45°35'24" N 18°38'40" E	84	25
Drava	2.05.2022.	2	45°35'24" N 18°38'40" E	84,5	41
Drava	2.05.2022.	3	45°35'25" N 18°38'41" E	85	8
Drava	2.05.2022.	4	45°35'25" N 18°38'41" E	85,5	59

All 186 hatched mosquitoes were determined to species level. All mosquitoes belong to the ecological group of floodwater mosquitoes which lay eggs on the soil surface. Two species noted were *Ae. vexans* and *Ae. sticticus*. Out of all mosquitoes, a total of 135 specimens belong to the species of *Ae. vexans*. There is a big difference in species composition in different areas of research. On the Danube area, a significantly larger share belongs to the species *Ae. sticticus* (Figure 2 and Figure 3).

As floodwater mosquitoes make big populations, according to our data we calculated number of mosquitoes per ha. The calculated number for the Danube area is 2.1 million and for the Drava area is 5,3 million specimens on researched area per ha.

**Figure 3** Composition of mosquito species from samples from Drava area**Slika 3.** Sastav vrsta komaraca iz uzoraka s područja Drave

Discussion - Rasprava

The biggest challenge for female floodwater mosquitoes is the ability to find appropriate egg-laying places which guarantees to breed. However, these tiny insects adapted their behavior to overcome the various conditions and find appropriate breeding sites.

It was a challenge for us to find those areas and according to some experience we chose rough terrain not far from a riverbed in the Danube area and close to the dike on the Drava area. Our plan was to take soil samples before the usual water level rise in spring. As there was no rise of water level during 2021 we took samples in April and May. More mosquitoes were developed in the Drava area. A possible reason for more eggs and consequently more mosquitoes in the Drava area is the place where we took samples. There was a place close to the dike where a one-meter bigger depression occurs. This is a place where water comes first when entering inundation. Out of all 4 localities in the Drava area the best one was the highest one, where 59 mosquitoes hatched. Unlike the Drava area, the samples from the Danube were obviously taken too low, which is confirmed with the first sample, which is also the lowest, where not a single egg was sampled.

Although the idea of this work was to determine which altitude is best for laying eggs in the area of the Danube and Drava rivers, based on the results obtained, that conclusion could not be given.

In previous research, the following species were recorded among floodwater mosquitoes in the Drava area: *Ae. vexans*, *Ae. sticticus*, *Ae. cinereus* and *Ae. rossicus*. The eudominant species was *Ae. vexans* with a different proportion from year to year, ranging from 75.59% in 2004 to 92.97% in 2016 (Merdić et al. 2016; Merdić et al. 2010). Therefore, it is not surprising that in this study *Ae. vexans* was determined with a share of 98% in the Drava region.

On the other side, in the Danube area, a large proportion of *Ae. sticticus*, which is a companion species of *Ae. vexans* in the whole of Europe (Mihaly 1963), with a larger share in the northern areas (Becker et al. 2010; Schäfer and Lundström 2006), was noted. Another possible reason is that in this area the locations were slightly lower than the altitudes of the Drava River and floods at slightly lower water levels.

Both study areas are known as areas with a lot of mosquitoes. The main reason for this is the extensive area suitable for oviposition in the surroundings of Osijek city and the town of Ilok. Generally, the bigger oviposition area is around Osijek, but the capacity of breeding sites along the Drava River seems to be more suitable for oviposition for floodwater mosquitoes. This is the reason why Osijek is the city with the biggest abundance of mosquitoes in Croatia.

Conclusion - Zaključak

Based on this research it can be concluded that we found suitable places for the oviposition of floodwater mosquitoes. The appropriate place for oviposition is the area not far from the river basin where water appears when the higher water level of lowland rivers Danube and Drava occurs. The inundation area of the river of Drava is more appropriate for the oviposition of floodwater mosquitoes than the researched area on the Danube River. Based on the results it seems that the main reason is that the altitude differences are too small to demonstrate variations.

Acknowledgments - Zahvale

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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 sjeću 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 Maodus 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 vulgarissimus* (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), *Epitheca 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"

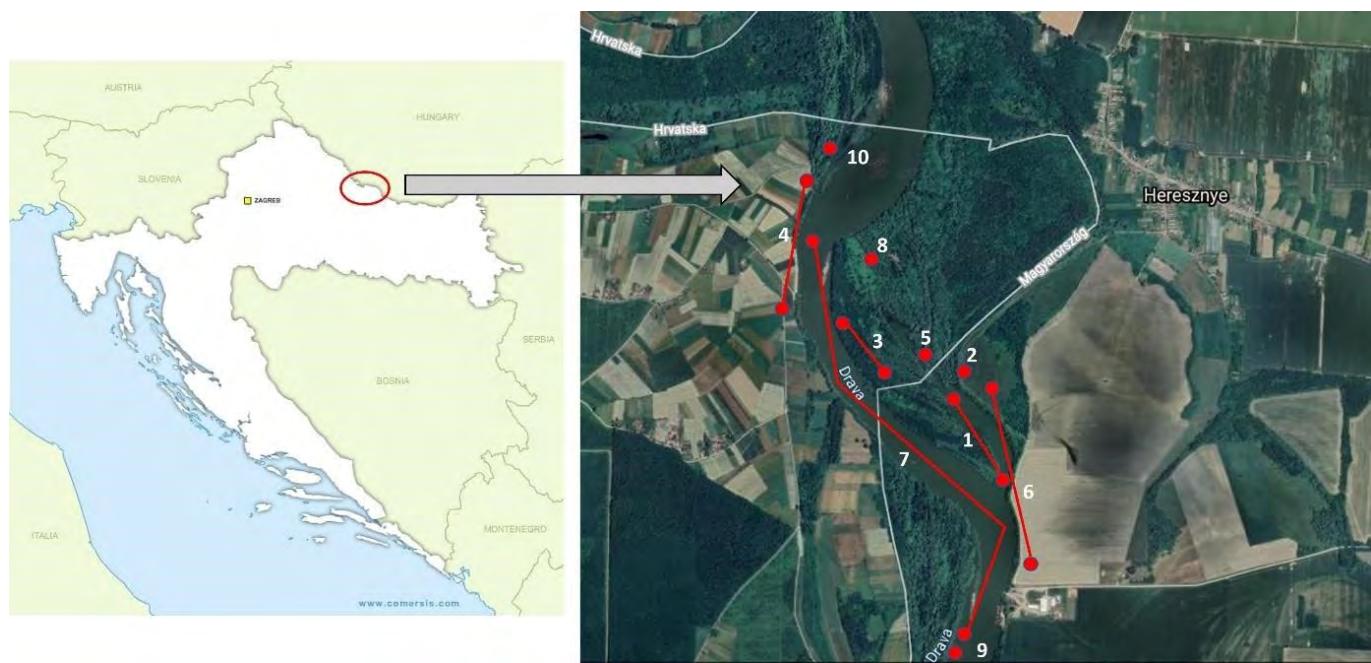


Figure 1 Study area position with the map of the study sites (study site numbers correspond to those in Table 1).

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 fresh-water 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 *Orthetrum albistylum* (Figure 3a) and *Sympetrum sanguineum* (Figure 3b) from the sub-order Anisoptera, and *Platycnemis pennipes* (Figure 3c) and *Calopteryx splendens* among the representatives of the suborder Zygoptera. *Orthetrum 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 isoceles* (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	1	2	3	4	5	6	7	8	9	10
Datum/lokacija istraživanja/vrsta	11.6.21.	11.6.21.	11.6.21.	11.6.21.	24.08.21.	23.6.21.	14.8.21.	23.6.21.	14.8.21.	24.08.21.
<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
<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	
<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
<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
<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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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%. Modificiranom 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 srpnju, 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 sadašnjih istraživanja u fauni obada uz rijeku Muru u Međimurju utvrđene su 22 svoje 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 italicica*, *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 gigas*, *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 Križovac and Goričan (81.81%), then Novakovec and Goričan (76.92%), Križovac 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 <i>Br. primjeraka i spol</i>	%	Zoogeographical group <i>Zoogeografska grupa</i>
<i>Haematopota pluvialis</i> (L., 1758)	778♀	60,07	BE
<i>Tabanus bromius</i> (L., 1758)	266♀, 9♂	21,23	BE
<i>Chrysops relictus</i> (Meigen, 1820)	47♀	3,62	BE
<i>Hybomitra solstitialis</i> (Meigen, 1820) nec (Lyneborg, 1959)	40♀, 2♂	3,24	BE
<i>Chrysops viduatus</i> (Fabricius, 1794)	27♀, 3♂	2,31	BE
<i>Hybomitra muehlfeldi</i> (Brauer in Brauer and Bergenstamm, 1880)	21♀, 1♂	1,69	BE
<i>Tabanus tergestinus</i> (Egger, 1859)	8♀, 12♂	1,54	SE (M)
<i>Chrysops caecutiens</i> (L., 1758)	17♀, 1♂	1,38	BE
<i>Tabanus maculicornis</i> (Zetterstedt, 1842)	13♀	1,00	BE
* <i>Tabanus sudeticus</i> (Zeller, 1842)	9♀, 1♂	0,77	BE
<i>Chrysops parallelogrammus</i> (Zeller, 1842)	9♀	0,69	BE
* <i>Haematopota scutellata</i> (Olsufjev, Moucha et Chvála, 1964)	7♀	0,54	BE
* <i>Heptatoma pellucens</i> (Fabricius, 1776)	3♀, 2♂	0,38	BE
<i>Tabanus autumnalis</i> (L., 1761)	4♀	0,30	BE
* <i>Haematopota italicica</i> (Meigen, 1804)	4♀	0,30	BE
<i>Hybomitra ukrainica</i> (Olsufjev, 1952)	3♀	0,23	AE
* <i>Haematopota subcylindrica</i> (Pandellé, 1883)	3♀	0,23	BE
<i>Therioplectes gigas</i> (Herbst, 1787)	1♀, 1♂	0,15	SE (M)
<i>Hybomitra bimaculata</i> (Macquart, 1826)	1♀	0,07	BE
* <i>Tabanus bovinus</i> (L., 1758)	1♂	0,07	BE
* <i>Tabanus cordiger</i> (Meigen, 1820)	1♀	0,07	BE
Σ21	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
<i>Haematopota pluvialis</i>	778	0
<i>Tabanus bromius</i>	249	26
<i>Chrysops relictus</i>	45	2
<i>Hybomitra solstitialis</i>	39	3
<i>Chrysops viduatus</i>	27	3
<i>Hybomitra muehlfeldi</i>	21	1
<i>Tabanus tergestinus</i>	4	16
<i>Chrysops caecutiens</i>	17	1
<i>Tabanus maculicornis</i>	10	3
<i>Tabanus sudeticus</i>	8	2
<i>Chrysops parallelogrammus</i>	9	0
<i>Haematopota scutellata</i>	7	0
<i>Heptatoma pellucens</i>	0	5
<i>Tabanus autumnalis</i>	3	1
<i>Haematopota italica</i>	4	0
<i>Hybomitra ukrainica</i>	3	0
<i>Haematopota subcylindrica</i>	3	0
<i>Therioplectes gigas</i>	0	2
<i>Hybomitra bimaculata</i>	1	0
<i>Tabanus bovinus</i>	0	1
<i>Tabanus cordiger</i>	0	1
Σ21	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
<i>Chrysops caecutiens</i>	1	-	1	4	4	-
<i>Chrysops parallelogrammus</i>	-	-	-	1	6	1
<i>Chrysops relictus</i>	9	11	-	6	13	6
<i>Chrysops viduatus</i>	2	1	6	7	4	1
<i>Hybomitra bimaculata</i>	1	-	-	-	-	-
<i>Hybomitra muehlfeldi</i>	-	-	4	16	-	-
<i>Hybomitra solstitialis</i>	-	5	12	19	2	1
<i>Hybomitra ukrainica</i>	-	1	1	1	-	-
<i>Tabanus autumnalis</i>	1	1	-	-	1	-
<i>Tabanus bromius</i>	2	36	25	72	51	23
<i>Tabanus maculicornis</i>	1	3	1	1	2	-
<i>Tabanus sudeticus</i>	-	3	-	-	3	1
<i>Tabanus tergestinus</i>	-	1	-	-	1	-
<i>Heptatoma pellucens</i>	-	1	-	-	3	-
<i>Haematopota italica</i>	-	-	-	1	3	-
<i>Haematopota pluvialis</i>	55	62	71	124	365	46
<i>Haematopota scutellata</i>	-	-	2	-	5	-
<i>Haematopota subcylindrica</i>	-	-	-	2	1	-
Σ18	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
<i>Chrysops caecutiens</i>	-	1	1	-	6
<i>Chrysops parallelogrammus</i>	-	-	-	-	1
<i>Chrysops relictus</i>	-	-	1	1	-
<i>Chrysops viduatus</i>	1	1	4	-	3
<i>Therioplectes gigas</i>	-	1	-	1	-
<i>Hybomitra muehlfeldi</i>	-	1	-	1	-
<i>Hybomitra solstitialis</i>	-	2	1	-	-
<i>Tabanus autumnalis</i>	-	-	1	-	-
<i>Tabanus bovinus</i>	-	-	1	-	-
<i>Tabanus bromius</i>	8	24	13	17	4
<i>Tabanus cordiger</i>	-	-	-	1	-
<i>Tabanus maculicornis</i>	-	-	4	1	-
<i>Tabanus sudeticus</i>	-	1	1	-	1
<i>Tabanus tergestinus</i>	-	-	9	7	2
<i>Heptatoma pellucens</i>	-	-	-	1	-
<i>Haematopota pluvialis</i>	1	9	31	7	7
$\Sigma 16$	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
<i>Haematopota pluvialis</i>	8	90	526	153	1	778
<i>Tabanus bromius</i>	63	56	130	26	-	275
<i>Chrysops relictus</i>	1	6	1	39	-	47
<i>Hybomitra solstitialis</i>	2	2	34	4	-	42
<i>Chrysops viduatus</i>	2	7	17	4	-	30
<i>Hybomitra muehlfeldi</i>	-	3	19	-	-	22
<i>Tabanus tergestinus</i>	-	13	7	-	-	20
<i>Chrysops caecutiens</i>	3	10	3	2	-	18
<i>Tabanus maculicornis</i>	6	7	-	-	-	13
<i>Tabanus sudeticus</i>	-	2	7	1	-	10
<i>Chrysops parallelogrammus</i>	-	3	5	1	-	9
<i>Haematopota scutellata</i>	-	-	7	-	-	7
<i>Heptatoma pellucens</i>	-	-	-	4	1	5
<i>Tabanus autumnalis</i>	1	-	2	1	-	4
<i>Haematopota italica</i>	-	-	4	-	-	4
<i>Hybomitra ukrainica</i>	2	-	1	-	-	3
<i>Haematopota subcylindrica</i>	-	1	2	-	-	3
<i>Therioplectes gigas</i>	2	-	-	-	-	2
<i>Hybomitra bimaculata</i>	1	-	-	-	-	1
<i>Tabanus bovinus</i>	1	-	-	-	-	1
<i>Tabanus cordiger</i>	1	-	-	-	-	1
$\Sigma 21$	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 conformis* Chvála et Moucha, 1971 was not confirmed in this study of the horseflies fauna, compared to earlier studies. Subspecies *Hybomitra nitidifrons conformis* 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 *Haematopota 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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Distribution of the species *Heptatoma pellucens* (Fabricius, 1776) (Diptera: Tabanidae) in Croatia

Rasprostranjenost vrste *Heptatoma pellucens* (Fabricius, 1776) (Diptera: Tabanidae) u Hrvatskoj

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Abstract

The genus *Heptatoma* contains only one species, *Hepatoma pellucens*, distributed almost throughout the whole Palaearctic region. Without the author's and collaborator's (J. Mikuska) previous and current research, this species had been recorded in six localities in Croatia. The author's previous unpublished data recorded the species in localities of Donja Bistra, Popovac, Šenkovec, Vinica and Duzluk. The findings of this species in the localities of Branjina, Karanac, Kotlina, on Bansko Hill in the Croatian part of Baranja during this year represent new locality records alongside unpublished ones. The total number of recorded localities where *Heptatoma pellucens* appears in Croatia has increased to 40. From all collected specimens from previous and current research (242), 29.34% (71) of specimens of this species in Croatia were collected during 2022. In the sample collected in 2022, 97.18% of specimens were collected by liquid oil trap (shiny black trays filled with transparent vegetable oil). The sex ratio of the collected specimens in 2022 showed there were 1.7 times more males than females, unlike in previous research where only one male specimen was recorded.

Keywords: Europe, fauna, horseflies, new locality records, liquid oil trap

Sažetak

Rod *Heptatoma* sadrži samo jednu vrstu, *Hepatoma pellucens*, rasprostranjenu gotovo na čitavom području Palearktika. Bez autorovih i suradnikovih (J. Mikuska) ranijih i sadašnjih istraživanja ova vrsta bila je zabilježena na šest lokaliteta u Hrvatskoj. U autorovim ranijim neobjavljenim podacima ova vrsta zabilježena je na lokalitetima Donja Bistra, Popovac, Šenkovec, Vinica i Duzluk. Nalazi ove vrste na lokalitetima Branjina, Karanac, Kotlina na Banskom brdu u hrvatskom dijelu Baranje tijekom ove godine predstavljaju s neobjavljenim podacima nove nalaze. Ukupan broj zabilježenih lokaliteta na kojima se vrsta *Heptatoma pellucens* pojavljuje u Hrvatskoj je 40. Od svih uzorkovanih jedinki iz ranijih i sadašnjih istraživanja (242), 29.34% (71) jedinka uzorkovana je tijekom 2022. godine. U ovom uzorku skupljenom 2022. godine 97.18% jedinki uzorkovano je uljnom tekućom klopkom (sjajna crna vrećica u obliku posude prelivena biljnim uljem). U skupljenom uzorku 2022. godine uzorkovano je 1.7 puta više mužjaka nego ženki, za razliku od ranijih istraživanja u kojima je samo jedan mužjak bio uzorkovan.

Ključne riječi: Europa, fauna, obadi, novi nalazi, tekuća uljna klopka

Introduction - Uvod

Published data on the distribution of horseflies in Croatia are scarce, because only data on distributions of genera with lesser numbers of species were published so far (Krčmar et al. 2008, 2010). Female horseflies are potential vectors of different pathogens such as bacteria, viruses and protozoa (Foil 1989). Therefore, faunistical and ecological research on horseflies is important from the point of view of medical and veterinarian entomology. In Croatia, data on the distribution of horseflies have been published so far only for species from the genera *Atylotus*, *Chrysops*, *Therioplectes*, *Dasyrhamphis*, and *Philipomyia* (Krčmar et al. 2008, 2010). The genus *Heptatoma* Meigen, 1803 is monotypic. The single known species is *Heptatoma pellucens* (Fabricius, 1776) and it is known widely throughout the Palaearctic region including the extreme north (Chvála et al. 1972). This species inhabits various types of biotopes, and it never occurs in large numbers (Chvála et al. 1972). The first data on the presence of *Heptatoma pellucens* in Croatia was recorded by Langhoffer (1918). The next records were published by Moucha (1965), Leclercq (1976), and Majer (1985) (Table 1). After that, there was no information about this species until the beginning of the nineties of the last century, when numerous samplings of horseflies throughout Croatia began (Krčmar and Mikuska 2001; Krčmar et al. 2006; Krčmar et al. 2008) (Table 1). After those, no further information on the distribution of this species was recorded. Some of the potential reasons for the rather small number of records of this species in Croatia are most likely in its morphological similarities to honeybees. Due to these similarities, it might have been unnoticed in various entomological studies (Brauer 1880; Strobl 1898, 1900, 1902; Coe 1958, 1960; Leclercq 1960, 1965, 1968; Moucha 1959; Danielova 1961). As it can be considered a rare species, and it does not appear anywhere in large numbers. The aim of this article is to present an updated distribution of this species in Croatia.

Materials and Methods - Materijali i metode

In this article, all the available data from the literature were used, as well as published and unpublished data from earlier studies of horseflies fauna throughout Croatia from 1992 to 2017. Unpublished data obtained from recent studies of horseflies fauna on Bansko Hill in the Croatian part of Baranja as well as data in press on Mura river in Međimurje were also included. In both studied areas, horseflies were sampled from May to September 2022 using liquid oil traps, which were made from a shiny black plastic tray (60 cm x 40 cm long) filled with transparent yellow sunflower oil at depth of 0.5 to 1 cm. Black and white linen canopy traps were constructed according to Hribar et al. (1991). A sticky trap (12-L black plastic buckets) was used only in the area of Međimurje. The outside surface of the black bucket was covered with a thin layer of horsefly glue. In both study areas, canopy traps were baited with 1-octen-3-ol as an attractant. Identifications were carried out using the standard keys for Tabanidae (Chvála et al. 1972; Krčmar et al. 2011), while the nomenclature follows the Catalogue of Palaearctic Diptera (Chvála 1988). For each record, the following information is provided: name of localities, sampling date, exact geographical coordinates of localities, UTM grid 10x10km, number of collected specimens, sex, and data source.

Results and Discussion - Rezultati i rasprava

Distribution - Rasprostranjenost

According to literature data, this species had been recorded in six localities in Croatia. The author's previous unpublished data recorded the species in localities of Donja Bistra, Popovac, Šenkovec, Vinica and Duzluk. The findings of this species in the localities of Branjina, Karanac, Kotlina on Bansko Hill in the Croatian part of Baranja during this year represent new locality records alongside unpublished ones. The total number of recorded localities where *Heptatoma pellucens* appears in Croatia has increased to 40 (Table 1, Figure 1). Only two locality records were found in the Mediterranean part of Croatia (Langhoffer 1918; Moucha 1965; Leclercq 1976), while 38 recorded localities belonged to the Alpine and Continental parts of the country. The flight period of this species is very long, ranging from May to the beginning of September, or even until the end of September (Chvála et al. 1972). In Croatia, the earliest date of collection of this species was recorded on May 8, and the latest on September 25. Altogether, 242 specimens of *Heptatoma pellucens* were collected in Croatia (Table 1) from which six belong to literature data and the rest (236) belong to published and unpublished data of the author and his collaborator (J. Mikuska). During 2022, in the Croatian part of Baranja 66 specimens (23♀, 43♂) of *Heptatoma pellucens* were recorded, while only 5 specimens (3♀, 2♂) were recorded in Medimurje. In 2022, a total of 71 horsefly specimens were collected, of which 45♂ and 24♀ were collected with liquid oil traps in the localities of Branjina, Karanac, Kotlina, Novakovec, Popovac, and Sveta Marija, while only 2♀ were collected with a canopy trap baited with the attractant 1-octen-3-ol in Križovec and Popovac localities. In the Croatian part of Baranja and Medimurje the species *Heptatoma pellucens* was mainly collected in localities close to water surfaces. Although it inhabits different types of habitats (white willow and black poplar forests alongside river areas, lakes, and ponds, common oak forests, birch forests, wet habitats with reeds, degraded mixed forests), it does not appear anywhere in large numbers. In white willow and black poplar forests alongside rivers of Karašica and Drava (in eight different localities) 55 specimens were collected, alongside lakes and ponds (in seven different localities) 18 were collected, in common oak forests (in 11 different localities) 100 were collected, in birch forests (on six different localities) eight were collected in wet habitats with reeds (on one locality) 54 specimens were collected and in degraded mixed forests (on one locality) one specimen was collected. Collected specimens of *Heptatoma pellucens* in 2022 represent 29.34% of all collected specimens of this species in Croatia. During this century, *Heptatoma pellucens* was recorded for the first time in the territory of neighbouring Serbia (Krčmar 2011) and Bosnia and Herzegovina (Mikuska et al. 2008). Due to its appearance and great similarity to honey bees, it most likely remained undetected in earlier studies in these countries, which leaves opportunities for more research and new entomologists to work with this interesting insect.

Traps - Lovke

Specimens collected by liquid oil traps (69) make up 28.51% from all of the collected specimens of this species in Croatia so far. During studies done in 2022, 1.7 times more males than females were trapped, while in previous studies only one male specimen of *Heptatoma pellucens* was recorded (Krčmar and Mikuska 2001). In previous studies, mainly female specimens were collected which were mostly attracted to olfactory cues the traps provided with different attractants (Krčmar and Mikuska 2001), unlike males which were mostly attracted to horizontally polarized light (Horváth et al. 2008). A similar ratio of males to females (1.8) was observed in the species *Tabanus shannonellus* in a study con-

ducted on the island of Badija in the Korčula archipelago when a liquid oil trap was first used for sampling of horseflies in Croatia (Krčmar 2013). The enhanced effectiveness of liquid oil traps in collecting male and female specimens of *Heptatoma pellucens* could be explained by their positive polarotaxis. Recently, Horváth et al. (2008) found that many horsefly species prefer horizontally polarizing black oil surfaces. This was however not known for *Heptatoma pellucens* prior to this study (Horváth et al. 2008). Furthermore, Egri et al. (2012) proved that shiny black oil traps are very successful in collecting both sexes of water-seeking horseflies. Females and males are attracted to horizontally polarized light, if such light stimulates the ventral side of their compound eyes (Száz et al. 2022).

Table 1 Historical and new records of *Heptatoma pellucens* in Croatia**Tablica 1.** Povijesni i novi nalazi vrste *Heptatoma pellucens* u Hrvatskoj.

Locality <i>Lokalitet</i>	Date of samplings <i>Datum uzorkovanja</i>	Coordinates <i>Koordinate</i>	UTM UTM	Number of collected specimens and sex <i>Broj ulovljenih primjeraka i spol</i>	Data Source <i>Izvor podataka</i>
Zagreb	17.05.1890.	45° 56' 39" N 15° 39' 44" E	WL 77	1♀	Langhoffer 1918; Moucha 1965; Majer 1985
Krapina	-	46° 09' 38" N 15° 52' 21" E	WM 61	-	Baranov 1945
Orehovica	26.06.1926.	45° 20' 03" N 14° 27' 19" E	VL 51	1♀	Langhoffer 1918; Moucha 1965
Livade	14.08.1975.	45° 21' 46" N 13° 48' 46" E	VL 02	2♀	Leclercq 1976
Trnovec	21.07.1982.	46° 17' 35" N 16° 23' 49" E	WM 61	1♀	Majer 1985
Draganić	2.05.2021.	45° 36' 07" N 15° 35' 55" E	WL 44	1♀	https://www.inaturalist.org/taxa/547151-Heptatoma-pellucens
Josipovac	18.07.1992.	45° 34' 55" N 18° 35' 01" E	CR 15	3♀	Krčmar and Mikuska 2001
Josipovac	19.07.1992.	45° 34' 55" N 18° 35' 01" E	CR 15	1♀	Krčmar and Mikuska 2001
Josipovac	20.07.1992.	45° 34' 55" N 18° 35' 01" E	CR 15	1♀	Krčmar and Mikuska 2001
Josipovac	23.07.1992.	45° 34' 55" N 18° 35' 01" E	CR 15	2♀	Krčmar and Mikuska 2001
Josipovac	25.07.1992.	45° 34' 55" N 18° 35' 01" E	CR 15	5♀	Krčmar and Mikuska 2001
Josipovac	1.08.1992.	45° 34' 55" N 18° 35' 01" E	CR 15	1♀	Krčmar and Mikuska 2001
Petrijevci	8.07.1993.	45° 36' 51" N 18° 32' 12" E	CR 05	3♀	Krčmar and Mikuska 2001
Petrijevci	9.07.1993.	45° 36' 51" N 18° 32' 12" E	CR 05	5♀	Krčmar and Mikuska 2001
Petrijevci	10.07.1993.	45° 36' 51" N 18° 32' 12" E	CR 05	3♀	Krčmar and Mikuska 2001
Petrijevci	25.07.1993.	45° 36' 51" N 18° 32' 12" E	CR 05	1♀	Krčmar and Mikuska 2001
Petrijevci	9.09.1993.	45° 36' 51" N 18° 32' 12" E	CR 05	3♀	Krčmar and Mikuska 2001
Osijek	21.09.1993.	45° 33' 18" N 18° 41' 44" E	CR 24	1♀	Krčmar and Mikuska 2001
Petrijevci	25.09.1993.	45° 36' 51" N 18° 32' 12" E	CR 05	1♀	Krčmar and Mikuska 2001
Petrijevci	18.05.1994.	45° 36' 51" N 18° 32' 12" E	CR 05	1♀	Krčmar and Mikuska 2001

Sunger	1.06.1994.	45° 21' 39" N 14° 44' 15" E	VL 81	1♀	Krčmar et al. 2008
Petrijevci	18.06.1994.	45° 36' 51" N 18° 32' 12" E	CR 05	2♀	Krčmar and Mikuska 2001
Petrijevci	16.07.1994.	45° 36' 51" N 18° 32' 12" E	CR 05	7♀	Krčmar and Mikuska 2001
Petrijevci	23.07.1994.	45° 36' 51" N 18° 32' 12" E	CR 05	1♀	Krčmar and Mikuska 2001
Borovik	5.08.1994.	45° 23' 02" N 18° 11' 55" E	BR 72	1♂	Krčmar and Mikuska 2001
Donja Bistra	31.08.1994.	45° 54' 35" N 15° 49' 25" E	WL 68	1♀	Krčmar collection
Bokšić Lug	2.07.1994.	45° 37' 11" N 18° 03' 40" E	YL 35	1♀	Krčmar and Mikuska 2001
Petrijevci	26.05.1995.	45° 36' 51" N 18° 32' 12" E	CR 05	3♀	Krčmar and Mikuska 2001
Petrijevci	2.07.1995.	45° 36' 51" N 18° 32' 12" E	CR 05	5♀	Krčmar and Mikuska 2001
Borovik	3.07.1995.	45° 23' 02" N 18° 11' 55" E	BR 72	1♀	Krčmar and Mikuska 2001
Šenkovec	9.07.1995.	46° 24' 08" N 16° 24' 57" E	XM 04	1♀	Krčmar collection
Musić	23.08.1995.	45° 18' 44" N 18° 06' 15" E	BR 72	1♀	Krčmar and Mikuska 2001
Normanci	8.05.1996.	45° 33' 21" N 18° 21' 44" E	BR 94	1♀	Krčmar and Mikuska 2001
Normanci	11.05.1996.	45° 33' 21" N 18° 21' 44" E	BR 94	10♀	Krčmar and Mikuska 2001
Zoljan	21.05.1996.	45° 28' 34" N 18° 03' 39" E	BR 63	1♀	Krčmar and Mikuska 2001
Vinica	31.05.1996.	46° 20' 22" N 16° 09' 14" E	WM 93	2♀	Krčmar collection
Babina Greda	21.06.1996.	45° 06' 54" N 18° 33' 07" E	CQ 09	1♀	Krčmar and Mikuska 2001
Lokve	29.06.1996.	45° 21' 30" N 14° 45' 03" E	VL 82	1♀	Krčmar et al. 2008
Spačva	4.07.1996.	45° 10' 06" N 18° 51' 06" E	CQ 39	1♀	Krčmar and Mikuska 2001
Babina Greda	5.07.1996.	45° 06' 54" N 18° 33' 07" E	CQ 09	1♀	Krčmar and Mikuska 2001
Normanci	6.05.1997.	45° 33' 21" N 18° 21' 44" E	BR 94	11♀	Krčmar and Mikuska 2001
Normanci	10.05.1997.	45° 33' 21" N 18° 21' 44" E	BR 94	11♀	Krčmar and Mikuska 2001
Koška	10.05.1997.	45° 32' 44" N 18° 16' 59" E	BR 84	4♀	Krčmar and Mikuska 2001
Zoljan	10.05.1997.	45° 28' 34" N 18° 03' 39" E	BR 63	6♀	Krčmar and Mikuska 2001
Borovik	12.05.1997.	45° 23' 02" N 18° 11' 55" E	BR 72	1♀	Krčmar and Mikuska 2001
Kutjevo	17.05.1997.	45° 25' 33" N 17° 53' 00" E	YL 23	14♀	Krčmar and Mikuska 2001
Pušine	17.05.1997.	45° 35' 50" N 17° 41' 09" E	YL 14	13♀	Krčmar and Mikuska 2001
Koška	17.05.1997.	45° 32' 44" N 18° 16' 59" E	BR 84	11♀	Krčmar and Mikuska 2001
Vrpolje	20.05.1997.	45° 12' 37" N 18° 24' 19" E	BR 90	2♀	Krčmar and Mikuska 2001
Babina Greda	20.05.1997.	45° 06' 54" N 18° 33' 07" E	CQ 09	4♀	Krčmar and Mikuska 2001

Lacići	7.06.1997.	45° 38' 11" N 18° 13' 02" E	BR 85	4♀	Krčmar and Mikuska 2001
Bukovac	27.07.1997.	45° 20' 37" N 14° 46' 42" E	VL 81	2♀	Krčmar et al. 2008
Sungerski					
Sakadaš, Kopački rit	28.07.1999.	45° 36' 30" N 18° 47' 58" E	CR 25	1♀	Krčmar and Mikuska 2001
Matić Poljana	21.06.2000.	45° 17' 12" N 14° 53' 45" E	VL 81	1♀	Krčmar et al. 2008
Legrad	28.07.2005.	46° 17' 45" N 16° 51' 19" E	XM 42	1♀	Krčmar et al. 2006
Ferdinandovac	20.08.2005.	46° 03' 37" N 17° 11' 25" E	XM 70	1♀	Krčmar et al. 2006
Zmajevac	2.05.2010.	45° 48' 03" N 18° 48' 29" E	CR 37	1♀	Krčmar collection
Popovac	20.08.2010.	45° 48' 22" N 18° 39' 34" E	CR 17	1♀	Krčmar collection
Zmajevac	29.05.2016.	45° 48' 03" N 18° 48' 29" E	CR 37	1♀	Krčmar et al. 2022
Duzluk	4.07.2017.	45° 30' 55" N 17° 51' 53" E	YL 24	1♀	Krčmar collection
Popovac	27.05.2022.	45° 48' 22" N 18° 39' 34" E	CR 17	1♀	Krčmar collection
Branjina	18.06.2022.	45° 49' 22" N 18° 41' 35" E	CR 17	3♂	Krčmar collection
Popovac	18.06.2022.	45° 48' 22" N 18° 39' 34" E	CR 17	1♂	Krčmar collection
Popovac	24.06.2022.	45° 48' 22" N 18° 39' 34" E	CR 17	12♂, 2♀	Krčmar collection
Popovac	26.06.2022.	45° 48' 22" N 18° 39' 34" E	CR 17	19♂, 3♀	Krčmar collection
Kotlina	29.06.2022.	45° 47' 17" N 18° 44' 16" E	CR 27	2♀	Krčmar collection
Branjina	14.07.2022.	45° 49' 22" N 18° 41' 35" E	CR 17	1♀	Krčmar collection
Popovac	14.07.2022.	45° 48' 22" N 18° 39' 34" E	CR 17	3♀	Krčmar collection
Branjina	17.07.2022.	45° 49' 22" N 18° 41' 35" E	CR 17	1♂, 1♀	Krčmar collection
Branjina	21.07.2022	45° 49' 22" N 18° 41' 35" E	CR 17	1♂, 1♀	Krčmar collection
Popovac	21.07.2022	45° 48' 22" N 18° 39' 34" E	CR 17	1♀	Krčmar collection
Popovac	8.08.2022	45° 48' 22" N 18° 39' 34" E	CR 17	1♂, 1♀	Krčmar collection
Branjina	13.08.2022	45° 49' 22" N 18° 41' 35" E	CR 17	1♂	Krčmar collection
Popovac	13.08.2022	45° 48' 22" N 18° 39' 34" E	CR 17	2♂, 1♀	Krčmar collection
Novakovec	18.08.2022	46° 27' 19" N 16° 34' 08" E	XM 14	2♂, 1♀	In press
Sveta Marija	18.08.2022	46° 19' 54" N 16° 44' 37" E	XM 33	1♀	In press
Karanac	31.08.2022	45° 45' 37" N 18° 41' 09" E	CR 27	1♀	Krčmar collection
Popovac	31.08.2022	45° 48' 22" N 18° 39' 34" E	CR 17	2♂, 4♀	Krčmar collection
Branjina	10.09.2022	45° 49' 22" N 18° 41' 35" E	CR 17	1♀	Krčmar collection
Križovec	13.09.2022	46° 30' 00" N 16° 29' 02" E	XM 15	1♀	In press

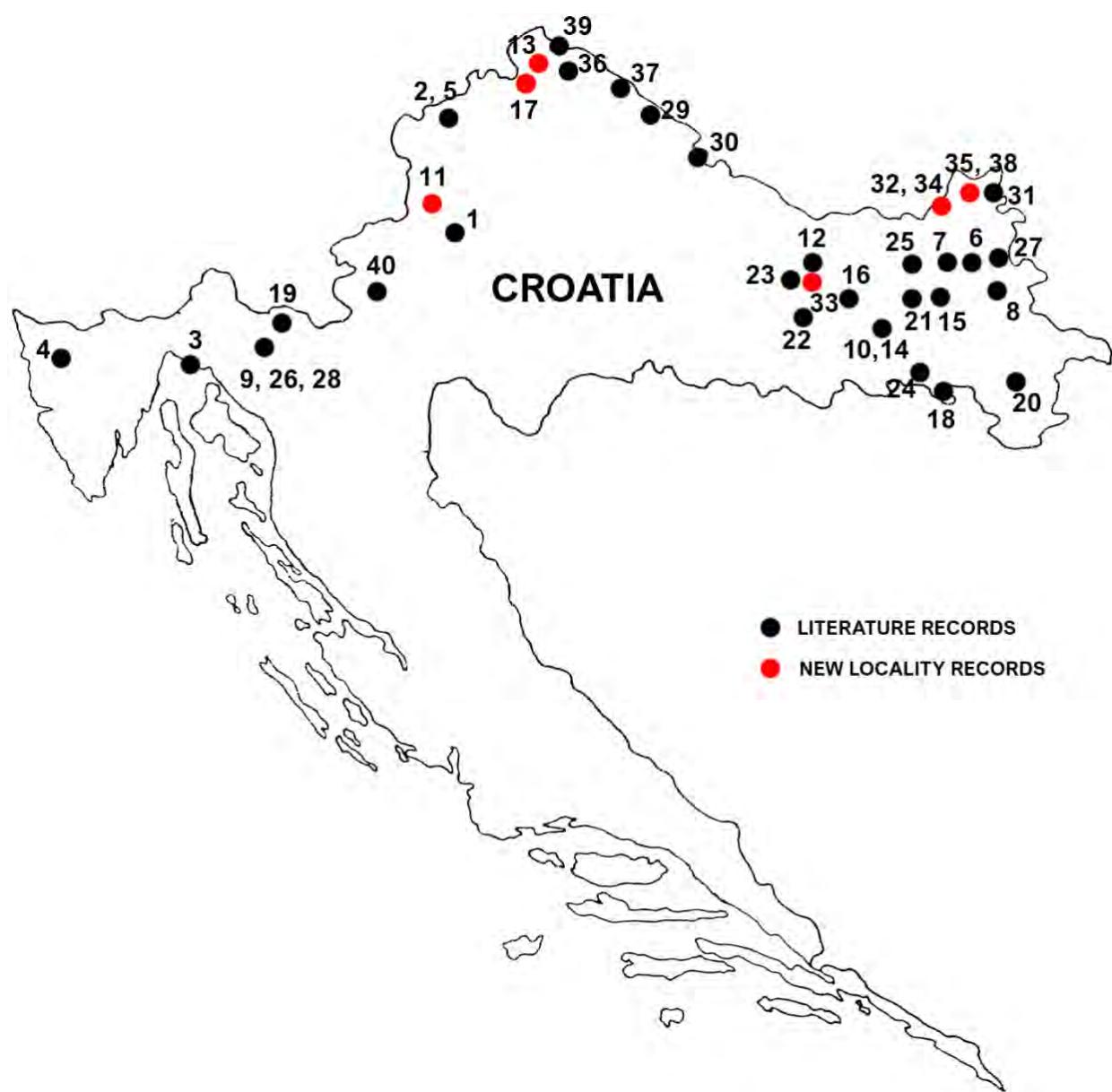


Figure 1 The distribution of *Heptatoma pellucens* in Croatia.

Slika 1. Rasprostranjenost vrste *Heptatoma pellucens* u Hrvatskoj.

Legend: List of localities: 1 Zagreb, 2 Krapina, 3 Oreohovica, 4 Livade, 5 Trnovec, 6 Josipovac, 7 Petrijevci, 8 Osijek, 9 Sunger, 10 Borovik, 11 Donja Bistra, 12 Bokšić Lug, 13 Šenkovec, 14 Musić, 15 Normanci, 16 Zoljan, 17 Vinica, 18 Babina Greda, 19 Lokve, 20 Spačva, 21 Koška, 22 Kutjevo, 23 Pušine, 24 Vrpolje, 25 Lacići, 26 Bukovac Sungerski, 27 Sakadaš-Kopački rit, 28 Matić poljana, 29 Legrad, 30 Ferdinandovac, 31 Zmajevac, 32 Popovac, 33 Duzluk, 34 Branjina, 35 Kotlina, 36 Novakovec, 37 Sveta Marija, 38 Karanac, 39 Križovec, 40 Draganić.

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<https://www.inaturalist.org/taxa/547151-Heptatoma-pellucens>

New records of true bugs (Heteroptera: Lygaeidae) for the fauna of Croatia and Bosnia and Herzegovina

Novi nalazi stjenica (Heteroptera: Lygaeidae) za faunu Hrvatske i Bosne i Hercegovine

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Abstract

The data on two new species for the Croatian fauna and one new species for the fauna of Bosnia and Herzegovina are given. *Caenocoris nerii* (Germar, 1847) represents a new genus and species for both countries, while *Tropidothorax sternalis* (Dallas, 1852) is recorded for the first time in Croatia. In addition, two new host plant species of *C. nerii* are reported, namely *Cynanchum acutum* L. and *Periploca graeca* L. (Apocynaceae), not previously mentioned as its hosts in the scientific literature.

Keywords: *Caenocoris nerii*, distribution, faunistics, first records, *Tropidothorax sternalis*

Sažetak

Dvije nove vrste stjenica zabilježene su za faunu Hrvatske i jedna nova vrsta za faunu Bosne i Hercegovine. *Caenocoris nerii* (Germar, 1847) predstavlja novi rod i vrstu za obje države, dok je vrsta *Tropidothorax sternalis* (Dallas, 1852) po prvi put pronađena u Hrvatskoj. Osim toga, *Cynanchum acutum* L. i *Periploca graeca* L. (Apocynaceae) zabilježene su kao nove biljke hraniteljice za stjenicu *C. nerii*, što do sada nije objavljeno u znanstvenoj literaturi.

Ključne riječi: *Caenocoris nerii*, rasprostranjenost, faunistika, prvi nalazi, *Tropidothorax sternalis*

Introduction - Uvod

This research puts the spotlight on two aposematic gregarious lygaeid bug species, both associated with Apocynaceae plant family. One of them is the oligophagous species *Caenocoris nerii* (Germar, 1847), feeding on *Nerium oleander* L. and *Periploca laevigata* Aiton, while the other one is *Tropidothorax sternalis* (Dallas, 1852), monophasous on *Cynanchum acutum* L. (Péricart 1998). *C. nerii* is South Mediterranean and Paleotropical species, in Europe distributed in Albania, Bulgaria, France, Greece, Italy, Malta, Portugal (Madeira), Serbia, and Spain (Péricart 1998; Josifov 1999; Lupoli 2008; Cuesta Segura et al. 2010; Simov 2011; Šeć et al. 2019). *T. sternalis* is species with Afrotropical-Mediterranean distribution, and until now in Europe, it was known only

from Spain and Southern Italy (Melber 1988; Péricart 1998; Olivieri 2013). The goal of this paper is to present the new records of the species mentioned above in Croatia and Bosnia and Herzegovina.

Materials and Methods - Materijali i metode

The work described in this paper is based on several collections and field observations carried out by the authors between 2020 and 2022. Most of the research took place within the Neretva River delta, the wetland shared by two countries, Croatia and Bosnia and Herzegovina. 70 % of the delta is situated on the Adriatic coast of Southern Croatia, and 30% in Bosnia and Herzegovina. It belongs to the Mediterranean phytogeographical region, while the most widespread and ecologically important vegetation type of the area is helophytic marshy vegetation (Vuković 2021).

Also, several scattered findings from the other parts of Dubrovnik Neretva County and Southern Herzegovina are added. Identification of the species was based on the morphological features described in Melber (1988) and Péricart (1998). Besides being the only representative of the genus *Caenocoris* in Europe, *C. nerii* is an easily recognizable species, characterized by a black-colored and elongated body, variegated with red. The legs are black with red-colored coxa, and distinctive teeth on the profemora (Péricart 1998). The *Tropidothorax* genera are characterized by the presence of one median and two marginal keels on the pronotum. The two species that are present in the European fauna, *T. leucopterus*, and *T. sternalis* can be distinguished by several morphological characteristics. Generally, *T. leucopterus* is larger species with an average body size of 8.9 mm in males, in contrast to the smaller *T. sternalis* with an average body size of males 7.5 mm. Additional differences are: the shape and arrangement of black markings, longer hairs on the lateral edges of pronotum and tibiae in *T. sternalis*, scutellum clearly keeled in *T. sternalis*, and weakly keeled in *T. leucopterus*, median keel on pronotum pronounced almost continuously in *T. sternalis*, while in *T. leucopterus* is indicated only in the frontal part (Fig 1) (Péricart 1998; Melber 1988). The nomenclature follows the Fauna Europaea database (de Yong et al. 2014). The collected specimens are stored in the Heteroptera collections of the Dubrovnik Natural History Museum and the National Museum of Bosnia and Herzegovina.

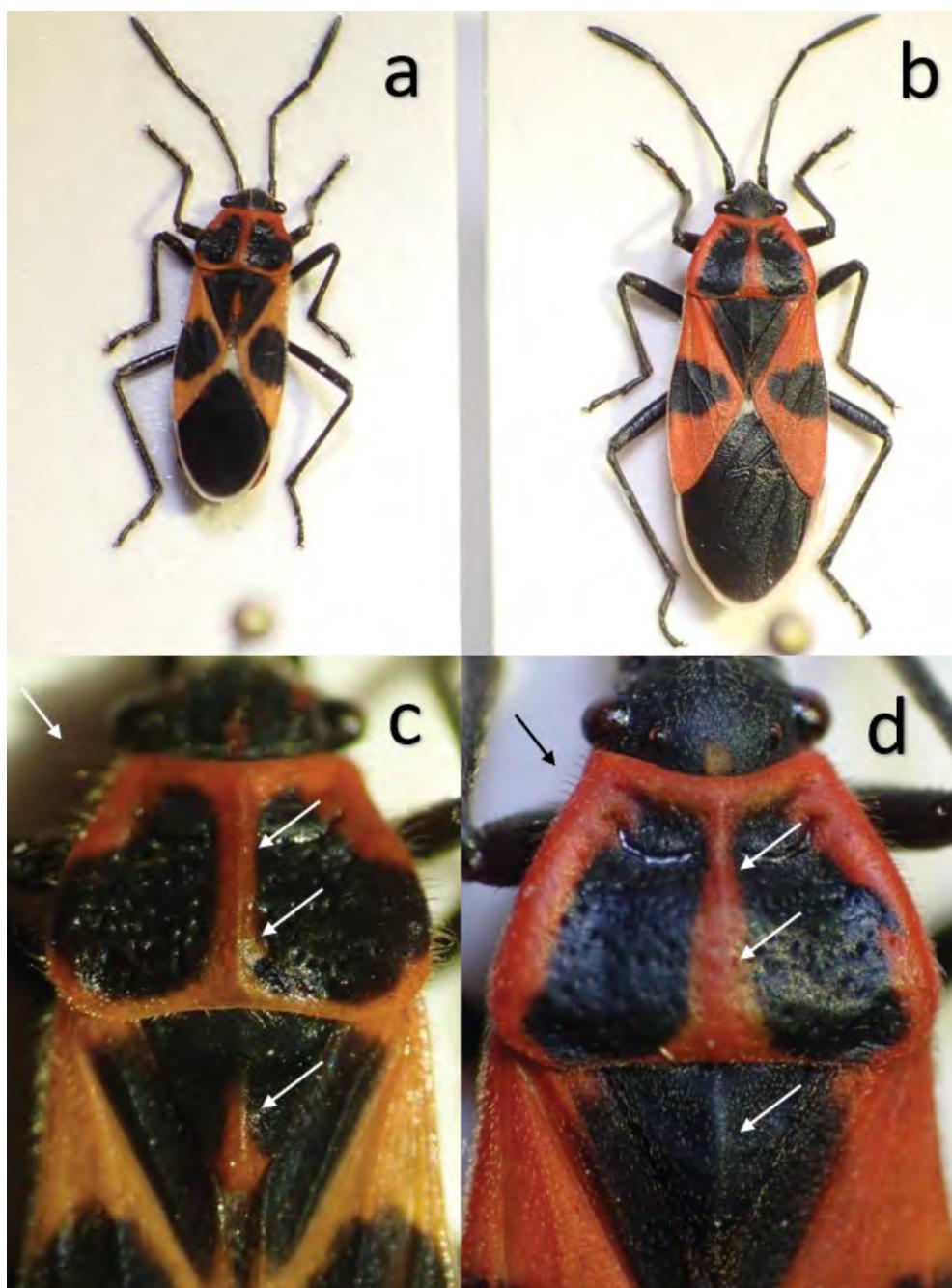


Figure 1 Comparison of morphological characters in *Tropidothorax sternalis* (Dallas, 1852) (a, c) and *Tropidothorax leucopterus* (Goeze, 1778) (b, d) males from Neretva River delta (Photo credit: Matea Martinović)

Slika 1. Usporedba morfoloških karakteristika kod mužjaka vrsta *Tropidothorax sternalis* (Dallas, 1852) (a, c) i *Tropidothorax leucopterus* (Goeze, 1778) (b, d) iz delte rijeke Neretve (autor fotografija: Matea Martinović)

Results and Discussion - Rezultati i rasprava

The Neretva River delta is the only area in Croatia where the reproduction of the African monarch, *Danaus chrysippus* (Linnaeus, 1758) occurs and the oviposition takes place on the host plant *Cynanchum acutum* L. (Koren et al. 2019). In late October 2020, the plants were examined for the presence of *D. chrysippus* through the delta again, and in addition to monarch eggs and caterpillars, two interesting lygaeid bug species, new for the Croatian fauna were recorded.

Caenocoris nerii (Germar, 1847)

New records: Croatia: South of Galičak Hill, 43.021195 17.463299 obs. D. Dender, 25.10.2020, 6.11.2021; Beach Ušće, 43.014465 17.468316 leg. T. Koren & M. Martinović, 29.10.2020; Neretva River mouth, 43.022099 17.451922, leg. T. Koren & M. Martinović, 30.10.2020; Ploče, 43.047363 17.439186, obs. T. Koren, 30.10.2020; Komin, 43.040634 17.49544, obs. T. Koren & M. Martinović, 30.10.2020; Blace, 43.004237 17.471165, leg. M. Martinović, 30.10.2020; Trsteno Arboretum, 42.713164 17.971115, leg. M. Martinović, 30.5.2021; Klek, 42.945527 17.563582, leg. D. Kulijer, 17.9.2022, 8.10.2022, 11.11.2022; **Bosnia and Herzegovina:** Dračevo, 43.053415 17.695945, leg. M. Martinović, 31.10.2020; Neum, 42.926608 17.628019, leg. D. Kulijer, 29.05.2021; Krča, Trebižat, 43.133853 17.666919, leg. D. Kulijer, 27.07.2021.

Caenocoris nerii (Germar, 1847) was present at all five localities surveyed in the Croatian part of the delta. Single adult specimens or mixed nymph and adult aggregations were present on the leaves of *C. acutum* (Fig 2), often close to aggregations of *Tropidothorax leucopterus* (Goeze, 1778) previously known from the area (Novak and Wagner 1951). In the late May of 2021, a single specimen of *C. nerii* was recorded on *Nerium oleander* L. in Trsteno Arboretum close to Dubrovnik, just like the few adults found in Klek from September to November of 2022.

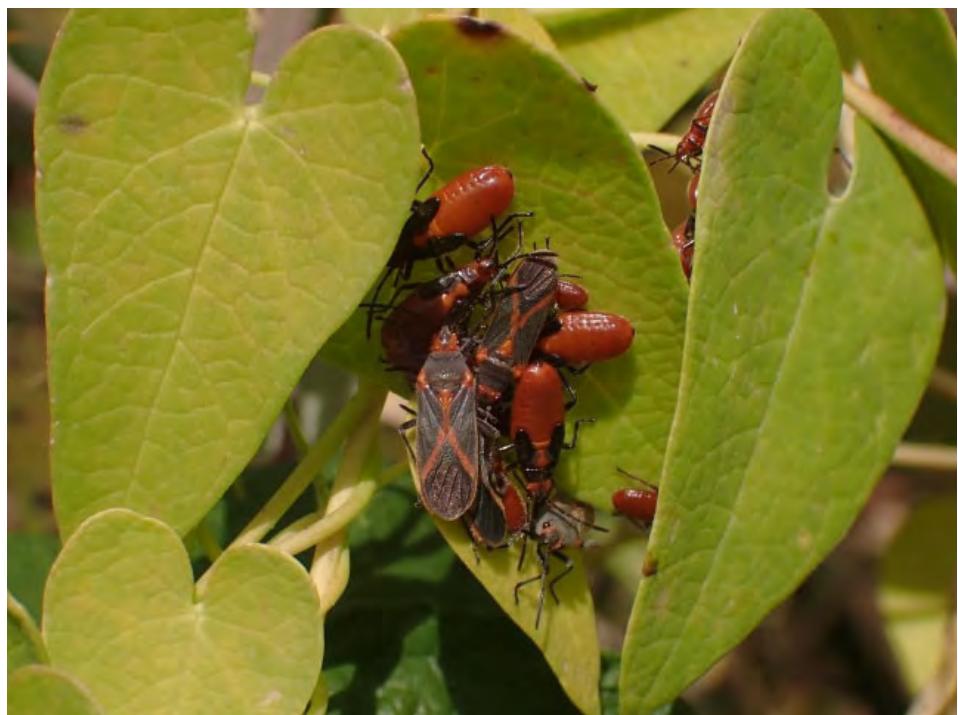


Figure 2 *Caenocoris nerii* (Germar, 1847) - aggregation on *Cynanchum acutum* L. in Komin, Croatia (Photo credit: Matea Martinović)
Slika 2. *Caenocoris nerii* (Germar, 1847) - agregacija na vrsti *Cynanchum acutum* L. u Kominu, Hrvatska (autor fotografije: Matea Martinović)

Driven by the first finding of *C. nerii* in the Croatian part of the delta, a quick survey of the Bosnian part was taken. Our expectation to find *C. nerii* for the first time in Bosnia and Herzegovina as well yielded a positive result, but this time on a different plant species. Numerous nymph and adult specimens were recorded feeding on seed pods of *Periploca graeca* L. on the eastern coast of the Neretva River in Dračevo (Fig 3). In May of 2021, few individuals were recorded in Neum on *N. oleander*, while in July it was abundant on *P. graeca* in Krča.



Figure 3 *Caenocoris nerii* (Germar, 1847) feeding on *Periploca graeca* L. seed pods in Dračeve, Bosnia and Herzegovina: a – adult, b – nymphs (Photo credit: Matea Martinović)

Slika 3. *Caenocoris nerii* (Germar, 1847) na plodovima vrste *Periploca graeca* L. u Dračevu, Bosna i Hercegovina: a – odrasli, b – ličinke (autor fotografija: Matea Martinović)

Tropidothorax sternalis (Dallas, 1852)

New records: Croatia: Ploče, 43.047363 17.439186, obs. T. Koren, 30.10.2020; South of Kozjak Hill, 43.028792 17.474803, obs. Toni Koren, 4.8.2022; South of Galičak Hill, 43.021195 17.463299 leg. D. Dender, 6.11.2021.

The second species new for the Croatian fauna was *Tropidothorax sternalis* (Dallas, 1852), recorded only within the Neretva River delta. The first record dates from 30 October 2020 when a single adult specimen was photographed on *C. acutum* in Ploče. Two years after, one adult specimen was photographed again, this time attracted to a light tent during the moth surveillance of the area in the August of 2022. And finally, the Neretva River delta was visited again in early November of 2022 to confirm the presence of the species. A fast examination of *C. acutum* revealed aggregations of nymphs and adults of *T. sternalis* on the leaves (Fig 4), and several adult specimens were collected.

The surveys in Bosnia and Herzegovina did not result in any records of *T. sternalis*, but this is not surprising as the only host of the species, *C. acutum* is not found in the country.



Figure 4 *Tropidothorax sternalis* (Dallas, 1852) - aggregation on *Cynanchum acutum* L., South of Galičak Hill, Croatia (Photo credit: Dubravko Dender)

Slika 4. *Tropidothorax sternalis* (Dallas, 1852) – agregacija na vrsti *Cynanchum acutum* L., južno od brda Galičak, Hrvatska (autor fotografije: Dubravko Dender)

According to the literature, *C. nerii* was known to use *N. oleander* and *P. laevigata* as its host plants (Péricart 1998), and this survey adds *C. acutum* and *P. graeca* to the list. Both newly recorded host plant species are listed as Endangered (EN) in Croatia (Nikolić & Topić 2005). In Bosnia and Herzegovina, *C. acutum* is not present while *P. graeca* is considered a vulnerable (VU) species according to the Red list of wild species and subspecies of plants, animals, and fungi of the Federation of Bosnia and Herzegovina (Službeni list Federacije Bosne i Hercegovine 2014), the only red list available for the country. In Croatia, both species have scattered distribution in the Mediterranean region, while *P. graeca* is also present to a lesser extent in the Western Pannonian region (Nikolić & Topić 2005). The range of *P. graeca* in Bosnia and Herzegovina is mostly restricted to the valleys of Trebižat and Neretva Rivers and Hutovo Blato wetland in the south of the country (Đug et al. 2013).

The finding of *C. nerii* in the Mediterranean parts of both countries was expected as it fills the gap in its distribution through the Mediterranean. On the other hand, finding *T. sternalis* in Croatia was quite surprising given the fact it was only known to occur in Spain and Southern Italy (Péricart 1998; Olivieri 2013). While the two members of *Tropidothorax* genera exist in separate geographical areas in Spain, *T. sternalis* in the Southern half and *T. leucopterus* in the Northern half of the country (Montagud 2014), the Neretva River delta in Croatia is the a place where they co-exist sympatrically, together with *C. nerii*. The first record of *T. sternalis* in Croatia significantly extends the distribution of the species northwards.

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Nove vrste iz porodice Psyllidae (Hemiptera: Sternorrhyncha: Psylloidea) zabilježene u Hrvatskoj

New species from the family Psyllidae (Hemiptera: Sternorrhyncha: Psylloidea) recorded in Croatia

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Sažetak

Lisne buhe (Hemiptera: Sternorrhyncha: Psylloidea) sitni su kukci koje je u prirodi teško otkriti, posebno kada se nalaze u populacijama niskog intenziteta. Procjenjuje se da je u svijetu do danas opisano oko 4000 vrsta klasificiranih u sedam porodica. Samo manji broj vrsta ubraja se u važne poljoprivredne štetnike, a u posljednje vrijeme dobivaju na značaju zahvaljujući spoznaji da prenose uzročnike biljnih bolesti. Faunističko istraživanje lisnih buha u Hrvatskoj započelo je 2015. godine. Cilj ovog istraživanja bio je sastaviti popis vrsta lisnih buha prisutnih u Hrvatskoj, uz pregled pripadajućih biljaka domaćina, kao i utvrditi potencijalno prisustvo nekih do danas u Hrvatskoj nepoznatih vrsta. Odrasli primjerici lisnih buha uzorkovani su entomološkim kečerom ili metodom otresanja biljaka na bijelu podlogu te su usnim aspiratorom prikupljeni u Falcon epruvete i do laboratorijske analize pohranjeni u 70% etilni alkohol. Identifikacija vrsta provedena je klasičnom makroskopskom i mikroskopskom analizom na osnovi morfoloških karakteristika odraslih stadija i genitalija mužjaka, vrlo rijetko i ženki, uz korištenje dihotomnih ključeva dostupnih u literaturi. U periodu od 2015. do 2021. godine sljedeće vrste lisnih buha iz porodice Psyllidae zabilježene su po prvi puta u Hrvatskoj: *Diaphorina chobauti* Puton, 1898, *Arytaina genistae* (Latreille, 1805), *Cacopsylla brunneipennis* (Edwards, 1896), *Cacopsylla myrthi* (Puton, 1876), *Cacopsylla saliceti* (Foerster, 1848), *Livilla variegata* (Löw, 1881), *Psylla foersteri* Flor, 1861 i *Psylla hartigii* Flor, 1861.

Ključne riječi: lisne buhe, Psyllidae, prvi nalazi, faunistika, Hrvatska

Abstract

Psyllids or jumping plant-lice (Hemiptera: Sternorrhyncha: Psylloidea) are a relatively small group of insects. Some 4000 species have been described so far, classified in seven families. Due to their small body size they often go unnoticed on their host plants. Not many psyllid species are known as plant pests, but they have recently gained attention as vectors of some very harmful plant pathogens. Field survey of psyllid fauna in Croatia started in 2015, with an aim to compile a check-list of psyllid species, with an emphasis on detecting new, previously unrecorded species, together with their host plants. Adult psyllids were collected with entomological fine mesh sweeping net or by beating of branches on a white tray. Entomofauna was subsequently collected with a mouth aspirator and deposited into 70% ethanol until laboratory identification. Species were identified following classical identification methods based on morphological characteristics of adults and male, rarely female, genitalia, using identification

keys available from the literature. During the period 2015-2021 following species from the family Psyllidae were recorded for the first time in Croatia: *Diaphorina chobauti* Puton, 1898, *Arytaina genistae* (Latreille, 1805), *Cacopsylla brunneipennis* (Edwards, 1896), *Cacopsylla myrthi* (Puton, 1876), *Cacopsylla saliceti* (Foerster, 1848), *Livilla variegata* (Löw, 1881), *Psylla foersteri* Flor, 1861 and *Psylla hartigii* Flor, 1861.

Keywords: psyllids, Psyllidae, first records, faunistic, Croatia

Uvod – Introduction

Poznavanje faune osnova je za izučavanje ekologije i bioraznolikosti određenog područja. S obzirom na to da su u Hrvatskoj u posljednjih petnaestak godina provedena faunistička istraživanja za četiri natporodice unutar podreda Sternorrhyncha (Gotlin Čuljak 2006; Masten Milek 2007; Šimala 2008), lisne buhe su preostale jedina faunistički neistražena natporodica ovog podreda u Hrvatskoj.

Lisne buhe sitni su, malim cvrčcima slični kukci (Maceljski 2002), koje je u prirodi teško otkriti, posebno kada se nalaze u populacijama niskog intenziteta. Taksonomski pripadaju redu Hemiptera, odnosno podredu Sternorrhyncha, gdje su svrstane u sedam porodica unutar natporodice Psylloidea (Burckhardt i sur. 2021). Procjenjuje se da je u svijetu opisano oko 4000 vrsta (Percy i sur. 2018). Najslabije su poznata natporodica unutar podreda Sternorrhyncha (Percy i sur. 2018), što proizlazi iz činjenice da se za razliku od brojnih drugih skupina kukaca, samo manji broj vrsta ubraja u važne poljoprivredne štetnike (Martoni 2017; Percy i sur. 2018). U posljednje su vrijeme dobile na značaju zahvaljujući sposobnosti da prenose biljkama vrlo štetne unutarstanične fitopatogene bakterije iz rodo 'Candidatus Liberibacter' i 'Candidatus Phytoplasma' (Weintraub i Beanland 2006; Drohojowska i Burckhardt 2014; Halbert i Burckhardt 2020). Lisne buhe rasprostranjene su u cijelom svijetu, a raznolikost im je najveća u tropskim i suptropskim područjima (Burckhardt 1987; Hollis 2004), gdje vrste stvaraju veliki broj, najčešće preklapajućih, generacija (Burckhardt 1994). Većina vrsta umjerenog klimata je univoltino (Ossiannilsson 1992). Lisne buhe isključivo su fitofagni kukci (Ossiannilsson 1992), a s obzirom na izbor biljnih domaćina za ishranu, uglavnom su monofagi. Manji je broj vrsta oligofagan, dok je polifaga među lisnim buhami vrlo malo (Ossiannilsson 1992; Malenovský i Lauterer 2017; Seljak 2020). S obzirom na usku povezanost lisnih buha uz biljne domaćine kojima se hrane, za uspješno istraživanje faune lisnih buha neophodno je dobro poznavanje flore istraživanog područja.

Novo zabilježene vrste lisnih buha iz porodice Psyllidae u Hrvatskoj, zajedno s lokalitetima nalaza i biljnim domaćinima, prikazane su u ovom radu.

Materijali i metode – Materials and Methods

Faunističko istraživanje lisnih buha u Hrvatskoj započelo je 2015. godine, na području 20 županija kontinentalne i priobalne Hrvatske. Odrasle lisne buhe uzorkovane su na dva načina, ovisno o habitusu i vrsti biljke domaćina. Prikupljanje entomofaune teleskopskim entomološkim kečerom promjera obruča 30 cm metoda je korištena za uzorkovanje kukaca sa zeljastog bilja, livada i travnjaka te drvenastog bilja s gustom lisnom masom dok je metoda otresanja biljaka na bijelu podlogu primjenjivana kod uzorkovanja odraslih stadija lisnih buha sa trnovitog drvenastog bilja i drvenastog bilja rijetke lisne mase. Primjerici odraslih lisnih buha izolirani su iz prikupljene entomofaune usnim aspiratorom u Falcon epruvete i pohranjeni u 70 % etilnom alkoholu

(EtOH). Svi prikupljeni uzorci etiketirani su i označeni osnovnim podacima relevantnim za faunistički nalaz (oznaka uzorka, biljka domaćin, lokalitet i datum uzorkovanja, GPS koordinate). Identifikacija vrsta provedena je klasičnom makroskopskom i mikroskopskom analizom na osnovi morfoloških karakteristika prikupljenih jedinki u Laboratoriju za zoologiju Centra za zaštitu bilja. Identifikacija lisnih buha do razine roda provedena je na odraslim stadijima dok se određivanje vrste temeljilo na morfološkim karakteristikama genitalija mužjaka, odnosno u slučaju jedne vrste, ženki. Za potrebe determinacije vrsta sakupljenih jedinki izrađivani su trajni mikroskopski preparati genitalija odraslih stadija prema modificiranoj metodi Watson i Chandler (1999). Za determinaciju lisnih buha korištena je binokularna lupa Olympus SZX7 te svjetlosni mikroskop Olympus BX 51 pod povećanjima 10x, 20x i 40x opremljeni digitalnim mikroskopskim kamerama i softverima za morfometriju. Nakon izrade trajnih preparata, provedena je usporedba morfoloških karakteristika genitalija s opisima, slikama i crtežima iz literature. Za identifikaciju novih vrsta lisnih buha iz porodice Psyllidae u fauni Hrvatske korištena je sljedeća literatura: Hodkinson i White (1979), Burckhardt (1984), Hodkinson i Hollis (1987), Rapisarda (1989), Ossiannilsson (1992) i Lauterer i Burckhardt (1997). Sistematska podjela slijedi Burckhardt i sur. (2021).

Za određivanje vrsta i rodova biljaka domaćina korištena je literatura prema Kovačić i sur. (2008) i Nikolić i Kovačić (2008) te online baza podataka prema Nikolić (2005-danas).

Rezultati – Results

Tijekom faunističkog istraživanja u periodu 2015.-2021. godine osam vrsta lisnih buha iz porodice Psyllidae zabilježeno je u Hrvatskoj po prvi put. Vrste koje su nove za entomofaunu Hrvatske su *Diaphorina chobauti* Puton, 1898, *Arytaina genistae* (Latreille, 1805), *Cacopsylla brunneipennis* (Edwards, 1896), *Cacopsylla myrthi* (Puton, 1876), *Cacopsylla saliceti* (Foerster, 1848), *Livilla variegata* (Löw, 1881), *Psylla foersteri* Flor, 1861 i *Psylla hartigii* Flor, 1861. Faunistički podatci o novim vrstama prikazani su u Tablici 1.

Tablica 1. Faunistički podaci o novozabilježenim vrstama iz porodice Psyllidae u Hrvatskoj

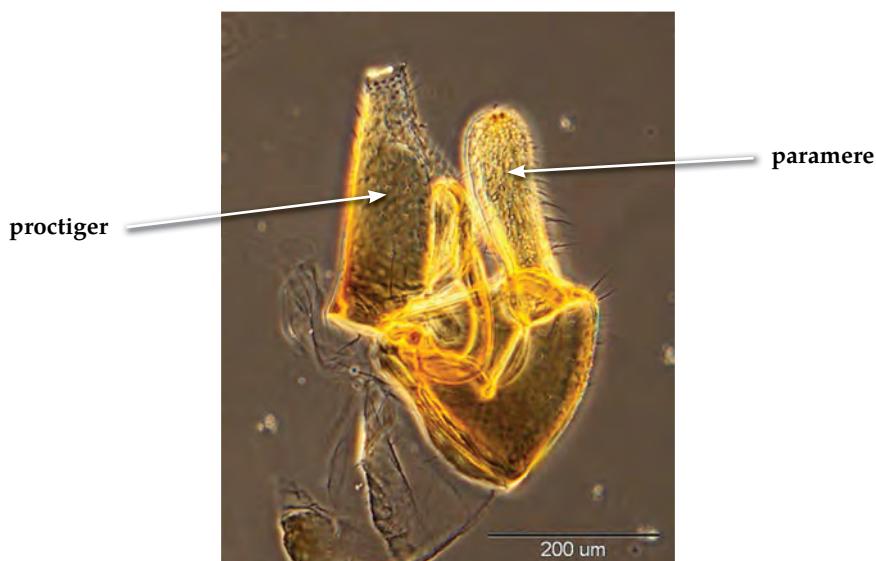
Table 1 Faunistic data for newly recorded species from the family Psyllidae in Croatia

Vrsta <i>Species</i>	Datum i lokalitet nalaza <i>Date and locality</i>	Koordinate <i>Coordinates</i>	Biljni domaćin <i>Host plant</i>
<i>Diaphorina chobauti</i> Puton, 1898	10.08.2017. Antenal	N 45° 19' 09.2" E 13° 35' 20.3"	<i>Convolvulus cantabrica</i> L.
	13.07.2018. Karigador	N 45° 21' 30.8" E 13° 33' 28.1"	
	13.07.2018. Umag	N 45° 25' 35.3" E 13° 33' 00.7"	<i>Daucus carota</i> L.*
	27.07.2016. Đurđevac	N 46° 01' 48.8" E 17° 05' 56.6"	<i>Cytisus scoparius</i> (L.) Link
	21.05.2020. Baćinska jezera	N 43° 04' 28.1" E 17° 25' 25.6"	<i>Genista</i> spp.
<i>Arytaina genistae</i> (Latreille, 1805)	20.05.2021. Kaštel Sućurac	N 43° 32' 43.2" E 16° 27' 21.7"	<i>Cytisus</i> spp.
	15.07.2021. Trojstveni Markovac	N 45° 54' 30.9" E 16° 52' 03.6"	
	09.08.2021. Zagreb	N 45° 46' 45.2" E 15° 57' 17.7"	

<i>Cacopsylla brunneipennis</i> (Edwards, 1896)	13.04.2015. Zaprešić 22.05.2020. Metković	N 45° 52' 42.1" E 15° 48' 59.3" N 43° 03' 05.8" E 17° 37' 54.0"	<i>Salix</i> spp.
<i>Cacopsylla myrthi</i> (Puton, 1876)	04.06.2021. Jadrija 01.06.2020. Zagreb-Medvednica	N 43° 43' 28.4" E 15° 50' 44.9" N 45° 52' 27.8" E 15° 58' 36.0"	<i>Rhamnus alaternus</i> L. <i>Salix</i> spp.
<i>Cacopsylla saliceti</i> (Foerster, 1848)	11.06.2021. Štefanec 11.06.2021. Varaždin	N 46° 21' 46.2" E 16° 29' 38.3" N 46° 18' 39.4" E 16° 19' 35.3"	<i>Salix alba</i> L.
<i>Livilla variegata</i> (Löw, 1881)	06.06.2020. Zagreb- Medvednica	N 45° 53' 16.8" E 15° 56' 03.6"	<i>Laburnum alpinum</i> (Mill.) Bercht. et J. Presl
<i>Psylla foersteri</i> Flor, 1861	24.05.2020. Gornji Stupnik 24.05.2021. Doljan	N 45° 44' 41.7" E 15° 48' 44.8" N 46° 14' 51.6" E 16° 20' 30.5"	<i>Alnus glutinosa</i> (L.) Gaertn.
<i>Psylla hartigii</i> Flor, 1861	10.05.2020. Zagreb	N 45° 50' 58.7" E 15° 56' 05.8"	<i>Betula pendula</i> Roth

*(slučajni domaćin- casual plant)

Osnovne makroskopske morfološke karakteristike odraslih stadija lisnih buha na osnovi kojih je obavljena identifikacija jedinki do rodova su: boja tijela; oblik, transparentnost i prošaranost krila; nervatura prednjih krila, odnosno način račvanja bazalne žile R+M+Cu₁; prisustvo pterostigme i reza na žili Costa (*costal break*) na prednjim krilima; prisustvo, oblik i veličina „izbočina“ na obrazima (*genal cones*); broj crnih trnova (*saltatorial spines*) na goljenicama stražnjih nogu (*metatibia*); broj vršnih trnića (*apical spur*) na prvom članku stopala stražnjih nogu (*metatarsus*). Identifikacija sedam vrsta obavljena je na temelju sljedećih morfoloških karakteristika genitalija odraslih mužjaka: oblik, veličina i struktura kliješta za parenje (*paramere*) i *proctigera* (Slike 1-6; Slika 8) te ponekad i oblik distalnog dijela penisa (*distaphalus*). Vrsta *P. foersteri* identificirana je na temelju morfoloških karakteristika genitalija ženki i to oblika, strukture i veličine *proctigera* (Slika 7).



Slika 1. Genitalni aparat mužjaka vrste *Diaphorina chobauti* s označenim glavnim razlikovnim dijelovima

Figure 1 *Diaphorina chobauti* male genital terminalia showing main differential characteristics



Slika 2. Genitalni aparat mužjaka vrste *Arytaina genistae*

Figure 2 *Arytaina genistae* male genital terminalia



Slika 3. Genitalni aparat mužjaka vrste *Cacopsylla brunneipennis*

Figure 3 *Cacopsylla brunneipennis* male genital terminalia



Slika 4. Genitalni aparat mužjaka vrste *Cacopsylla myrthi*

Figure 4 *Cacopsylla myrthi* male genital terminalia



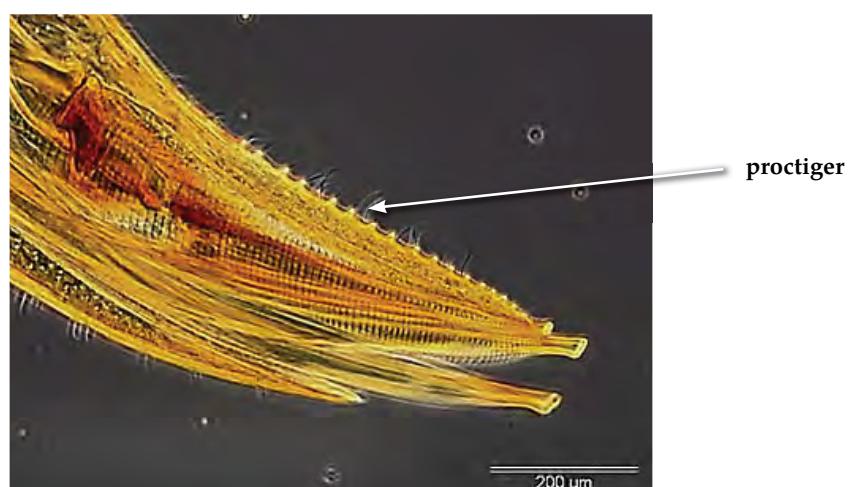
Slika 5. Genitalni aparat mužjaka vrste *Cacopsylla saliceti*

Figure 5 *Cacopsylla saliceti* male genital terminalia



Slika 6. Genitalni aparat mužjaka vrste *Livilla variegata*

Figure 6 *Livilla variegata* male genital terminalia



Slika 7. Genitalni aparat ženke vrste *Psylla foersteri* s „nazubljenim“ proctigerom

Figure 7 *Psylla foersteri* female genital terminalia with dentate proctiger



Slika 8. Genitalni aparat mužjaka vrste *Psylla hartigii*

Figure 8 *Psylla hartigii* male genital terminalia

Rasprava – Discussion

S obzirom na uniformnost genitalnog aparata ženki lisnih buha, odnosno činjenicu da su oblik i veličina *proctigera* i subgenitalne ploče kod ženki uglavnom ujednačeni, određivanje vrsta uglavnom se temelji na genitalnom aparatu mužjaka. Identifikacija svega nekoliko vrsta provodi se na ženkama, uključujući vrstu *P. foersteri*. S obzirom da je mužjake *P. foersteri* vrlo teško razlikovati od mužjaka vrste *Psylla alni* (Linné, 1758), koju pronalazimo na istim biljnim domaćinima (*Alnus glutinosa* (L.) Gaertn., *Alnus incana* (L.) Moench), determinacija prema genitalnom aparatu ženke omogućava nedvojbeno razlikovanje ovih dviju vrsta. *Proctiger* genitalnog aparata ženke *P. foersteri* karakterizira niz sitnih trnica poredanih s gornje strane (Slika 7), koji izostaju kod *P. alni*.

Prema Burckhardt i sur. (2014) primarnim domaćinima lisnih buha smatraju se one biljne vrste na kojima ličinke mogu završiti svoj razvoj do odraslog stadija dok se „slučajnim“ domaćinima nazivaju biljke na kojima lisne buhe borave nemamjerno te se na njima ne hrane. S obzirom na to da su tijekom ovog faunističkog istraživanja lisne buhe prikupljane uglavnom ciljano, sa flore poznate kao biljni domaćini lisnih buha, pronalazak jedinki na biljkama koje određenim vrstama lisnih buha ne predstavljaju primarne domaćine sveden je na minimum i odnosi se na pronalazak vrste *D. chobauti* na divljoj mrkvi (*Daucus carota* L.). Iako ružičasti slak (*Convolvulus cantabrica* L.) predstavlja primarnog domaćina ove vrste lisne buhe, pronalazak jedinki na divljoj mrkvi ne iznenađuje, s obzirom na to da ove dvije biljne vrste često pronalazimo zajedno u mješovitim primorskim zajednicama suhih livada i kamenitih staništa.

U radu prikazane novozabilježene vrste mogu se smatrati autohtonima za hrvatsku faunu. Osnovni kriterij za određivanje je li neka fitofagna vrsta na određenom području strana ili autohtona je prirodna rasprostranjenost njezina biljnog domaćina. To znači da se vrste lisnih buha zabilježene na biljnim domaćinima čiji prirodni areal rasprostranjenosti obuhvaća područje Hrvatske i europskih zemalja usporedivih biogeografskih i klimatskih obilježja, mogu smatrati autohtonima za naše područje. Ovo je najlakše odrediti za lisne buhe kojima biljne vrste prirodno rasprostranjene na području Mediterana predstavljaju domaćine, što se u ovom slučaju odnosi na vrste

D. chobauti i *C. myrthi*. Za preostale vrste lisnih buha prirodna rasprostranjenost njihovih biljnih domaćina provjeravana je u dostupnoj literaturi autora Alegro (2000), Nikolić (2005-nadalje) i Nikolić i Kovačić (2008).

Brojnim vrstama iz roda *Cacopsylla* Ossiannilsson 1970, poput *C. brunneipennis* i *C. saliceti*, mnoge vrste vrba, u Hrvatskoj prirodno široko rasprostranjene na hidromorfnim tlima, predstavljaju primarne domaćine. Primarnog domaćina *A. genistae*, metlastu žućicu (*Cytisus scoparius* (L.) Link), pronalazimo na pjeskovitim tlima u umjerenim područjima dok se vrsta *L. variegata* hrani na planinskom zanovijetu [*Laburnum alpinum* (Mill.)], prirodno rasprostranjenom na području Balkana. Vrstama *P. foersteri* i *P. harti-gii* primarne domaćine predstavljaju u Europi i Hrvatskoj široko rasprostranjena stabla crne johe (*Alnus glutinosa* (L.) Gaertn.), odnosno obične breze (*Betula pendula* Roth).

Ovaj rad značajan je prilog poznavanju entomofaune Hrvatske s aspekta praćenja bioraznolikosti. Međutim, fauna lisnih buha Hrvatske i dalje ostaje uvelike neistražena, zbog čega se posao proučavanja ove skupine kukaca nastavlja, a u predstojećim je godinama realno za očekivati pronalazak novih, još nezabilježenih vrsta.

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Rezultati programa posebnog nadzora karantenske vrste tripsa *Thrips palmi* Karny, 1925 (Thysanoptera: Thripidae) u Hrvatskoj u 2021.

Results of a survey of quarantine thrips species *Thrips palmi* Karny, 1925 (Thysanoptera: Thripidae) in Croatia in 2021

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Sažetak

Thrips palmi Karny, 1925 polifagna je fitofagna vrsta tripsa zabilježena na biljnim vrstama iz više od 36 porodica, posebice iz porodica Cucurbitaceae i Solanaceae. Vektor je destruktivnih biljnih tospovirusa. Pretpostavlja se da vrsta potječe iz južne Azije. Vrsta u EU ima status karantenskog štetnog organizma i često se presreće u uvoznim izvaneuropskim pošiljkama rezanog cvijeća, plodova i povrća. Štetnik predstavlja ozbiljan fitosanitarni rizik za poljoprivrednu proizvodnju na području Mediteranskog bazena. Provođenje programa posebnog nadzora nad štetnim organizmom *T. palmi* započeto je u Hrvatskoj 2021. godini. Vizualnim pregledima obuhvaćeni su nasadi povrća u zaštićenim prostorima te ukrasno bilje u rasadnicima i vrtnim centrima na 34 lokaliteta u 13 županija. Odrasli primjerici tripsa prikupljeni su otresanjem biljaka na bijelu podlogu ili izravno finim kistom s biljnih organa te pohranjeni do laboratorijske analize u AGA mješavini u Eppendorf epruvetama. Ukupno je obavljeno 46 vizualnih pregleda i pritom je prikupljen 101 uzorak tripsa s 43 biljne vrste za laboratorijsku analizu. Primjerici tripsa su u prikupljenim uzorcima mikroskopski identificirani do razine vrste na osnovi morfoloških karakteristika odraslih ženki, pomoću EPPO dijagnostičkog protokola PM 7/3 (3) i relevantnih ključeva za identifikaciju. U prikupljenim uzorcima determinirano je 19 vrsta tripsa, od kojih su *Chaetanaphothrips orchidii* (Moulton, 1907) i *Scirtothrips cf. canizoi* Titchak, 1964 nove za faunu tripsa u Hrvatskoj. Niti u jednom analiziranom uzorku nije identificirana karantenska vrsta *T. palmi*.

Ključne riječi: Thysanoptera, *Thrips palmi*, *Chaetanaphothrips orchidii*, *Scirtothrips cf. canizoi*, prvi nalaz, Hrvatska

Abstract

Thrips palmi Karny, 1925 is a polyphagous, phytophagous thrips species recorded on numerous plant species from more than 36 families, with species from Cucurbitaceae and Solanaceae predominating. It is a vector of destructive plant tospoviruses. It appears to have originated in Southern Asia. In the EU the species has a status as a quarantine harmful organism and it is regularly intercepted in imported non-European shipments of cut-flowers, fruits and vegetables. *T. palmi* presents a serious phytosani-

tary risk for agricultural production in the Mediterranean basin. A survey of quarantine species *T. palmi* started in Croatia in 2021. Visual inspections were conducted in vegetable plantations in greenhouses as well as on ornamentals in nurseries and garden centers, in 34 localities in 13 counties. Adult thrips specimens were collected by beating of plants on a white plastic tray or directly from plant organs with a fine brush and stored in AGA mixture in Eppendorf vials until laboratory analysis. Altogether 46 visual inspections were carried out and 101 samples of trips from 43 plant species were collected for laboratory analysis. Thrips from collected samples were identified to the species level on the basis of morphological characters of adult females, using classical identification method according to the EPPO diagnostic protocol PM 7/3 (3) and relevant morphological keys. Nineteen species of thrips were identified in the collected samples, of which *Chaetanaphothrips orchidii* (Moulton, 1907) and *Scirtothrips cf. canizoi* Titchak, 1964 are new for the thrips fauna in Croatia. Quarantine species *T. palmi* was not determined in any of the analyzed samples.

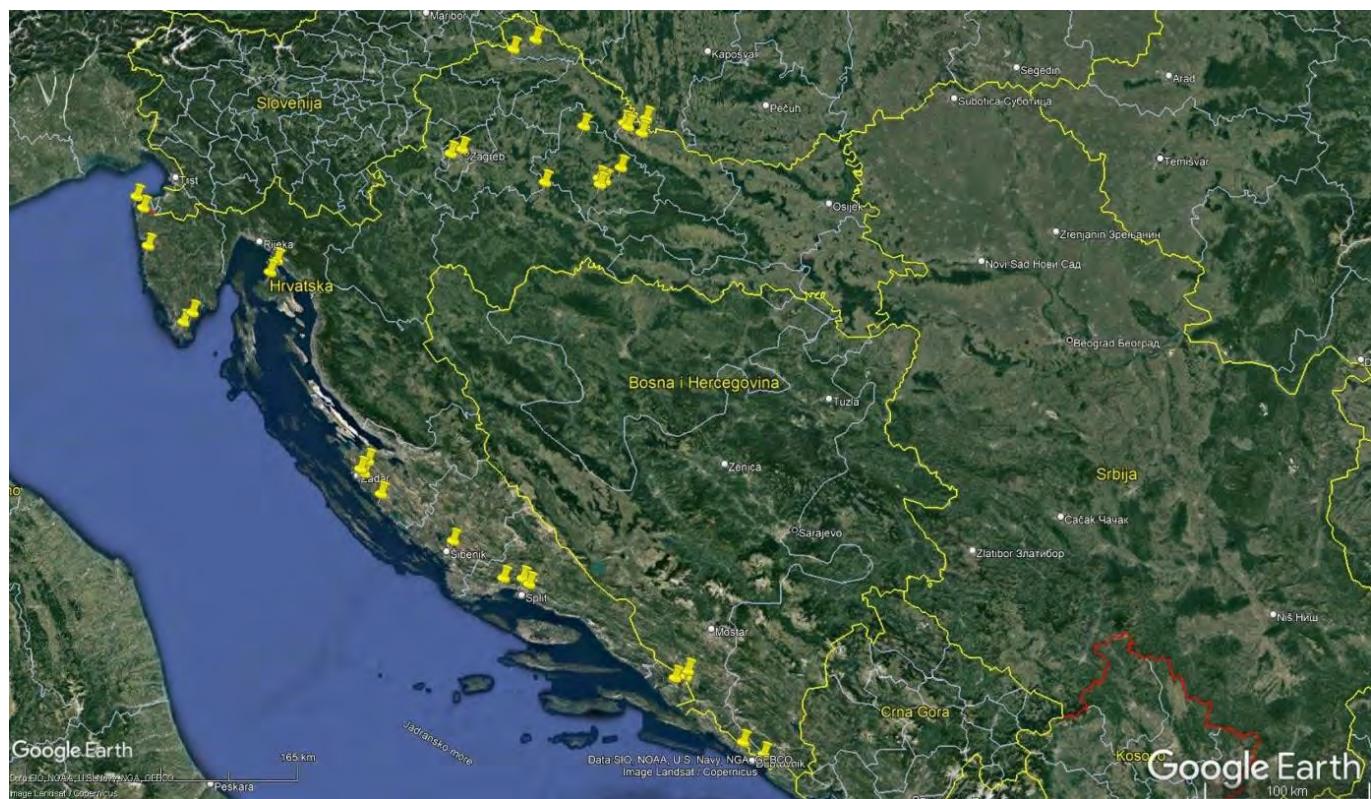
Keywords: Thysanoptera, *Thrips palmi*, *Chaetanaphothrips orchidii*, *Scirtothrips cf. canizoi*, first record, Croatia

Uvod – Introduction

Thrips palmi Karny, 1925 (Thysanoptera: Thripidae) vrsta je tripsa prvi puta opisana na osnovi primjeraka nađenih na Sumatri i Javi, a naziv joj je dodijeljen u čast dr. B. T. Palma, istaknutog specijalista ove grupe kukaca. Primarno je suptropska i tropска vrsta koja se u posljednja tri desetljeća 20. stoljeća proširila, poglavito zahvaljujući međunarodnoj trgovini bilja južnom Azijom, Pacifikom i Karibima. Lokalno je prisutna i u Sjevernoj, Središnjoj i Južnoj Americi te Africi i Australiji (EFSA 2019; Mound i Masumoto 2005). Izrazito je polifagan štetnik, u svijetu zabilježen na vrstama iz više od 36 biljnih porodica, pri čemu preferira one iz porodica Cucurbitaceae i Solanaceae. Na kultiviranom bilju uzrokuje izravne gospodarske štete ishranom ličinki i odraslih stadija te neizravne kao vektor destruktivnih biljnih tospovirusa: *Groundnut bud necrosis virus*, *Melon yellow spot virus* i *Watermelon silver mottle virus* (OEPP/EPPO 2018). Prema podatcima EFSA-e (2019a) većina teritorija južne Europe, posebice Iberijski poluotok, mediteranski dio Francuske i Italije te obalni dio Balkanskog poluotoka, uključujući cijelu Grčku, pogodni su za potencijalnu aklimatizaciju i udomaćenje *T. palmi*, zbog čega vrsta predstavlja ozbiljan fitosanitarni rizik za proizvodnju plodovitog povrća i ukrašnog bilja, posebice u zaštićenim prostorima Republike Hrvatske. Vrsta *T. palmi* ima status karantenskog štetnika na području Europske Unije i prema Provedbenoj uredbi Komisije (EU) 2019/2072 svrstana je u Prilog II. Dio A, koji obuhvaća štetne organizme za koje nije poznato da se pojavljuju na području Unije (Službeni list Europske unije 2019). Do sada su na području EU zabilježene redovite intercepcije ovog štetnika u izvaneuropskim uvoznim pošiljkama rezanog cvijeća, plodova voća i povrća te posljedično nekoliko izbijanja zaraza koje su eradicirane u Nizozemskoj (1998), Ujedinjenom Kraljevstvu (2000) i Njemačkoj (2014) (OEPP/EPPO 2018). U Hrvatskoj ova vrsta tripsa nije nikada detektirana. Sukladno aktualnoj nacionalnoj i europskoj legislativi, nakon razdoblja praćenja ovog štetnog organizma od 2003. do 2006. (Šimala i Masten Milek 2008), HAPIH – CZB ponovno je 2021. započeo provođenje programa nadzora karantenske vrste *T. palmi*, s primarnim ciljem određivanja njezinog fitosanitarnog statusa na području Republike Hrvatske. Neposredni cilj programa bio je potencijalni pronalažak karantenskih vrsta iz roda *Scirtothrips* Shull, 1909 navedenih na popisu reguliranih štetnih organizama EU, odnosno vrsta tripsa s EPPO Alert, A1 i A2 liste.

Materijali i metode – Materials and Methods

Program posebnog nadzora karantenske vrste štetnika *T. palmi* proveden je od svibnja do studenog 2021. u nasadima povrća u zaštićenim prostorima te na ukrasnom bilju u rasadnicima i vrtnim centrima. Vizualni pregledi bilja i prikupljanje uzoraka tripsa za laboratorijsku analizu obavljeni su na ukupno 34 lokaliteta u 13 županija obalne i kontinentalne Hrvatske (Slika 1.). Na svakom od odabralih lokaliteta obavljeno je jedan do dva vizualna pregleda bilja, odnosno ukupno njih 46.



Slika 1. Lokaliteti na kojima je proveden program posebnog nadzora vrste *T. palmi* u Hrvatskoj 2021. (žute oznake)

Figure 1 Localities where the survey of species *T. palmi* was carried out in Croatia in 2021 (yellow marks)

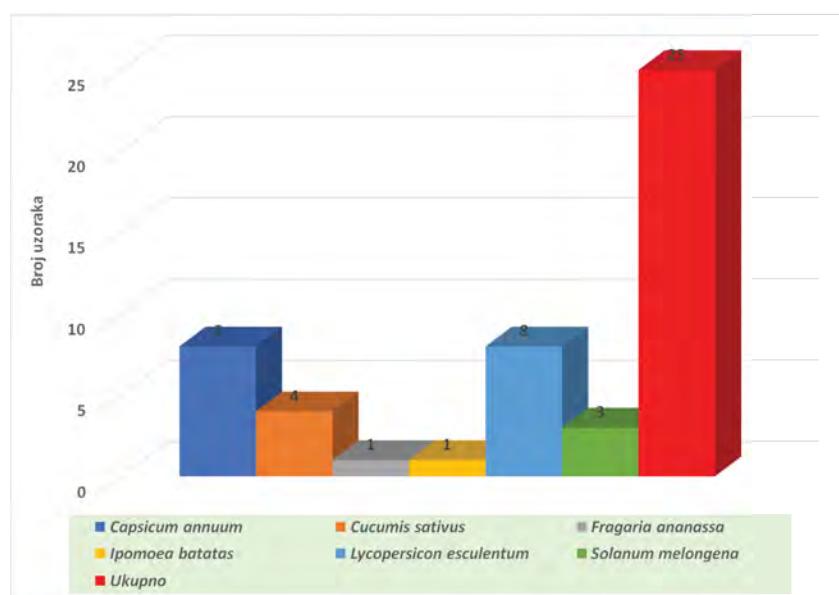
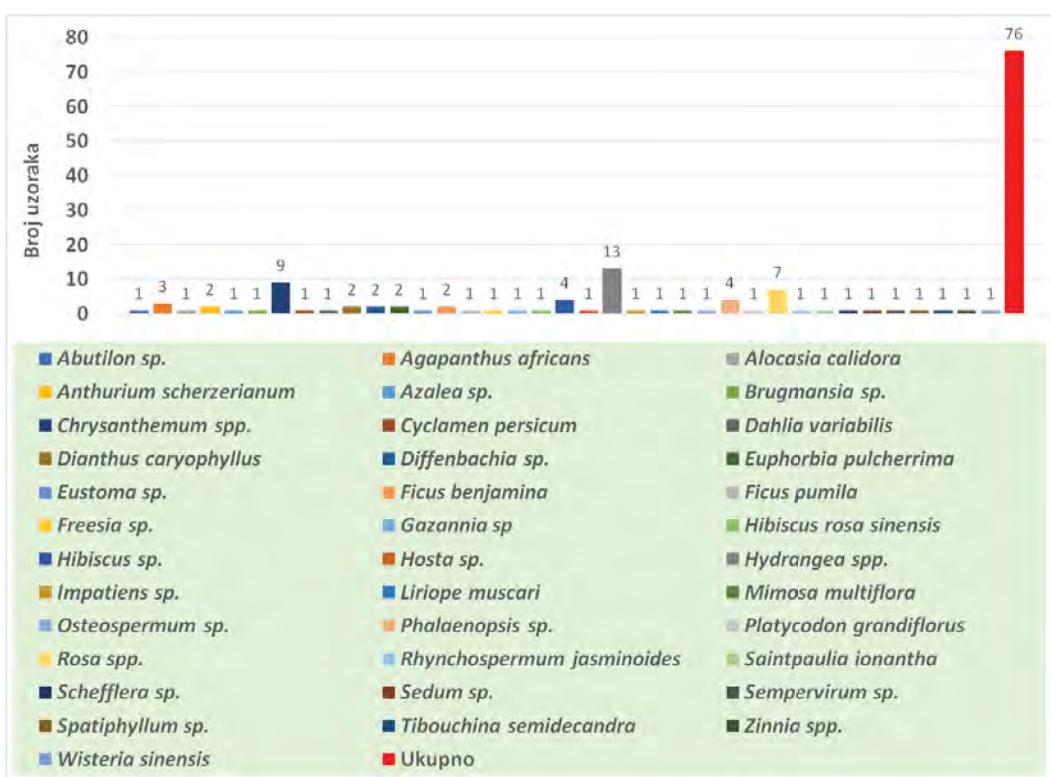
Vizualni pregledi realizirani su kontrolom listova i cvjetova povrtnih i ukrasnih biljaka na prisutnost simptoma napada tripsa te na prisutnost odraslih primjeraka tripsa. Uzorci tripsa prikupljeni su metodom otresanja suspektnih biljaka na bijelu podlogu ili izravnim prikupljanjem tripsa s nadzemnih biljnih organa finim kistom. Jedan uzorak predstavljalo je 1 do 10 odraslih jedinki prikupljenih s jedne biljne vrste na jednom lokalitetu. Primjeri odraslih razvojnih stadija tripsa pohranjeni su u mješavini devet dijelova 60-postotnog etilnog alkohola i po jednog dijela glacijalne octene kiseline te glicerina u Eppendorf epruveti (Mound i Kibby 1998) te čuvani do laboratorijske analize na hladnom, u priručnom prenosivom hladnjaku. Prikupljeni uzorci tripsa označeni su relevantnim podatcima, što obuhvaća oznaku uzorka, biljnu vrstu, lokalitet, pripadajuću GPS koordinatu i datum uzorkovanja. Vrsta tripsa u prikupljenim uzorcima identificirana je klasičnom mikroskopskom metodom na osnovi morfoloških karakteristika odraslih stadija ženki, uz pomoć EPPO dijagnostičkog protokola PM 7/3(3) (OEPP/EPPO 2018) te dihotomnih identifikacijskih ključeva (Mound i Kibby 1998; Zur Strassen 2003). Kod determinacije vrste iz roda *Scirtothrips* Shull, 1909

dodatno su korišteni dijagnostički EPPO protokol PM 7/56(1) (OEPP/EPPO 2005) i literarni opis vrste (Titschack 1964; Lacasa i sur. 1996). Odrasle ženke prikupljene u uzorcima pripremljene su za izradu trajnih mikroskopskih preparata uz pomoć binokularne lupe Olympus SZX 7, opremljene digitalnom kamerom Olympus LC 20. Postupak preparacije tripsa proveden je modificiranim metodom opisanom od Mo und i Kibby (1998). Primjeri tripsa pincetom su iz Eppendorf epruvete premješteni u 40 postotnu mlijecnu kiselinu u staklenoj epruveti. Sadržaj je zagrijavan 10 minuta u sterilizatoru tipa MS-1 na 90 °C. Tripsi su zatim pincetom preneseni iz epruvete u satno stakalce ispunjeno benzil alkoholom i pokriveno polovicom staklene petrijeve posude. Nakon jednog sata, preparirani primjeri položeni su dorzo-ventralno na predmetno stakalce, u nekoliko kapi mješavine kemikalija Canada balsam (dva dijela) i benzil alkohola (jedan dio) te su pokriveni pokrovnim stakalcem. Determinacija tripsa obavljena je korištenjem svjetlosnog mikroskopa Olympus BX 51 (okulari s povećanjem 10x i objektivi s povećanjem 4, 10, 20, 40 i 100x) opremljenog digitalnom kamerom Olympus model DP 25. Mikroskopski trajni preparati tripsa nakon završenoga postupka preparacije, identifikacije vrste te etiketiranja podvrgnuti su procesu sušenja u sterilizatoru oko dva mjeseca na 40 °C. Trajni preparati tripsa pohranjeni su u entomološkoj zbirci HAPIH – Centra za zaštitu bilja.

Rezultati i rasprava – Results and Discussion

Opće prihvaćena međunarodna imena vrste *T. palmi* prevedena na hrvatski jezik su dinjin trips („melon thrips“), orijentalni trips („oriental thrips“) i južni žuti trips („southern yellow thrips“). U literaturi se također često navodi i engleski naziv „palm thrips“, ali se on ne referira na biljku domaćina štetnika, već je povezan s entomologom Palmom. U stručnoj hrvatskoj literaturi pogrešno se navodi hrvatsko ime za ovu vrstu tripsa kao palmin trips (Maceljski 2002), što implicira na to da se hrani i na palmama. Međutim, niti jedna vrsta palme nije zabilježena u literaturi kao domaćin vrste *T. palmi*, već je autor ime vrste posvetio Palmu (EFSA 2019). Stoga bi za vrstu *T. palmi* entomolozi i lingvisti trebali odrediti jedan od triju prethodno navedenih hrvatskih naziva.

U okviru programa posebnog nadzora vrste *T. palmi* u 2021. ukupno je prikupljen 101 uzorak tripsa. Laboratorijski je obrađeno 100 uzoraka, jer su u jednom uzorku prikupljenom na ukrasnoj biljnoj vrsti detektirane samo ličinke tripsa, što nije relevantni stadij za morfološku identifikaciju te taj uzorak nije analiziran, odnosno nije bilo moguće odrediti vrstu. Sa povrtnih kultura ukupno je uzorkovano 25 uzoraka, pri čemu je najviše uzoraka prikupljeno s paprike i rajčice kao važnih povrtnih domaćina štetnika iz porodice Solanaceae (Slika 2). Na ukrasnom bilju prikupljeno je ukupno 76 uzoraka tripsa s 37 različitim biljnim vrstama, podrijetla uglavnom iz premeštanja unutar EU (Slika 3).

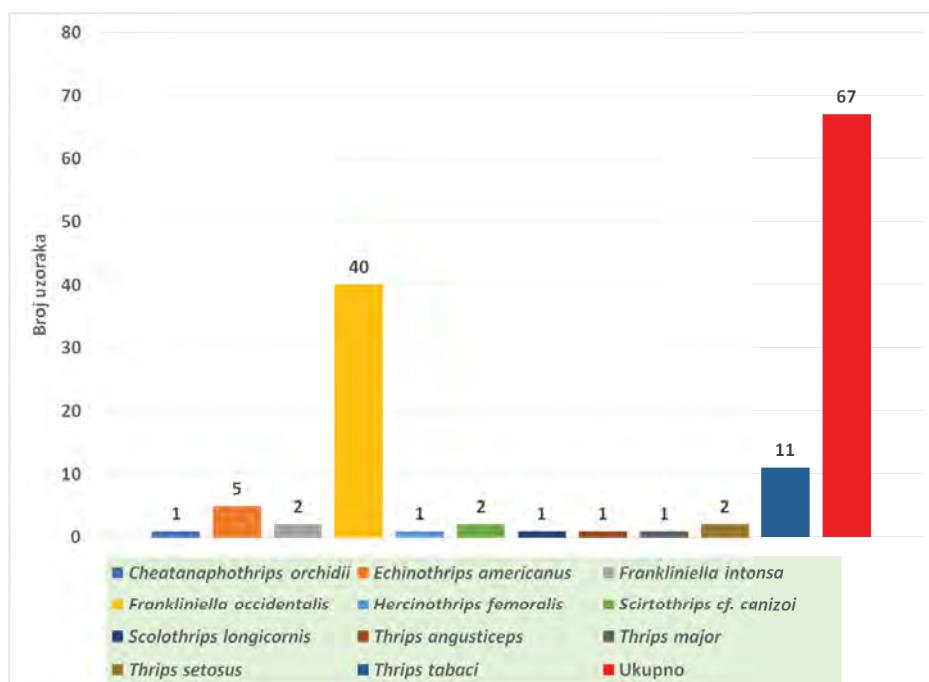
**Slika 2.** Uzorci tripsa prikupljeni na povrtnim kulturama**Figure 2** Samples of thrips collected on vegetables**Slika 3.** Uzorci tripsa prikupljeni na ukrasnem bilju**Figure 3** Samples of thrips collected on ornamentals

U prikupljenim uzorcima laboratorijski su analizirana i preparirana ukupno 363 primjerka odraslih razvojnih stadija tripsa (327 ženki i 36 mužjaka). Morfološki je identificirano 19 vrsta tripsa iz dviju porodica unutar podreda Terebrantia te jedne porodice koja taksonomski pripada podredu Tubulifera (Tablica 1.). Očekivano, najveći broj pripadao je fitofagnim vrstama iz porodice Thripidae. Nađene su i tri zoofagne te jedna mikofagna vrsta tripsa.

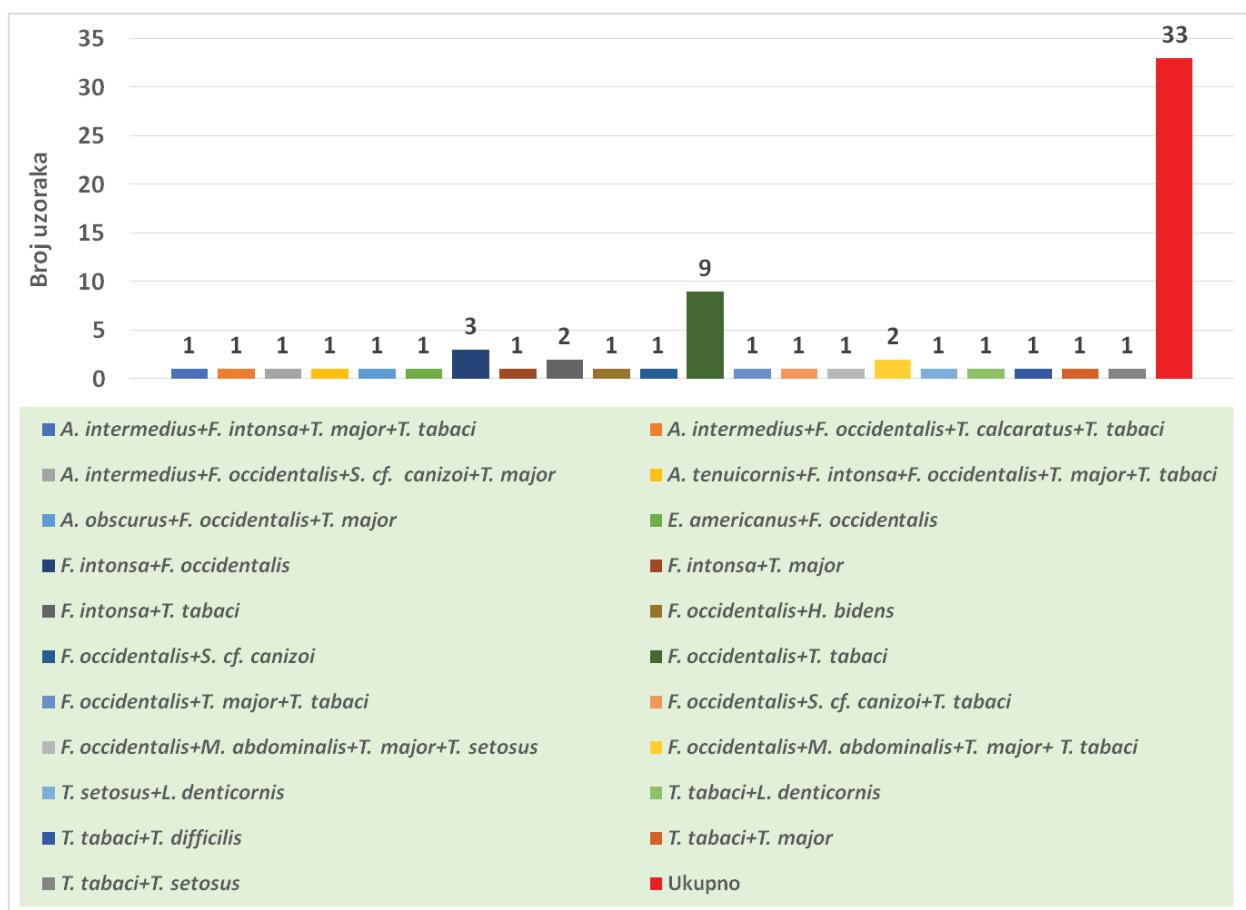
Tablica 1. Identificirane vrste tripsa u prikupljenim uzorcima**Table 1** Identified thrips species in collected samples

Porodicatripsa <i>Thrips family</i>	Fitofagne vrste <i>Phytophagous species</i>	Zoofagne vrste <i>Zooprophagous species</i>	Mikofagne vrste <i>Mycophagous species</i>
Aeolothripidae		<i>Aeolothrips intermedius</i> Bagnall, 1934	
		<i>Aeolothrips tenuicornis</i> Bagnall, 1926	
Thripidae	<i>Anaphothrips obscurus</i> Müller, 1776 <i>Chaetanaphothrips orchidii</i> Moulton, 1907 <i>Echinothrips americanus</i> Morgan, 1913 <i>Frankliniella intonsa</i> Trybom, 1895 <i>Frankliniella occidentalis</i> Pergande, 1895 <i>Hercinothrips femoralis</i> Reuter, 1891 <i>Limothrips denticornis</i> Haliday, 1836 <i>Microcephalothrips abdominalis</i> Crawford, 1910 <i>Scirtothrips cf. canizoi</i> Titschack, 1964 <i>Thrips angusticeps</i> Uzel, 1895 <i>Thrips calcaratus</i> Uzel, 1895 <i>Thrips difficilis</i> Priesner, 1920 <i>Thrips major</i> Uzel, 1895 <i>Thrips setosus</i> Moulton, 1928 <i>Thrips tabaci</i> Lindeman, 1889	<i>Scolothrips longicornis</i> Priesner, 1926	<i>Hoplandrothrips bidens</i> Bagnall, 1910
Phlaeothripidae			

U 67 prikupljenih uzoraka identificirana je samo po jedna vrsta tripsa (Slika 4.). Najveći broj uzoraka sadržavao je invazivnu, sjevernoameričku vrstu *Frankliniella occidentalis* (Pergande, 1895) nađenu u Hrvatskoj 1989. godine (Šimala 1991). Ubrzo nakon udomaćenja, ova je vrsta postala gospodarski najvažniji štetni trips na povrću i ukrašnom bilju u zaštićenim prostorima.

**Slika 4.** Broj analiziranih uzoraka prema vrstama tripsa (1 vrsta u uzorku)**Figure 4** Number of analyzed samples according to thrips species (1 species in sample)

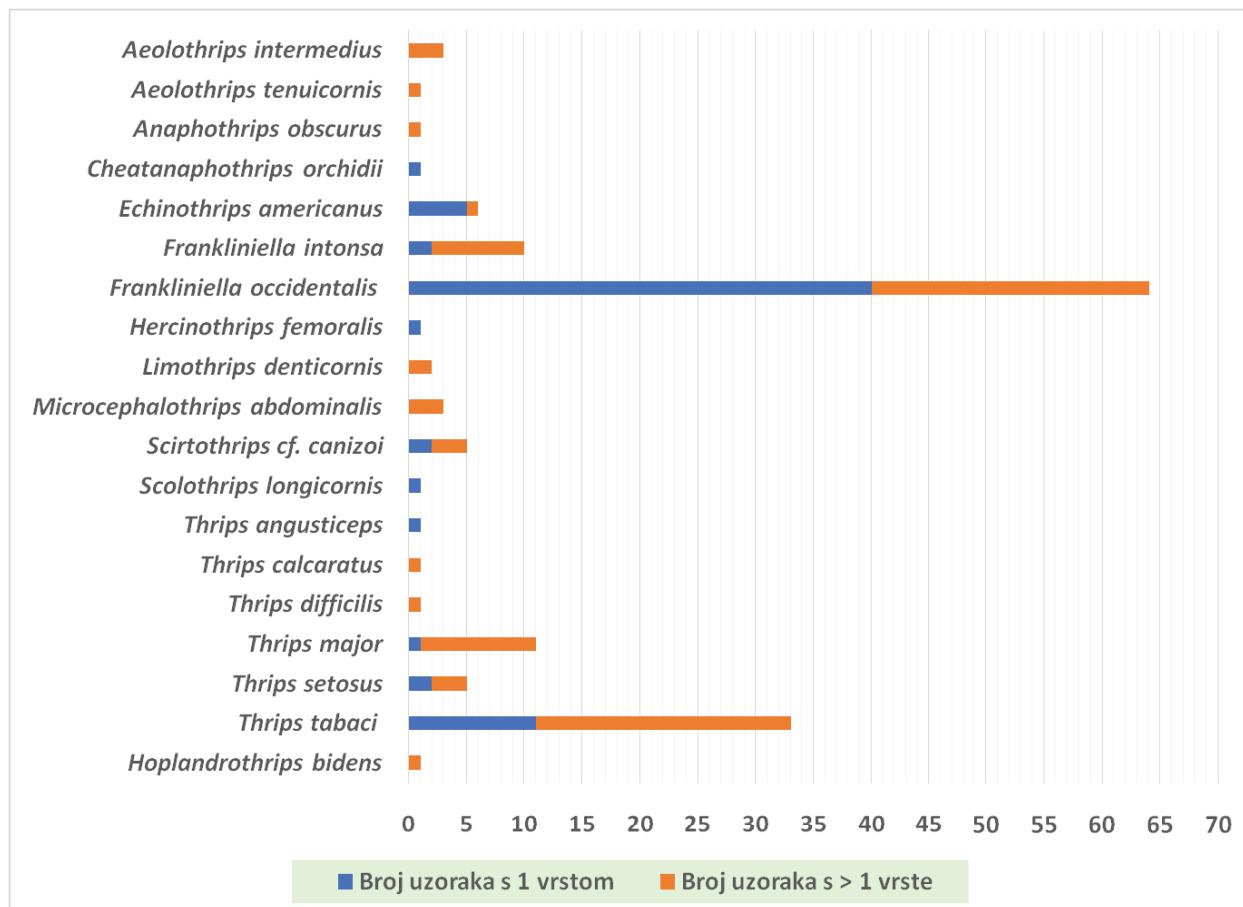
Trideset tri prikupljena uzorka sadržavala su smjesu dviju ili više vrsta tripsa, od kojih je najviše, njih devet, bila kombinacija dviju fitofagnih, gospodarski štetnih vrsta *F. occidentalis* i *Thrips tabaci* Lindeman, 1889 (Slika 5).



Slika 5. Broj analiziranih uzoraka prema vrstama tripsa (>1 vrsta u uzorku)

Figure 5 Number of analyzed samples according to thrips species (>1 species in sample)

Tijekom provođenja istraživanja vrsta *F. occidentalis* iskazala je najvišu frekvenciju pojavljivanja budući da je vrsta identificirana u 42,4 % ukupno analiziranih uzoraka tripsa. Značajnu frekvenciju pojavljivanja imala je i vrsta *T. tabaci*, koja je detektirana u 21,9 % prikupljenih uzoraka (Slika 6).



Slika 6. Kvantitativna distribucija frekvencija pojavljivanja vrsta tripsa u uzorcima

Figure 6 Quantitative distribution of thrips species appearing frequency in samples

Laboratorijskom analizom prikupljenih uzoraka tripsa niti u jednom uzorku nije identificirana za EU karantenska vrsta *T. palmi*. Tri palearktičke vrste iz roda *Thrips* Linnaeus, 1758 zabilježene u Hrvatskoj (Raspudić i sur. 2003), odnosno *Thrips tabaci*, *Thrips flavus* Schrank, 1776 i *Thrips nigropilosus* Uzel, 1895, morfološki su vrlo slične vrsti *T. palmi* i mogu se lako zamijeniti tijekom identifikacije. Morfološki najsličnije vrste koje su rijetke i nisu nađene u nas su palearktička vrsta *Thrips alni* Uzel, 1895 i europska vrsta *Thrips urticae* Fabricius, 1781 (OEPP/EPPO 2018). Od navedenih, samo je vrsta *T. tabaci* identificirana u prikupljenim uzorcima. Osnovne morfološke karakteristike za razlikovanje vrste *T. tabaci* od *T. palmi* nalaze se na *metascutumu*, prvoj žili prednjih krila te na II i IX *abdominalnom tergitu* odrasle ženke. U analiziranim uzorcima identificirane su za entomofaunu Hrvatske dvije nove vrste tripsa. To su: *Chaetanaphothrips orchidii* (Moulton, 1907) i *Scirtothrips cf. canizoi* Titschack, 1964. Faunistički podatci o nalazima vrsta prikazani su u Tablici 2.

Tablica 2. Faunistički podaci za nalaze novo zabilježenih vrsta tripsa
Table 2 Faunistic data for findings of newly recorded thrips species

Županija County	Lokalitet (Zemljopisna pozicija) Locality (Geographical position)	Biljna vrsta Plant species	Vrsta tripsa (Broj primjeraka i spol) <i>Thrips species</i> (Number of specimens and sex)	Datum uzorkovanja Date of sampling
Primorsko-goranska	Žgombići (45°6'46.85"N 14°32'26.33"E)	<i>Chrysanthemum indicum</i> L.	<i>Chaetanaphothrips orchidii</i> Moulton, 1907 (1♀)	10.8.2021.
		<i>Hydrangea macrophylla</i> (Thunb.) Ser.	<i>Scirtothrips cf. canizoi</i> Titschack, 1964 (2♀)	20.5.2021.
	Kaštel Novi (43°32'44.73"N 16°19'0.08"E)	<i>Rosa</i> L. spp.	<i>Scirtothrips cf. canizoi</i> Titschack, 1964 (1♀)	20.5.2021.
Splitsko-dalmatinska		<i>Rhynchospermum jasminoides</i> Lindl.	<i>Scirtothrips cf. canizoi</i> Titschack, 1964 (1♀)	20.5.2021.
	Split (43°30'57.1"N 16°30'8.20"E)	<i>Ficus pumila</i> L.	<i>Scirtothrips cf. canizoi</i> Titschack, 1964 (1♀)	15.10.2021.
	Metković (43°04'5.2"N 17°38'30.6"E)	<i>Hydrangea macrophylla</i> (Thunb.) Ser.	<i>Scirtothrips cf. canizoi</i> Titschack, 1964 (1♀)	15.9.2021.

Vrsta *C. orchidii* potječe iz jugoistočne Azije, otkuda se proširila u tropска područja. Danas je postala kozmopolitska vrsta (Vacante 2012). Jedina je vrsta iz roda *Chaetanaphothrips* Priesner, 1925, koji uključuje 20 vrsta, prisutna u Europi (Zur Strassen 2003; Mound i sur. 2016). Polifagan je štetnik koji u Europi obitava samo u zaštićenim prostorima. Napada bananu, agrume, avokado i ukrasno bilje (orhideje, anturium, begonija, bugenvilea) (Vacante 2012). Mikroskopske morfološke karakteristike odraslog stadija ženke, na osnovi kojih je obavljena identifikacija vrste *C. orchidii* su: tijelo je svijetlo žuto; glava je šira nego duga, s dva para ocelarnih pravih dlaka (*setae*), od kojih je par III pozicioniran unutar trokuta kojeg čine čeone oči (*ocelle*); ticala su sastavljena od osam članaka, članci V-VI imaju smeđi vrh; na III i IV članku ticala prisutni su osjetilni otvori (*sensoria*) u obliku vilice; prvi članak prsišta na leđnoj strani (*pronotum*) ima na stražnjem rubu dva para debljih pravih dlaka (*posteroangular setae*), od kojih je vanjski par kraći od širine III članka ticala; stražnji članak prsišta (*metanotum*) ima na leđnoj strani slabo izraženu mrežastu strukturu, s parom kratkih središnjih pravih dlaka prilično udaljenih od prednjeg ruba (Slika 7); prednje krilo je tanko, žućkasto bijelo s dvjema tamnim poprečnim prugama (jedna bazalna i jedna medijalna); na stražnjoj polovici prve žile prednjih krila nalaze se tri prave dlake; druga žila prednjih krila ima četiri prave dlake (Slika 8); članci zatka su na leđnoj strani (*abdominal tergites*) u središnjem dijelu slabo skulpturirani, a na stražnjem se rubu u cijelosti nastavlja širok pojas (*craspedum*); VIII članak zatka na rubnom dijelu leđne strane ima za rod karakteristično mikroskopsko obilježje u vidu ornamentirane, točkaste površine koja omeđuje poru (*spiracle*), smještenu bliže sredini članka u odnosu na samu poru (Slika 9); središnji par pravih dlaka na leđnoj strani članaka zatka pozicioniran je ispred stražnjeg ruba; članci zatka i na trbušnoj strani (*abdominal sternites*), osim središnjeg dijela VII članka imaju također na stražnjem rubu prisutan širok pojas (*craspedum*).



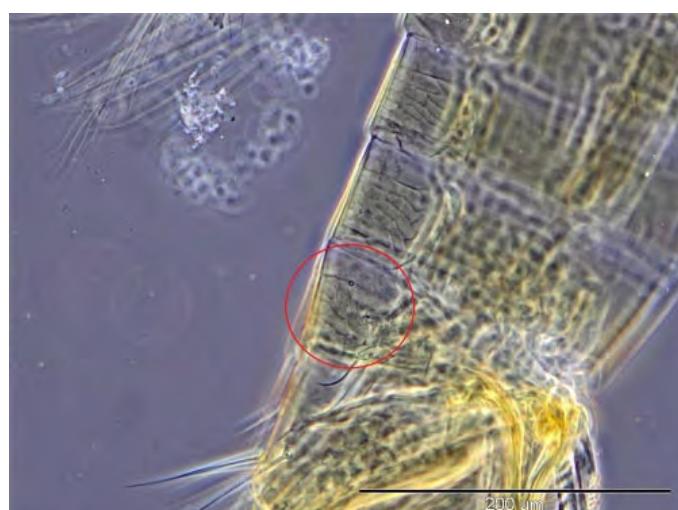
Slika 7. *Chaetanaphothrips orchidii* stražnji članak prsišta (metanotum)

Figure 7 *Chaetanaphothrips orchidii* metanotum



Slika 8. *Chaetanaphothrips orchidii* prednje krilo

Figure 8 *Chaetanaphothrips orchidii* fore wing



Slika 9. *Chaetanaphothrips orchidii* leđna strana VIII članka zatka (abdominal tergite) s ornamentiranim površinom smještenom bliže sredini članka u odnosu na poru

Figure 9 *Chaetanaphothrips orchidii* abdominal tergite VIII with area of specialized sculpture extending anteromesad from spiracle

Druga novo zabilježena vrsta tripsa tijekom istraživanja *S. cf. canizoi* ne može se s apsolutnom sigurnošću morfološki identificirati. Vrsta *S. canizoi* autohtona je za Europu i Mediteran te nađena vrlo rijetko. Zabilježena je samo u južnoj Turskoj i Španjolskoj (Andaluzija) na *Crataegus* spp., *Prunus amygdalus* Batsch i *Salix* spp. (Zur Strassen 2003). U ovom su istraživanju primjerci tripsa iz roda *Scirtothrips* prikupljeni na biljnim vrstama *Ficus pumila* L., *Rosa* L. spp., *Rhynchospermum jasminoides* Lindl. i *Hydrangea macrophylla* (Thunb.) Ser. (Tablica 2). Identifikacija vrsta tripsa unutar roda *Scirtothrips* na osnovi morfoloških karakteristika vrlo je složena, jer su neke vrste međusobno morfološki gotovo identične i njihova taksonomija nije uviјek jasna, stoga se mikroskopski teško mogu pouzdano razlikovati. Tijekom morfološke analize prikupljenih primjeraka roda *Scirtothrips* postojala je sumnja da se radi o zapadno-palearktičkoj vrsti *Scirtothrips inermis* Priesner, 1933, ili o azijskoj, tropsko-suptropskoj vrsti tripsa *Scirtothrips dorsalis* Hood, 1919, karantenskoj za EU. Prema autorima ključa za vrste roda *Scirtothrips* zabilježene u Australiji (Hoodle i Mound 2003) osnovna, mikroskopski prilično teško razlučiva razlikovna morfološka karakteristika za te dvije vrste razmještaj je redova sitnih dlačica (*microtrichia*) na trbušnoj strani IV-VI članka zatka (*abdominal sternites*). Međutim, u tom se ključu ne navodi vrsta *S. canizoi*. Zur Strassen (2003) u ključu za europske i mediteranske vrste tripsa iz podreda Terebrantia nije uključio azijsku vrstu *S. dorsalis*, stoga ne daje razlikovne morfološke karakteristike između vrsta *S. dorsalis*, *S. inermis* te vrste *S. canizoi*, ali jasno navodi razliku između vrsta *S. inermis* i *S. canizoi* u duljini i omjeru duljine para pravih dlaka S_1 (*setae*) na stražnjem rubu leđne strane prvog članka prsišta (*pronotum*) u odnosu na duljinu pravih dlaka u sredini članka (*discal setae*). Morfološki opis vrsta *S. inermis* i *S. canizoi* te dihotomni ključ za razlikovanje objavio je Titschack (1964). Dakle, ne postoji relevantni morfološki ključ za međusobno razlikovanje vrsta *S. dorsalis* i *S. canizoi*. Česta vrsta *S. inermis* i izuzetno rijetka vrsta u zapadnom palearktiku *S. canizoi* dijele sve ili veliku većinu morfoloških karakteristika koje je moguće mikroskopski detektirati.

Morfološkom identifikacijom i molekularnim PCR-COI sekvenciranjem obavljenim u Netherlands Institute for Vectors, Invasive Plants and Plant Health, NPPO, Wageningen (Nizozemska) potvrđeno je da primjerici tripsa u prikupljenim uzorcima pripadaju kriptičkoj vrsti „East Asia 1“ kompleksa *S. dorsalis* (Dickey i sur. 2015). Međutim, COI sekvenca *S. canizoi* nije poznata i njena podudarnost s „East Asia 1“ također je nepoznata. Primjerici tripsa prikupljeni u Hrvatskoj morfološki se podudaraju s opisom vrste *S. dorsalis* autora Masumoto i Okajima (2007). To ukazuje na azijsko podrijetlo populacije iz Hrvatske. Međutim, Dickey i sur. (2015) kao rezultat posljednjih molekularnih istraživanja navode kako vrsta *S. dorsalis* pripada kompleksu vrsta koji se sastoji od minimalno 9 kriptičkih, morfološki nerazlučivih vrsta i 2 morfološki različite vrste *S. oligochaetus* (Karny, 1926) i *S. cf. dorsalis*. Dakle, ne može se isključiti da bi *S. canizoi* mogao biti identičan kriptičnim vrstama „East Asia 1“ kompleksa *S. dorsalis*, budući da je to najčešći kompleks vrsta u Japanu. Zaključno, sve dok se europske i zapadnoazijske populacije *S. canizoi* ne prikupe i finalno ne analiziraju, hrvatsku vrstu označavamo kao *S. cf. canizoi*. Morfološkom komparacijom referentnih mikroskopskih preparata dvaju primjeraka ženki identificiranih morfološki kao vrsta *S. canizoi* (identificirao R. Zur Strassen) uzorkovanih u Španjolskoj, odnosno Turskoj, a pohranjenih u Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main (Njemačka), utvrđeno je da se S_2 *setae* na *pronotumu* podudaraju s *pronotalnim S₂ setama* kod ženki prikupljenih u Hrvatskoj. Međutim, uočena je razlika na IX *abdominalnom tergitu* u pojavnosti poprečnih, paralelnih redova sitnih dlačica (*microtrichia*) između središnjih *setae*. Kod primjerka iz Španjolske te *microtrichia* nisu

prisutne, dok su kod primjerka iz Turske prisutne, ali reducirane. Primjeri ženki iz Hrvatske imali su dobro razvijene *microtrichia*. Dodatna istraživanja trebala bi otkriti stupanj intraspecifične varijacije u odsutnosti/prisutnosti ovih mikrotrihijalnih redova i do koje mjere se oni mogu smatrati pouzdanim razlikovnim znakom u morfološkoj identifikaciji *S. canizoi*.

Mikroskopske morfološke karakteristike odraslog stadija ženke na osnovi kojih je obavljena identifikacija vrste *S. cf. canizoi* su: tijelo je žuto sa smeđim dijelovima uz sredinu prednjeg ruba leđne i trbušne strane abdominalnih članaka; glava je šira nego duga, s tri para ocelarnih pravih dlaka (*setae*), od kojih je par III pozicioniran unutar trokuta kojeg čine čone oči (*ocelle*), u ravnini sa stražnjim čeonim očima; područje unutar trokuta čeonih oči i iza složenih očiju (*postocular*) sadrži guste valovite linije; ticala su sastavljena od osam članaka; na III i IV članku ticala prisutni su osjetilni otvori (*sensoria*) u obliku vilice; prvi članak prsišta na leđnoj strani (*pronotum*) pokriven je brojnim, gustim poprečnim valovitim linijama (*striae*), prava dlaka S_1 na stražnjem rubu leđne strane prvog članka prsišta jednako je duga kao prave dlake u središnjem dijelu, a S_2 prava dlaka duga je 30-40 μm , odnosno oko 2,5 puta dulja od onih u središnjem dijelu (Slika 10); na leđnoj strani stražnjeg članka prsišta (*metanotum*) središnji je par pravih dlaka smješten blizu prednjeg ruba, a zvonoliki osjetilni organ (*sensillum campaniformium*) nije prisutan (Slika 10); sklerotizirana tvorevina poput vilice (*furca*) sadrži bodlju (*spinula*) ina srednjem (*mesothorax*) i na stražnjem članku (*metathorax*) prsišta; prva žila prednjih krila ima 3 međusobno udaljene prave dlake, a druga žila 2; stražnje resice prednjih krila su ravne, a ne valovite; članci zatka su na leđnoj strani (*abdominal tergites*) rubno gusto prekriveni kratkim poprečnim, paralelnim redovima sitnih dlačica (*microtrichia*) (Slika 11); VIII abdominalni tergit na stražnjem rubu ima potpuni niz tankih, dugih dlačica (Slika 11); članci zatka na trbušnoj strani (*abdominal sternites*) u srednjem dijelu nemaju pravih dlaka (*diskal setae*), a rubne prave dlake pozicionirane su na samom stražnjem rubu te su pokriveni kratkim poprečnim, paralelnim redovima sitnih dlačica (*microtrichia*), osim u središtu gornje polovine (Slika 12).



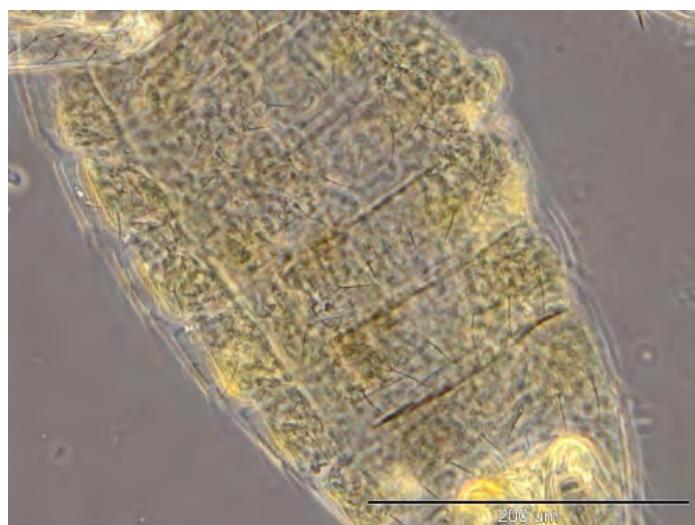
Slika 10. *Scirtothrips cf. canizoi* prvi i stražnji članak prsišta (*pronotum* i *metanotum*)

Figure 10 *Scirtothrips cf. canizoi* *pronotum* and *metanotum*



Slika 11. *Scirtothrips* cf. *canizoi* leđna strana IV-VIII članka zatka (abdominal tergites)

Figure 11 *Scirtothrips* cf. *canizoi* abdominal tergites IV-VIII



Slika 12. *Scirtothrips* cf. *canizoi* trbušna strana IV-VIII članka zatka (abdominal sternites)

Figure 12 *Scirtothrips* cf. *canizoi* abdominal sternites IV-VIII

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Additions to the owlet moth fauna (Lepidoptera: Noctuidae) of Croatia

Dodaci fauni sovica (Lepidoptera: Noctuidae) Hrvatske

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Abstract

Two Noctuidae species are reported as new members of the fauna of Croatia, *Amphipyra stix* Herrich-Schäffer, [1850] was recorded near Smrden grad in southern Dalmatia while *Lenisa geminipuncta* (Haworth, 1809) was recorded in Nature Park Kopački rit and northern part of Međimurje county. *Amphipyra cinnamomea* (Goeze, 1781) is reported as a second country record, from Bilje near Osijek, 106 years after the last record in Croatia. All three species can be considered rare, and probably endangered in the country, and their status should be assessed in the creation of any Red lists in the future.

Keywords: Apameinae, Xyleninae, *Lenisa geminipuncta*, *Amphipyra cinnamomea*, *Amphipyra stix*, distribution

Sažetak

Dvije vrste sovica (Noctuidae) po prvi puta su zabilježene u fauni Hrvatske *Amphipyra stix* Herrich-Schäffer, [1850] kod Smrden grada u južnoj Dalmaciji a *Lenisa geminipuncta* (Haworth, 1809) u Parku prirode Kopački rit i sjevernom dijelu Međimurske županije. *Amphipyra cinnamomea* (Goeze, 1781) zabilježena je drugi puta u državi, u Bilju kod Osijeka, 106 godina nakon zadnjeg nalaza u Hrvatskoj. Sve tri vrste mogu se smatrati rijetkima, a vjerojatno i ugroženima u zemlji, te bi njihov status trebalo procijeniti pri izradi eventualnih Crvenih popisa u budućnosti.

Ključne riječi: Amphipyrinae, Xyleninae, *Lenisa geminipuncta*, *Amphipyra cinnamomea*, *Amphipyra stix*, rasprostranjenost

Introduction

During the last decades, the surveys of moths in Croatia started to intensify, resulting in some previously completely unsurveyed areas to be explored (Gumhalter and Kučinić 2020; Koren 2022; Koren et al. 2015; Vignjević et al. 2010). This also resulted in the records of many new and interesting moth species new for the fauna of the country (Koren 2019, 2020, 2021; Koren and Gomboc 2015). Still, it seems that with every new survey additional species are being recorded, even in some of the well-surveyed families such as Noctuidae (Kučinić 1997). And while some new species are colonizing the country, like the olive-shaded bird-dropping moth, *Acontia candefacta* (Hubner, 1831) (Koren 2019) some seem to represent relicts from previously more widespread

wetlands like *Hydraecia osseola* (Staudinger, 1882) (Koren 2021) or overlooked mountain species like *Antitype suda* (Geyer, [1832]) (Mrnjavčić Vojvoda et al. 2014) or *Cherotis rectangula* ([Denis & Schiffermüller], 1775) (Koren and Gomboc 2015). Especially important are the border areas with other countries, which also in the past shown to contain immense biodiversity like the cases of the Podravina region (Kranjčev 1985) and Kupa River valley (Mladinov 1980, 1977). During the recent surveys of borderline areas of Croatia, three rare Noctuidae species have been recorded in the country, two for the first time and one for a second time, and their observations are discussed here.

Materials and methods

This survey was conducted in the period from 2021 to 2022 in Croatia. Two main light-trapping sources were used. The primary method was light tent pyramids consisting of a metal frame, and 15W UV lamps connected to a 12 V battery and covered with a white canvas. Six tent pyramids were used, distanced about ten meters apart. The second method was the usage of a 6W 12V Portable Heath Moth Trap which was left on site and then collected the following morning. Two to three Portable Heath Moth Traps were used per locality and night. The android application and digital platform Biologer were used to record field data during this research (Popović et al. 2020). The specimens were set, identified, and stored in the private collection Koren. For each record, the exact locality, coordinates, altitude, and dates are provided.

Results and Discussion

Two species new for the fauna of Croatia are reported: *Lenisa geminipuncta* (Haworth, 1809) and *Amphipyra stix* Herrich-Schäffer, [1850] and one very rare species, *Amphipyra cinnamomea* (Goeze, 1781), which has been recorded for the second time in Croatia (fig. 1). For each of them, the exact collecting data, as well as complementary notes, are provided.

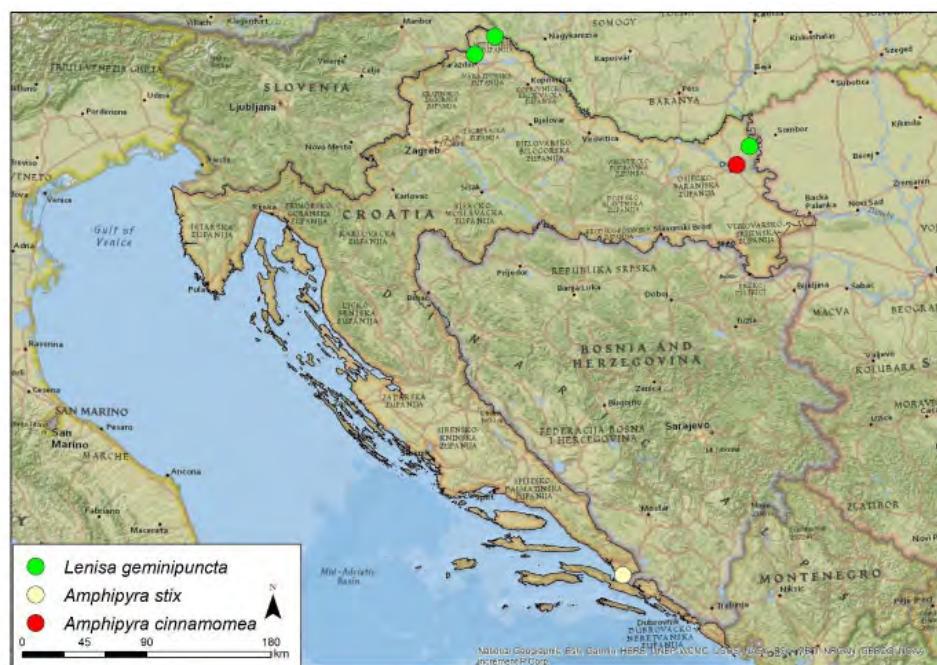


Figure 1. Distribution of three newly recorded Noctuidae species in Croatia; *Lenisa geminipuncta* (green circles), *Amphipyra stix* (yellow circle) and *Amphipyra cinnamomea* (red circle).

***Lenisa geminipuncta* (Haworth, 1809)**

Examined material: Croatia, Međimurje county, Ferketinec, a forest at the banks of Mura river, 46.477864° N, 16.521053° E, 226 m a.s.l., 11.8.2021, 2♂; Croatia, Međimurje county, Pušćine, northern part at the edge of floodplain forest, 46.362939° N, 16.327453° E, 174 m, 10.8.2021, 1 ex; Croatia, Osječko-baranjska county, Nature park Kopački Rit, Zlatna greda, banks of Čarna stream, 45.707233° N, 18.869745° E, 81 m, 4.8.2022, 1♂.

This is an easily recognizable species (fig. 2) due to its rounded forewings with uniformly dark chocolate-brown coloration and two tiny white dots on its forewing (Zilli et al. 2005). It has a Holo-Mediterranean distribution, including the European parts of the Mediterranean, central and northern Europe, as well as parts of the Near East (Zilli et al. 2005). Still, its distribution is far from continuous in Europe, and it is connected to lowland marshes and coastal areas (Zilli et al. 2005). The only mention of this species in Croatia originates from Vukotinović (1879). This is an important work, being one of the first papers about Lepidoptera written in the Croatian language, but full of mistakes and wrong identification. As the collection on which that paper is based has not been conserved, the lists of species mentioned in it cannot be taken as correct (Vukotinović 1879). During this survey, the species has been recorded at three localities, close to the Drava river, Međimurje county, and Kopački rit. This indicates that this species is probably more widespread across the border area with Hungary, around the mentioned river. It inhabits extensive reed beds and small reed patches around ponds, riversides, and fens (Skinner 2009) which is in accordance with the observations from Croatia.

While these records indicate that the species has a wider distribution in the region than it was previously assumed, its habitats are very endangered. With some rare examples of larger wetlands such as Nature Park Kopački rit, most of the surroundings around continental rivers like Drava, once surrounded by swamps and floodplain forests, are now reduced to narrow tree patches along the watercourses. Still, it seems that this is still enough for this species to survive in Croatia, but the question is for how long. An interesting fact to note is that the species has not been recorded in the Podravina region, located between Međimurje and Kopački rit, despite long-term and intensive surveys which resulted in the records of many wetland species (Kranjčev 1985).



Figure 2. *Lenisa geminipuncta* (Haworth, 1809) from Nature park Kopački rit. (Photo T. Koren)

***Amphipyra stix* Herrich-Schäffer, [1850]**

Examined material: Croatia, Dubrovačko-neretvanska county, Slivno Ravno, ruins of Smrden grad, edge of maquis, 42.951018° N, 17.566503° E, 3.8.2022, 1♂.

This is one of the smallest members of the genus *Amphipyra* with a wingspan between 29-35 mm. It is an easily recognizable species (fig. 3) with almost black forewings and with a lighter, usually beige subterminal area. It has a Mediterranean-Asiatic distribution. In Europe, it is present in scattered populations in eastern Serbia, Northern Macedonia, Romania, Bulgaria, Albania, and Greece (Fibiger et al. 2007). In Croatia, it was recorded at the edge of maquis around the abandoned medieval town Smrden grad. A single specimen arrived on light tents around 23.30h. This species in general inhabits open rocky areas with low plants (Fibiger et al. 2007), a habitat located around Smrden grad. Adults fly from late June to the beginning of September. The food plants are still unknown. The closest known populations to the one discovered in Croatia have only recently been discovered in Montenegro (Beshkov and Nahirnić 2020).



Figure 3. *Amphipyra stix* Herrich-Schäffer, [1850] from Smrden grad (Photo T. Koren)

***Amphipyra cinnamomea* (Goeze, 1781)**

Examined material: Croatia, Osječko-baranjska county, Bilje, banks of Biljsko lake, 45.590872, 18.741327, 2.10.2022, 1♂.

Literature records: Moš. ul. (Zagreb) 26. III. 1917. (coll. Badovinac) (Kučinić & Hrašovec, 1999)

This is a larger moth with a wingspan between 45-51 mm (fig. 4). The sex dimorphism is evident in antennae, as the male antennae are fasciculate and those of females are filiform. While it is rather similar to some other congeneric species like *Amphipyra pyramidea* (Linnaeus, 1758) and *Amphipyra berbera* Rungs, 1949, it can be recognized by the longitudinal dark brownish streak dividing the forewing and the brownish dorsal part of the same wing (Fibiger et al. 2007).

This species had formerly a Euro-Asiatic distribution but is now in Europe limited to the Mediterranean area as the populations north of the Alps are considered extinct (Fibiger et al. 2007, Tóth et al. 2022). The closest recent records to the one in Croatia originate from Hungary where the species has been recorded very close to the state border (Tóth

et al. 2022). In general, Hungary is the country with the most recent records in Europe so it is most probable that the specimen recorded in Croatia is a part of that population (Tóth et al. 2022). Recent records exist also for Serbia where it was also recorded on bait at Kupinovo and Progar localities by Zoran Boživić (Lepiforum e.V. 2021). In Croatia, it was recorded at the banks of Biljsko lake, between Osijek and Bilje. A single specimen was observed feeding on a mix of the vine, vinegar, and sugar, at around 23.30h. The locality is under strong anthropogenic pressure as it is used for recreational sites and swimming and fishing activity. Still, it contains several dozen large willow and poplar trees. This is in line with the known habitat, mainly park-like areas where the primary food plant, poplar, is present (Fibiger et al. 2007). As the imagos are rarely recorded, and in small numbers (Fibiger et al. 2007), it is extremely difficult to assume the distribution of this species in Croatia. So far, this is the second record of this species in Croatia, after the specimen recorded in Zagreb in 1917 (Kučinić & Hrašovec 1999). With the known trends of the decline of this species in some European countries like Germany (Wachlin and Bolz 2012) and Switzerland (Luginbühl 2015), it is possible to assume that this species is also endangered in Croatia and should be assessed in any future Red lists.



Figure 4. *Amphipyra cinnamomea* (Goeze, 1781) from Bilje (Photo T. Koren)

Conclusions

This work contributes to the owlet moth fauna of Croatia with the record of two previously unrecorded and one very rare species. All three species can be regarded as rare or even endangered in the country, due to the scarcity of their habitat or the generally small number of records within these parts of Europe. And while these records still represent only faunistic curiosities, they will in the future surely contribute to a better understanding of the specie's status and distribution and in the end, the creation of Red lists. Essential data for each species present in a country is the exact locality where their population occurs. Only in this way, concrete conservation actions could be planned in the future.

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Osvrt na 5. Simpozij Hrvatskog entomološkog društva

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Peti Simpozij Hrvatskog entomološkog društva održao se 29. i 30. rujna u Osijeku. Organizator Simpozija bilo je Hrvatsko entomološko društvo sa sjedištem u Osijeku pod rukovodstvom predsjednice Društva doc. dr. sc. Ankice Sarajlić i Znanstveno-organizacijskog obora članova Upravnog odbora HED-a. Simpozij je izuzetno dobro organiziran u prostoru Fakulteta agrobiotehničkih znanosti Sveučilišta Josipa Jurja Strossmayera u Osijeku (Slika 1).

Suorganizatori skupa su bili: Agronomski fakultet Sveučilišta u Zagrebu, Biološki odjek Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu, Fakultet agrobiotehničkih znanosti Sveučilišta Josipa Jurja Strossmayera u Osijeku, Fakultet šumarstva i drvene tehnologije Sveučilišta u Zagrebu, Hrvatski šumarski institut u Jastrebarskom, Odjel za biologiju Sveučilišta Josipa Jurja Strossmayera u Osijeku, Poljoprivredni institut Osijek i Udruga Hyla, Zagreb.

Skup je započeo nakon pozdravnih riječi domaćina plenarnim izlaganjem prof. dr. sc. Paule Durbešić „Nenapisane istine o našem HED-u mojim sjećanjima“.

Povelje počasnim članovima dodjeljene su prof. dr. sc. Pauli Dubović (Slika 2.) te posthumno dr. sc. Miroslavu Harapinu, čiju je povelju preuzeo Milan Pernek te je predao sinu Dubravku Hrapinu (Slika 3.).

Na Simpoziju je sudjelovalo 66 sudionika, izloženo je 20 usmenih izlaganja i 9 postera.

U dvodnevnim usmenim izlaganjima i putem postera obrađene su mnoge vrste kukača iz raznih redova, a posebna je pozornost dana karantenskim i invazivnim vrstama.

Drugi dan nakon izlaganja postera posjetili smo prezentacijsko-edukacijski centar Ti-kveš u parku prirode Kopački rit (Slika 4.), te je Simpozij završio u ugodnom druženju sudionika u Zmajevcu u restoranu Josić.



Slika 1. Sudionici 5. Simpozija Hrvatskog entomološkog društva

Figure 1 Participants of the 5th Symposium of the Croatian Entomological Society



Slika 2. Profesorica Paula Durbešić preuzima povelju počasne članice HED-a

Figure 2 Professor Paula Durbešić is presented with the certificate of honorary member



Slika 3. Povelju počasnog člana HED-a za dr. sc. Miroslava Harapina preuzeo sin Dubravko
Figure 3 The certificate of honorary member for Dr. Miroslav Harapin is presented to his son Dubravko



Slika 4. Hrvatsko entomološko društvo ispred dvorca u Tikvešu
Figure 4 Croatian Entomological Society in front of Tikveš castle

20. europski susret karabidologa

20th European Carabidologists Meeting

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Trčci (Coleoptera: Carabidae) jedna su od najbrojnijih porodica kornjaša i među najbolje istraženim skupinama kukaca. Vrste ovih kukaca dobri su pokazatelji (bioindikatori) kvalitete staništa i promjena u ekosustavu. S obzirom na način ishrane, predatorske i granivorne vrste važne su u biološkom suzbijanju biljnih nametnika i korova. Slobodno se može reći da dio europske karabidološke priče čine i hrvatski entomolozi i njihova istraživanja.

Gotovo više od tri godine nakon uspješnog 19. susreta karabidologa u Primiero San Marino di Castrozza, Trento u Italiji te 53 godine nakon prvog susreta karabidologa u Biološkoj stanici u Wijsteru u Nizozemskoj, 20. susret održan je u Poljskoj, u Varšavi, u razdoblju od 25. do 27. srpnja 2022. godine.

Karabidološki skup u Poljskoj organizirali su stručnjaci Warsaw University of Life Sciences te pod pokroviteljstvom poljskog entomološkog društva i poljskih državnih šuma. Treba naglasiti da je on hrabro organiziran nakon utišavanja COVID krize, koja je značajno poremetila mnoga znanstvena okupljanja uživo. Na skupu se okupilo oko 25 karabidologa iz desetak država Europe i iz Kanade, s izostankom drugih zemalja svijeta koje su obično pratile ovu skupinu istraživača. Ovim događanjem skup se vratio u europski kontekst.

Slogan skupa bio je: „Što je valjana osnovna vrijednost u komparativnim istraživanjima karabidologa“. Izlaganja su obuhvaćala područja ekologije, morfologije i zaštite prirode. Skup je tematski bio manje intenzivan nego prethodni, ali zbog okolnosti hrabar i obnoviteljski. Pozvana predavanja održali su cijenjeni karabidolozi i eminentni znanstvenici: Axel Schwerk – „Carabid beetle assemblages of the Białowieża Forest depending on protection categories and habitat parameters with notes on their indicator potential“ i Lucija Šerić Jelaska – „Carabids in the Dinaric Mountain forests“. Tijekom kongresa karabidolog veteran i eminentni stručnjak Rikjan Vermeulen održao je govor u sjećanje na Jana Szyszka „In Memoriam Jan Szyszko (19 April 1944 - 9 October 2019“. Karabidolog Jan Szyszko bio je pionir suvremene zaštite prirode u Poljskoj. U nekoliko navrata visoki državni dužnosnik, ministar zaštite okoliša Republike Poljske. Jan Szyszko ostavio je duboki pečat u zaštiti prirode osnovavši istraživačku stanicu u mjestu Tuczno u Poljskoj koju su posjećivali mnogi europski ekolozi.

Predavanja na 20. europskom karabidološkom kongresu bila su grupirana unutar šest tematskih sekcija tijekom kojih je dobiven pregled svih aktualnih istraživanja trčaka u Europi. Vrlo su zanimljiva bila izlaganja o istraživanjima trčaka na specifičnim staništima vezanim uz poljoprivrednu proizvodnju ili agronomске ekološke sustave (Sacco-Martret de Préville i sur. 2022., Willenborg i sur. 2022., Sienkiewicz i sur. 2022., Piotrowska i sur. 2022.) i prirodne pašnjake (Venn 2022. i Venn i sur. 2022) te šumske ekosustave (Schwerk 2022., Skłodowski 2022. i Šerić Jelaska 2022.) i dr. Osim njih, kao doprinos cjelokupnom sustavu zaštite prirode, održana su i predavanja Kosewska i sur. (2022), Gorczyca i sur. (2022) i Vermeulen i sur. (2022).

Na kongresu su aktivno sudjelovali istraživači s Biološkog odsjeka Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu, iz istraživačke grupe dr. sc. Lucije Šerić Jelaska, članice znanstvenog odbora 20. ECM-a, i izv. prof. dr. sc. Tomislav Kos sa Sveučilišta u Zadru, Odjela za ekologiju, agronomiju i akvakulturu. Hrvatski su istraživači trima izlaganjima, jednim usmenim (Šerić Jelaska 2022.) i dvama posterima (Šerić Jelaska i sur. 2022. i Ivanković Tatalović i sur. 2022.) predstavili rezultate istraživanja na projektu MEDITERATRI (HRZZ UIP-05-2017-1046). Plenarnim izlaganjem prikazana su višegodišnja istraživanja trčaka na Dinaridima. Ostalim radovima prikazani su rezultati funkcionalnih značajki populacija trčaka u vinogradima i maslinicima na području Zadarske županije, u Italiji i Grčkoj te utjecaj pesticida iz skupine neonikotinoida i organofosfata na ponašanje trčaka kao i njihovo širenje trofičkim interakcijama, dominantnim u istraživanim ekosustavima.

Iz projekta MEDITERATRI (HRZZ UIP-05-2017-1046) i PESCAR (HR-BA-ME277) ostvarena su sredstava i financirano sudjelovanje na skupu.

Pri završetku kongresa uručeno je priznanje za najbolji poster. Sudionici su pozvani da prikazane rezultate objave u posebnom broju časopisa European Journal of Entomology.

Uz znanstveni dio organiziran je posjet poljskim državnim šumama u Kozienice, gdje su sudionici uz druženje uživali u krajoliku i prirodnim ljepotama sastojina tipičnim za ovaj dio Poljske. Svečana večera upriličena je u rektoratu sveučilišta domaćina.

Više o 20. ECM-u može se pronaći na <http://www.20ecm.sggw.pl/>.

Ponovno okupljanje karabidologa i posjećenost karabidoloških kongresa proizlazi iz aktualnih istraživanja trčaka u globalno važnim temama, osobito održivom odnosu prema okolišu. Sljedeći susret bit će organiziran u Mađarskoj, 2024. godine, u organizaciji mađarskih karabidologa.

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