NAT. CROAT. | VOL. 32 | No 2 | 523-534 | ZAGREB | December 30, 2023

original scientific paper/izvorni znanstveni rad
DOI 10.20302/NC.2023.32.34

# DIVERSITY OF HORSEFLY FAUNA (DIPTERA: TABANIDAE) OF BANSKO HILL

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**Krčmar, S. & Kovačić, M.: Diversity of horsefly fauna (Diptera: Tabanidae) of Bansko Hill. Nat. Croat., Vol. 32, No. 2, 523-534, Zagreb, 2023.**

From 2018 to 2022, at 10 localities on Bansko Hill, 3,639 horseflies were sampled. Most specimens (3,404) were sampled in 2022 in the period from mid-May to mid-September. The horseflies sampled are classified into two subfamilies, six genera and 19 species. The species *Hybomitra ukrainica* (Olsufjev, 1952), *Tabanus miki* Brauer *in* Brauer and Bergenstamm, 1880, *Haematopota grandis* Meigen, 1820 and *Haematopota pandazisi* (Kröber, 1936) are new finds of horsefly species for the studied area. The species *Tabanus tergestinus* Egger, 1859 is the most abundant species and makes up 71.11% of the horseflies sampled. The species *Tabanus bromius* L., 1758 followed with 10.16% of the abundance, *Tabanus sudeticus* Zeller, 1842 with 8.82% and *Atylotus loewianus* (Villeneuve, 1920) with 5.74% of the horseflies sampled, while 15 other species of horseflies were represented by the remaining 4.17%. In the collected sample, male horseflies accounted for 51.71% of the sample; all of them were sampled with an oil liquid trap. The largest number of horseflies (84.14%) were sampled in localities on the northeastern side of Bansko Hill, covered with forest vegetation of secondary origin. Three species, *T. bromius*, *T. tergestinus* and *Heptatoma pellucens*, (Fabricius, 1776) have the longest flight period, from mid-May to mid-September. The highest peaks of abundance for *T. tergestinus*, *T. bromius*, and *T. sudeticus* were recorded in July, for *H. pellucens* in June and for *A. loewianus* in August. The greatest similarity in horsefly fauna (85.71%) was recorded in the localities Popovac and Karanac. 90.98% of horseflies were collected by liquid oil traps, followed by sticky traps (5.22%) and canopy traps (3.79%). Data from earlier studies from 2011 and data from the current studies in the area of Bansko Hill have yielded records of 22 species of horsefly.

**Keywords:** Horseflies, Tabanidae, Diptera, Bansko Hill, Baranja, Croatia

**Krčmar, S. & Kovačić, M.: Raznolikost faune obada (Diptera: Tabanidae) Banskog brda. Nat. Croat., Vol. 32, No. 2, 523-534, Zagreb, 2023.**

U razdoblju od 2018. do 2022. godine na 10 lokaliteta na Banskom brdu uzorkovano je 3639 obada. Najviše jedinki (3404) uzorkovano je 2022. godine u razdoblju od sredine svibnja do sredine kolovoza. Svi uzorkovani obadi svrstani su u dvije podporodice, šest rodova i 19 vrsta. Vrste *Hybomitra ukrainica* (Olsufjev, 1952), *Tabanus miki* Brauer *in* Brauer and Bergenstamm, 1880, *Haematopota grandis* Meigen, 1820 i *Haematopota pandazisi* (Kröber, 1936) novi su nalazi vrsta obada za istraživano područje. Vrsta *Tabanus tergestinus* Egger, 1859 najbrojnija je uzorkovana vrsta te iznosi 71.11% od sveukupno uzorkovanih obada. Slijedi vrsta *Tabanus bromius* L., 1758 s 10.16%, *Tabanus sudeticus* Zeller, 1842 s 8.82% i *Atylotus loewianus* (Villeneuve, 1920) s 5.74% uzorkovanih obada, dok ostalih 15 vrsta iznosi 4.17%. U skupljenom uzorku mužjaci obada zastupljeni su s 51.71% i svi su uzorkovani uljnom tekućom klopkom. Najviše obada (84.14%) uzorkovano je na lokalitetima na sjeveroistočnoj strani Banskog brda obrasloj šumskom vegetacijom sekundarnog porijekla. Najduži letni period od sredine svibnja do sredine rujna zabilježen je za vrste *T. bromius*, *T. tergestinus* i *Heptatoma pellucens* (Fabricius, 1776).Vrste *T. tergestinus*, *T. bromius*, i *T. sudeticus* najveću brojnost bilježe u srpnju, dok vrsta *H. pellucens* u lipnju, a vrsta *A. loewianus* u kolovozu. Najveća sličnost faune obada (85.71%) zabilježena je između lokaliteta Popovac i Karanac. 90.98% obada uzorkovano je uljnom tekućom klopkom, slijedi ljepljiva klopka s 5.22% te modificirana Manitoba klopka (tzv. canopy trap) s 3.79%. Sumirajući podatke ranije

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obavljenih istraživanja iz 2011. godine i podatke sadašnjih istraživanja, na području Banskog brda utvrđene su 22 vrste obada.

**Ključne riječi:** Obadi, Tabanidae, Diptera, Bansko brdo, Baranja, Hrvatska

## INTRODUCTION

The first systematic research into the insect fauna in the Croatian part of Baranja was carried out in 1943 by entomologists of the Albertina biological station, which was part of the Hungarian National Museum in Budapest, with its centre in the castle of Eugene of Savoy in Bilje (Szént-Iványi, 1944). Despite this, Majer and Mikuska recorded the first data for the horsefly fauna (Tabanidae) of the Croatian part of Baranja at the end of the 1980s (Majer & Mikuska, 1988). In the period from 2001 to 2020, the horseflies in Baranja were the subject of numerous studies, especially in the analysis of the influence of different attractants on the effectiveness of traps during sampling (Krčmar, 2005a, 2007; Krčmar *et al*., 2005, 2010) and the influence of the colour and design of traps on sampling success (Krčmar *et al*., 2014; Krčmar, 2017, 2021; Bučanović *et al*., 2020). Because of the number of studies conducted on the topic, the Croatian part of Baranja is the area of Croatia in which the largest number of horseflies have been sampled; despite this, not all areas in the Croatian part of Baranja have been equally covered by these studies. These studies were mainly carried out in the lowland part of Baranja, on the edges of the flooded belt, in the area of the Kopački rit Nature Park, and in the area of the Batina Forestry (Himahat, Monjoroš and Zatonj Forest complexes), as well as in Haljevo Forest located at a distance from these floodplain areas. Bansko Hill (Bansko brdo), the most prominent part of Baranja, with a height of 243 m above sea level, remained outside the area of interest for horsefly sampling in the numerous previous studies in the Croatian part of Baranja. The only studies of the horsefly fauna on Bansko Hill were carried out in 2010 (Jukić, 2011; Krčmar & Lajoš, 2011). In addition to faunistic studies, females of horseflies are often the subject of study in veterinary and medical entomology because females of any species are mechanical or biological vectors of many animal and human pathogens (bacteria, viruses, protozoa) (Foil, 1989; Baldacchino *et al*., 2014). Male horseflies do not have a vector role (Chvála *et al*., 1972). For this reason, faunistic research with data on the presence of potential vector species of horseflies in any area can contribute to protection measures, as they indicate the potential possibility of the occurrence of various diseases in wild and domestic animals, as well as in humans. The main goal of this study was to investigate the diversity of the horsefly fauna of Bansko Hill, the qualitative and quantitative composition of the fauna of horseflies and their abundance, and to contribute to a better knowledge of the biological diversity of the Croatian part of Baranja.

## MATERIALS AND METHODS

### Study area

Bansko Hill (Bansko brdo) is the highest part of Baranja with a maximum height of 243 meters, extending in a northeast-southwest direction for a length of 21 kilometres, while its width is significantly smaller (Bognar *et al*., 1975). It is characterized by numerous ridges and loess valleys, which contributes to a greater relief diversity and microclimatic differentiation. The northeastern side of Bansko Hill is covered with

forest vegetation of secondary origin (*Robinia pseudoacacia*, *Alianthus altissima*, and *Juglans regia*). Different agrobiocenoses are prevalent on the south-western side, with a very few degraded semi-natural stands of steppe grasslands and the small remnants of xero-thermophilous woods (Purger & Csiky, 2008). The climate is classified as temperate-continental with an average annual temperature of 10 to 11 °C, while the average annual amount of precipitation is 600 to 700 mm. Precipitation occurs mostly in late spring and autumn, which gives the climate of this area a sub-Mediterranean character (Purger & Csiky, 2008).

**Field work and identification of sampled horseflies**

Systematic sampling of horseflies on Bansko Hill was carried out in 2021 and 2022, and sporadic sampling in 2018. During 2021, horseflies were sampled twice per month in the period from mid-June to mid-September with sticky traps at ten localities (five on the northeastern and five on the southwestern side). A sticky trap was constructed using a 12- L black bucket, which was hung upside down from an iron pipe as bucket holder (Krčmar, 2021). The iron pipe was bent at a 90-degree angle at the top so that the bucket could be attached to it. The 12-L black bucket was fixed to a holder by a rope through a hole in the centre of the bucket. The height of the lower edge of the black bucket from the ground was 70 cm (Krčmar, 2021). The black bucket was coated on the outside with a thin layer of horsefly trap glue purchased from RD Haaksbergen, Geesteren, Netherlands. In 2022, horsefly sampling was performed 21 times (on four days in May, seven in June, five in July, four in August and one day in September) at five localities. Horseflies were sampled with five canopy traps according to the design of Hribar *et al*., (1991) and with the same number of liquid oil traps. Canopy traps were baited with 2 ml quantities of 1-octen-3-ol (Sigma-Aldrich Chemie, GmbH, Steinheim, Germany) as attractants and were put into plastic vials, while liquid oil traps were baited with yellow sunflower oil (Tena, Čepin, Croatia). Liquid oil traps (Horváth *et al*., 2008) were made out of shiny black plastic sheets of dimensions 60cm x 40cm covered with yellow sunflower oil at depths of 0.5 to 1 cm. The distances between these two types of traps at each locality were 10 metres. In 2018, horsefly sampling was carried out at two localities (Branjina and Zmajevac) with one canopy trap per locality. In the Zmajevac locality horseflies were sampled once in July, and twice in Branjina in August. Canopy traps were baited with 2 ml of 1-octen-3-ol. All sampled horseflies from these above mentioned samplings were stored in glass bottles with 96% ethanol solution. The identification of the horseflies in the samples was performed according to Chvála *et al*. (1972), Krčmar *et al*. (2011) and Zeegers (2018), while zoogeographical division of horsefly fauna was described according to Olsufjev (1977). The faunal similarity analysis was performed using the Sørensen index of faunal similarity according to Durbešić (1988), but only for localities with 5 or more recorded horsefly species.

## RESULTS

From 2018 to 2022, at 10 localities on Bansko Hill 3,639 horseflies were collected, and classified in two subfamilies (Chrysopsinae and Tabaninae), six genera and 19 species (Tab. 1). The most represented genus is *Tabanus* with seven species, followed by the genera *Haematopota* with four species, *Chrysops* with three, *Atylotus* and *Hybomitra* each

with two species, and the genus *Heptatoma* with one species (Tab. 1). 14 species belong to the boreal-Eurasian type of fauna, four species belong to the Mediterranean type of fauna, i.e. the south European subtype, while one species belongs to the Afro-Eurasian-arid type of fauna. *Tabanus tergestinus* Egger, 1859 was the most abundant species and accounted for 71.11% of the total collected horseflies. The species *Tabanus bromius* L., 1758 followed with 10.16%, *Tabanus sudeticus* Zeller, 1842 with 8.82% and *Atylotus loewianus* (Villeneuve, 1920) with 5.74% of collected specimens. The other 15 species of horseflies accounted for 4.17%. Two species, *T. tergestinus* and *A. loewianus*, from the south European subtype (Mediterranean type of fauna), made up 76.85% of the horseflies collected on Bansko Hill. Most of the horseflies collected (90.40%), were from the genus *Tabanus*, followed by the genera *Atylotus* 5.82%, *Heptatoma* 1.81%, *Chrysops* 0.90%, *Hybomitra* 0.63%, and *Haematopota* 0.41% (Tab. 1, 2). In the collected sample, male horseflies were prevalent and made 51.71% of overall sample (Tab. 1, 2). Male specimens of horseflies were recorded for 12 species and all of them were sampled with a liquid oil trap (Tab. 2). In the sample of the six most abundant horseflies, males are more represented than females (Tab. 1, 2). Four species were recorded for the first time for the studied area: *Hybomitra ukrainica* (Olsufjev, 1952), *Tabanus miki* Brauer *in* Brauer and Bergenstamm, 1880, *Haematopota grandis* Meigen, 1820 and *Haematopota pandazisi* (Kröber, 1936) and made up 0.22% in the collected sample of horseflies. 90.98% of horseflies were collected by liquid oil traps, followed by sticky traps with 5.22% and canopy traps with 3.79%. In liquid oil traps 17 times more horseflies were collected than in sticky traps and 24 more than in canopy traps. The most species were collected from liquid oil traps (15), followed by canopy traps with 14 species and sticky traps with 8 species (Tab. 2). Three species: *T. bromius*, *T. tergestinus* and *Heptatoma pellucens* (Fabricius, 1776), had the longest flight period, from mid-May to mid-September (Tab. 3). A unimodal peak of abundance was observed for all recorded species of horseflies. The highest peaks of abundance for *T. tergestinus*, *T. bromius*, and *T. sudeticus* were recorded in July, for *H. pellucens* in June and for *A. loewianus* in August (Tab. 3). The most horseflies were collected in July. In the sample from July, *T. tergestinus* accounts for 73.41%, *T. bromius* for 9,54% and *T. sudeticus* for 12.98%. In the sample of horseflies collected in June *T. tergestinus* accounted for 85.46% (Tab. 3). The largest number of horseflies (88.58%) was collected in June and July. On the northeastern side of Bansko Hill, 84.14% of the horseflies were collected and in this sample 18 species were recorded (Tab. 4), while on the southwestern side 15.85% of the horseflies, classified in 14 species, were collected (Tab. 5). Only *T. miki* was not collected at the localities on the northeastern side of Bansko Hill (Tab. 5). The largest number of horseflies and species were collected in the Branjina and Popovac localities. At these two localities 61.61% of sampled horseflies were collected (Tab. 4). Only at six localities were 5 or more species of horseflies recorded (Tab. 4, 5). The greatest similarity in horsefly fauna (85.71%) was recorded at the Popovac and Karanac localities, then at the Popovac and Branjina localities (76.92%) (Tab. 6). The values of the Sørensen index of faunal similarity of the populations of horseflies compared at six localities on Banko Hill ranged from 42.10% to 85.71%, indicating some qualitative differences in the horsefly fauna composition (Tab. 6).

Tab 1. List of recorded horseflies (Tabanidae) on Bansko Hill from 2018 to 2022.

| Species | No. specimens and sex | % | Zoogeographical group |
|---|---|---|---|
| *Tabanus tergestinus* Egger, 1859 | 1279♀, 1309♂ | 71.11% | SE (M) |
| *Tabanus bromius* L., 1758 | 220♀, 150♂ | 10.16%, | BE |
| *Tabanus sudeticus* Zeller, 1842 | 110♀, 211♂ | 8.82% | BE |
| *Atylotus loewianus* (Villeneuve, 1920) | 72♀, 137♂ | 5.74% | SE (M) |
| *Heptatoma pellucens* (Fabricius, 1776) | 23♀, 43♂ | 1.81% | BE |
| *Hybomitra solstitialis* (Meigen, 1820) nec (Lyneborg, 1959) | 9♀, 11♂ | 0.54% | BE |
| *Chrysops viduatus* (Fabricius, 1794) | 11♀, 6♂ | 0.46% | BE |
| *Chrysops relictus* Meigen, 1820 | 3♀, 10♂ | 0.35% | BE |
| *Haematopota pluvialis* (L., 1758) | 9♀ | 0.24% | BE |
| *Tabanus autumnalis* L., 1761 | 3♀, 1♂ | 0.10% | BE |
| *Tabanus maculicornis* Zetterstedt, 1842 | 3♀, 1♂ | 0.10% | BE |
| *Chrysops caecutiens* (L., 1758) | 3♀ | 0.08% | BE |
| *Atylotus rusticus* (L., 1767) | 1♀, 2♂ | 0.08% | BE |
| *Hybomitra ukrainica* (Olsufjev, 1952) | 2♀, 1♂ | 0.08% | AE |
| *Tabanus bovinus* L., 1758 | 2♀ | 0.05% | BE |
| *Haematopota grandis* Meigen, 1820 | 2♀ | 0.05% | SE (M) |
| *Haematopota pandazisi* (Kröber, 1936) | 2♀ | 0.05% | SE (M) |
| *Haematopota subcylindrica* Pandellé, 1883 | 2♀ | 0.05% | BE |
| *Tabanus miki* Brauer *in* Brauer and Bergenstamm, 1880 | 1♀ | 0.02% | BE |
| ∑ 19 | 1757♀, 1882♂ | | 3 |

**Tab. 2.** Number of collected horseflies on Bansko Hill by different traps.

| Species/traps | Liquid oil trap | Sticky trap | Canopy trap | ∑ |
|---|---|---|---|---|
| *Tabanus tergestinus* | 1105♀, 1309♂ | 143♀ | 31♀ | 2588 |
| *Tabanus bromius* | 116♀, 150♂ | 33♀ | 71♀ | 370 |
| *Tabanus sudeticus* | 93♀, 211♂ | 7♀ | 10♀ | 321 |
| *Atylotus loewianus* | 67♀, 137♂ | - | 5♀ | 209 |
| *Heptatoma pellucens* | 22♀, 43♂ | - | 1♀ | 66 |
| *Hybomitra solstitialis* | 8♀, 11♂ | - | 1♀ | 20 |
| *Chrysops viduatus* | 8♀, 6♂ | 1♀ | 2♀ | 17 |
| *Chrysops relictus* | 1♀, 10♂ | 2♀ | - | 13 |
| *Haematopota pluvialis* | 1♀ | 1♀ | 7♀ | 9 |
| *Tabanus autumnalis* | 1♀, 1♂ | - | 2♀ | 4 |
| *Tabanus maculicornis* | 1♂ | - | 3♀ | 4 |
| *Chrysops caecutiens* | 2♀ | - | 1♀ | 3 |
| *Atylotus rusticus* | 1♀, 2♂ | - | - | 3 |
| *Hybomitra ukrainica* | 2♀, 1♂ | - | - | 3 |
| *Tabanus bovinus* | 2♀ | - | - | 2 |
| *Haematopota grandis* | - | 2♀ | - | 2 |
| *Haematopota pandazisi* | - | - | 2♀ | 2 |
| *Haematopota subcylindrica* | - | 1♀ | 1♀ | 2 |
| *Tabanus miki* | - | - | 1♀ | 1 |
| ∑ 19 | 1429♀, 1882♂ | 190♀ | 138♀ | 3639 |

**Tab. 3.** Seasonal dynamic of most abundant horseflies on Bansko Hill on the basis of a two-year study (2021 and 2022).

| Species/Month | V | VI | VII | VIII | IX |
|---|---|---|---|---|---|
| *Tabanus tergestinus* | 4 | 1164 | 1323 | 86 | 5 |
| *Tabanus bromius* | 10 | 78 | 172 | 79 | 5 |
| *Tabanus sudeticus* | - | 78 | 234 | 6 | 2 |
| *Atylotus loewianus* | - | - | 64 | 136 | 4 |
| *Heptatoma pellucens* | 1 | 42 | 9 | 13 | 1 |
| ∑ 5 | 15 | 1362 | 1802 | 320 | 17 |

**Tab. 4.** Diversity of horsefly fauna on the northeastern side of Bansko Hill in the period from 2018 to 2022.

| Species/locality | Branjina | Draž | Podolje | Popovac |
|---|---|---|---|---|
| *Tabanus tergestinus* | 778 | 646 | 12 | 700 |
| *Tabanus bromius* | 174 | 61 | - | 89 |
| *Atylotus loewianus* | 139 | 8 | - | 53 |
| *Tabanus sudeticus* | 117 | 89 | - | 75 |
| *Heptatoma pellucens* | 10 | - | - | 53 |
| *Hybomitra solstitialis* | 9 | - | - | 7 |
| *Chrysops viduatus* | 6 | - | - | 3 |
| *Chrysops relictus* | 1 | 1 | - | 5 |
| *Haematopota pluvialis* | 2 | - | - | 5 |
| *Atylotus rusticus* | 3 | - | - | - |
| *Tabanus maculicornis* | - | - | - | 3 |
| *Tabanus bovinus* | - | - | - | 2 |
| *Tabanus autumnalis* | 2 | - | - | 2 |
| *Haematopota grandis* | - | 2 | - | - |
| *Haematopota pandazisi* | 2 | - | - | - |
| *Chrysops caecutiens* | 1 | - | - | - |
| *Haematopota subcylindrica* | 1 | - | - | - |
| *Hybomitra ukrainica* | - | 1 | - | - |
| ∑ 18 | 1245 | 808 | 12 | 997 |

**Tab. 5.** Diversity of horsefly fauna on the southwestern side of Bansko Hill in the period from 2018 to 2022.

| Species/locality | Batina | Beli Manastir | Kamenac | Karanac | Kotlina | Zmajevac |
|---|---|---|---|---|---|---|
| *Tabanus tergestinus* | 5 | 44 | 6 | 118 | 271 | 8 |
| *Tabanus bromius* | 5 | 11 | 1 | 16 | 10 | 3 |
| *Tabanus sudeticus* | - | 1 | 1 | 14 | 21 | 3 |
| *Atylotus loewianus* | - | - | - | 6 | 3 | - |
| *Chrysops viduatus* | - | - | - | 1 | 7 | - |
| *Chrysops relictus* | - | - | - | - | 4 | 2 |
| *Hybomitra solstitialis* | - | - | - | 1 | 3 | - |
| *Haematopota pluvialis* | - | - | - | 2 | - | - |
| *Chrysops caecutiens* | - | - | - | - | 2 | - |
| *Hybomitra ukrainica* | - | - | - | - | 2 | - |

| Species/locality | Batina | Beli Manastir | Kamenac | Karanac | Kotlina | Zmajevac |
|---|---|---|---|---|---|---|
| *Heptatoma pellucens* | | | | 1 | 2 | - |
| *Tabanus maculicornis* | | | | 1 | - | - |
| *Tabanus miki* | - | - | - | - | - | 1 |
| *Haematopota subcylindrica* | - | - | 1 | - | - | - |
| ∑ 14 | 10 | 56 | 9 | 160 | 325 | 17 |

**Tab. 6.** Sørensen index of faunal similarity of horseflies on Bansko Hill in localities with a minimum of five species per locality.

| Localities | Branjina | Draž | Karanac | Kotlina | Popovac | Zmajevac |
|---|---|---|---|---|---|---|
| Branjina | | | | | | |
| Draž | 50% | | | | | |
| Karanac | 69,56% | 53,33% | | | | |
| Kotlina | 75% | 75% | 73,68% | | | |
| Popovac | 76,92% | 55,55% | 85,71% | 72,72% | | |
| Zmajevac | 42,10% | 72,72% | 42,85% | 53,33% | 47,05% | |

## DISCUSSION

In total, 31 species of horseflies from the Croatian part of Baranja were collected in the area of the flooded belt of the Danube River and Kopački rit Nature Park (Krčmar, 2004a; Krčmar *et al*., 2005; Krčmar, 2014, Krčmar *et al*., 2014, Krčmar & Gvozdić, 2016). In the previously conducted study in the area of Bansko Hill during 2010, 16 species of horseflies were sampled at nine localities (Jukić, 2011; Krčmar & Lajoš, 2011). An additional two species were determined through a review of unidentified horseflies in the collection of S. Krčmar or literature data, increasing the number of identified horsefly species to 18 (Jukić, 2011). In studies of horsefly fauna diversity from 2018 to 2022, the presences of *Hybomitra bimaculata* (Macquart, 1826), *Hybomitra muehlfeldi* (Brauer *in* Brauer and Bergenstamm, 1880) and *Haematopota scutellata* (Olsufjev, Moucha et Chvála, 1964) were not confirmed, although they had been featured in earlier studies. In earlier studies *Hy. bimaculata* was recorded at four localities (Batina, Branjina, Kotlina, Zmajevac), *Hy. muehlfeldi* in Batina and Popovac, and *Ha. scutellata* in Branjina locality (Krčmar & Mikuska, 2001; Jukić, 2011). The largest number of horseflies was sampled in July and accounts for 50.28% of all collected horseflies. In an earlier study, July was also the month with the largest number of collected horseflies (Jukić, 2011). In studies carried out by Krčmar & Lajoš (2011), the order of the two most abundant species of horseflies on Bansko Hill was the same as in this study. Similar species compositions were observed in Stara Zagora District, South Bulgaria by Ganeva & Penev (2002), and in the Central Balkan Mountains (Stara Planina) (Ganeva & Ivanov, 2015), then partially in the eastern French Pyrenees by Baldacchino *et al*., (2013). In the Central Balkan Mountains (Stara Planina) and in two pastures near the villages of Trakia and Oryahovitsa (altitudes from 150 to 350 m) *T. tergestinus* and *T. bromius* were the dominant species (Ganeva & Penev, 2002; Ganeva & Ivanov, 2015), as in this study on Bansko Hill. Data on the seasonal dynamic of the two most abundant species, *T. tergestinus* and *T. bromius*, was the same as the data of studies obtained by Jukić (2011). The data on the peak abundance of *T. bromius* and *T. sudeticus* during the summer months overlap

with many other studies from the area of eastern Croatia (Krčmar, 2004b; Krčmar, 2005b; Krčmar *et al*., 2006). However during 1998, the highest peaks of abundance for *T. bromius*, *T. sudeticus*, and *T. tergestinus* were recorded in June (Krčmar, 1999). The same was observed for *T. tergestinus* in 2004 in the area of Tikveš Forest in Kopački rit Nature Park (Krčmar, 2005b). However, data on the seasonal dynamic of *T. tergestinus* and *T. bromius* recorded in Bansko Hill completely overlap with data observed in the Mediterranean part of Croatia (Krčmar & Durbešić, 1999). In Bulgaria in the area of the Chirpan hills and at a horse farm in Göd (Hungary), the highest peak of abundance for *T. tergestinus* was recorded in July (Ganeva & Kalmushka, 2019; Horváth *et al*., 2019), as it was in this study. Several studies in Europe report data on the seasonal dynamic of *T. bromius* similar to those yielded by this study. Altunsoy & Kilic (2012) reported that *T. bromius* reached a peak of abundance in July on the area of Western Anatolia in Turkey. Similar data on the seasonal abundance of *T. bromius* were recorded in the Lazio region, Central Italy (Deliberato *et al*., 2019). The highest peak of abundance for the third most abundant species, *A. loewianus*, was recorded in August. That is in accordance with the data obtained in earlier studies of the seasonal dynamic of this species in the Mediterranean and eastern areas of Croatia (Krčmar, 1999; Krčmar & Durbešić, 1999). Also, in the Lazio region (Italy) and the Chirpan hills (Bulgaria) at altitudes of between 600 and 650 m, *A. loewianus* reached a peak of abundance in August, as it did in the area of southern France (Deliberato *et al*., 2019; Ganeva & Kalmushka, 2019; Azza *et al*., 2020). *Heptatoma pellucens* is the fourth most abundant species in this study. However, this species does not appear anywhere in large numbers (Chvála *et al*., 1972) which is why data are scarce on the seasonal activity of this species. Despite this, data on the seasonal flight activity of *H. pellucens* from the area of Bansko Hill are in accordance with data of flight activity for this species recorded by Agasoi *et al*., 2020 in Pskov Province (Russia). In both studies *H. pellucens* reached its peak of abundance in June. Furthermore, in many earlier studies in the area of eastern Croatia, mainly in wet habitats along Danube or Drava River, *T. bromius* was recorded as the first or the second most abundant species (Krčmar, 2005b; Krčmar *et al*., 2005, 2006; Bučanović *et al*., 2020), while *T. tergestinus* and *T. sudeticus* were the most prevalent in habitats out of the reach of flood water i.e. Haljevo Forest in the foot of Bansko Hill (Krčmar *et al*., 2009). These data strongly support the thesis that the species *T. tergestinus* prefers dry habitats such as Bansko Hill and is therefore present in the sample with more than 71% of the overall specimens sampled. On the northeastern side of Bansko Hill according to Jukić's data from 2011, 14 species of horseflies were recorded, while on the southwestern side there were 13. In this study, 18 species of horseflies were recorded on the northeastern side of Bansko Hill as against the 14 species recorded in earlier studies. In the previous study carried out by Jukić (2011), the highest percentage of similarity of horsefly fauna was 80%, while in this recent study it was 85.71%. The greatest diversity of horseflies (14 species) was recorded at the Branjina locality, while according to Jukić (2011) nearly the same number of species was recorded at the Popovac locality (13 species). On the southwestern side of Bansko Hill, 10 species of horseflies were recorded in both studies, as the largest number of species per locality. In the previous study, the highest number was recorded at the Zmajevac locality (Jukić, 2011), while in the current study sit was recorded at the Kotlina locality. Comparison of horsefly fauna of Bansko Hill with other areas in Croatia revealed similarity only in the number of recorded horsefly species. The same number of species was recorded along the Mura River in Međimurje (Krčmar, 2023). Nearly the same number of species

(21) was recorded in the flooded belt of the Monjoroš forest (Krčmar, 2004a), and 20 species in the area of Lonjsko polje (Krčmar & Leclercq, 1999). However, in none of the mentioned areas was the most numerous species of horseflies as dominant as *T. tergestinus* was in this study on Bansko Hill. In this study, 90.98% of horseflies were collected by liquid oil traps. This data is very similar to Krčmar's report from (2013) when 88.77% of horseflies were collected by this type of trap on the island of Badija. Also, the ratio of collected males (56.83%) on the island of Badija (Krčmar, 2013) compared to 51.71% in this study was very similar. The behaviour of horseflies towards these types of traps was regulated by linearly polarized light, because they are polarization sensitive insects (Horváth *et al*., 2008; Meglič *et al*., 2019; Száz *et al*., 2022). Horizontally polarized light reflected from shiny black plastic surfaces stimulates the ventral eye region of horseflies and attracts water seeking males and females (Horváth *et al*., 2008, 2020a, 2020b; Egri *et al*., 2012, 2013). Thus, the behaviour of horseflies is clearly explained in the almost identical number of collected males and females of horseflies in liquid oil traps on Bansko Hill. Horváth *et al*., 2019 reports that *T. tergestinus* prefers sunny warm shiny black targets over shady cool ones. This contributes to the explanation of the large number of *T. tergestinus* collected in the liquid oil trap in this study, since the traps were placed on open sunlit localities. 17 times more horseflies were collected in liquid oil traps than in sticky traps and 24 more than in canopy traps. The large differences in trap efficiency in horsefly sampling were very similar to the study conducted on the island of Badija, where the liquid oil traps collected 16.5 times more horseflies than the canopy traps (Krčmar, 2013). This study on Bansko Hill and an earlier study on Badija Island show that horseflies of the genus *Tabanus* prefer traps based on polarization sensitivity more than traps based on olfactory cues when both types of traps are used.

## CONCLUSIONS

During this study *Hy.ukrainica*, *T.miki*, *Ha. grandis* and *Ha. pandazisi* were recorded on Bansko Hill for the first time. The total number of species of horseflies currently known from Bansko Hill increased to 22. *Tabanus tergestinus* was the most abundant species and accounted for 71.11% of the total number of collected horseflies. The largest number of horseflies (50.28%) was collected in July, followed by June with 38.30%, then August with 10.22%, and September and May with 0.63% and 0.54%, respectively, of the sampled horseflies. *T. tergestinus*, *T. bromius*, *T. sudeticus* and *A. loewianus* made up 95.83% of all sampled horseflies. *Tabanus tergestinus* was the most frequently collected species, and was collected in all localities, followed by *T. bromius* in nine localities and *T. sudeticus* in eight. 17 times more horseflies were collected in liquid oil traps than in sticky traps and 24 more than in canopy traps. A unimodal peak of abundance was observed for all recorded species of horseflies. *T. bromius*, *T. tergestinus* and *H. pellucens* had the longest flight periods from mid-May to mid-September.

## ACKNOWLEDGEMENTS

This study was funded by the Department of Biology, Josip Juraj Strossmayer University of Osijek under the project OZB-ZP2022- Tabanidae (31053), Horsefly fauna diversity (Diptera: Tabanidae) of Bansko Hill (P.I. Stjepan Krčmar).

*Received July 26, 2023*

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