

Unmasking the bycatch: New records and faunistic value of Phoridae from CO₂-baited traps in Slovakia

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Abstract: Carbon dioxide-baited BG-Sentinel 2 traps are widely used for mosquito surveillance, but their bycatch (often dismissed as irrelevant) can reveal surprising biodiversity. In this study, we analyzed the non-target captures from 414 such traps deployed at 16 localities across Slovakia in 2024, focusing on the scuttle fly family Phoridae. Despite a modest detection rate of 6.52 %, we identified 44 phorid species, including five recorded in Slovakia for the first time: *Conicera similis*, *Diplonevra freyi*, *Pseudacteon lundbecki*, *Megaselia insons*, and *M. mimodensior*. These findings raise the known national phorid fauna from 254 to 259 species. Several species such as *Megaselia albocingulata*, *M. verralli*, and *M. involuta* were widespread and abundant, suggesting ecological generalism. Others appeared only once, highlighting the value of broad and sustained sampling. Our results underscore the untapped potential of repurposing CO₂ trap bycatch for biodiversity research – an efficient, cost-effective tool to uncover hidden insect diversity.

Keywords: scuttle flies, traps, faunistic, new records, Slovakia

Introduction

Carbon dioxide-baited traps, such as the BG-Sentinel 2 (Biogents, Germany), are widely used in entomological surveillance, especially for monitoring mosquitoes. These traps mimic mammalian respiration by emitting CO₂ plumes, effectively attracting hematophagous Diptera like mosquitoes and sand flies (Farajollahi et al. 2009; Cilek et al. 2024). However, while target species are routinely analyzed, the substantial bycatch of non-target insects often remains overlooked (Grundmann et al. 2025; Kurina et al. 2025; Oboňa et al. 2025).

Yet, this "incidental noise" may offer important ecological insights. Many Diptera families are attracted to CO₂ due to their associations with decaying matter, animal hosts, or other shared cues (e.g. Oboňa et al. 2025; Kurina et al. 2025). Recent studies (such as those from the Košice Zoo (see Grundmann et al. 2025)) have begun to explore this untapped potential. There, CO₂-baited traps revealed notable phorid diversity, including several species new to the Slovak fauna.

Currently, 254 phorid species are known from Slovakia (Grundmann & Mocek 2025), yet this number continues to grow with the application of novel sampling methods. Although CO₂-based surveillance is not tailored for phorids, it can serve as a complementary, cost-effective approach to biodiversity assessment.

In this study, we examine the faunistic value of phorid flies captured as bycatch in CO₂-baited BG-Sentinel 2 traps deployed across 16 Slovak sites in 2024. Our aims are to assess species richness, detect rare or previously undocumented taxa, and evaluate the broader potential of non-target sampling in biodiversity research.

Materials and Methods

Sampling

The bycatch analyzed in this study was collected during mosquito surveillance using BG-Sentinel 2 traps (Biogents, Germany), baited with pressurized CO₂ cylinders (Fig. 1). Traps were deployed across 16 localities in Slovakia throughout 2024 (see Tab. 1). Collection nets were replaced weekly twice, with samples first stored at -20°C and later at -80°C until laboratory processing.

After mosquitoes were removed, the remaining material was preserved in 70 % ethanol. Specimens were initially sorted to family level by the last author and subsequently identified to species level by the first author, using standard keys (Schmitz 1941, 1943, 1951, 1956; Disney 1983, 1989, 1994, 1999). All examined material is housed in the insect collection of the first author.



Fig. 1: Photograph of BG Sentinel 2 traps (Biogents, Germany), documentary photo by Tomáš Csank.

Localities

Sampling was conducted at 16 sites representing various habitats (see Table 1). GPS coordinates, district, and site codes are provided. The site code is used in the species list to indicate locality and sampling date.

Tab. 1: An overview of all sampling sites from 2024.

Code	District	City/Municipality	Locality	GPS
SC	Senec	Hrubý Šúr	Hrubý Šúr ostrov	48°11'27"N 17°23'24"E
TT	Trnava	Slovenská Nová Ves	Ronava	48°18'25"N 17°32'32"E
DS	Dunajská streda	Potônske Lúky	Potônske Lúky	48°05'43"N 17°35'22"E
PD	Prievidza	Bojnice	Bojnice	48°46'49"N 18°34'34"E
NR	Nitra	Nitra	Sokoliareň SPU	48°18'13.5"N 18°05'51.6"E
KN	Komárno	Zlatná na Ostrove	Veľký Lél	47°45'23"N 17°56'30"E
ZA	Žilina	Žilina	Mojšova lúčka	49°11'33"N 18°49'15"E
VK	Veľký Krtíš	Lesenice	Lesenice	48°06'18"N 19°14'57"E
RS	Rimavská Sobota	Mojín	Mojín	48°20'17"N 19°58'20"E
BB	Banská Bystrica	Rakytovce	Rakytovce	48°40'39"N 19°07'27"E
SL	Stará Ľubovňa	Nová Ľubovňa	Farma Stará Ľubovňa	49°15'43"N 20°41'20"E
SP	Stropkov	Lomné	Lomné	49°06'17"N 21°38'24"E
MI1	Michalovce	Senné	Senianské rybníky	48°40'11"N 22°01'54"E
KE	Košice	Kavečany	ZOO Kavečany	48°47'01"N 21°12'14"E
BA	Bratislava	Podunajské Biskupice	Podunajské Biskupice	48°07'08.5"N 17°12'40.1"E
MI2	Trebišov	Beša	Beša	48°32'04.8"N 21°57'20.2"E

The "Annotated list of recorded species" includes the number and sex of specimens, the date of trap exposure, and the site code (see Table 1). For newly recorded species in Slovakia, references to their GBIF pages are provided along with brief notes on their European distribution.

Results

A total of 44 phorid species were collected using BG-Sentinel 2 traps in 2024. Phorid flies were detected in 27 out of 414 total samples, corresponding to a detection rate of 6.52 %.

Annotated list of recorded species

Conicera floricola Schmitz, 1938

Material examined: ♂, 15.-21.07., RS; ♂, 02.-08.09., KN; ♂, 23.-29.09., MI1.

Conicera similis (Haliday, 1833)

Material examined: ♂, 22.-28.07., BA.

GBIF records. In Europe, this species is primarily recorded in northern regions and is rare in central and southern Europe, as well as in European Russia. It is likely a Holarctic species, also known from Asia and North America. <https://www.gbif.org/species/1546026>.

Comments: New record for Slovakia.

Diplonevra abbreviata (von Roser, 1840)

Material examined: ♂, 17.-23.06., SP.

Diplonevra freyi (Schmitz, 1927)

Material examined: ♂, 03.-09.06., RS.

GBIF records. European records of this species are scarce, with only occasional findings in northern Europe and European Russia. <https://www.gbif.org/species/1548541>.

Comments: New record for Slovakia.

Dohrniphora cornuta (Bigot, 1857)

Material examined: ♂, 22.-28.07., ♂, 29.-31.07., SL.

Gymnophora arcuata (Meigen, 1830)

Material examined: 2 ♂♂, ♀, 30.09.-06.10., ♂, 07.-13.10., MI1.

Megaselia albocingulata (Strobl, 1906)

Material examined: ♂, 03.-09.06., KN; ♂, 03.-09.06., 3 ♂♂, 22.-28.07., 2 ♂♂, 29.-31.07., ♂, 01.-04.08., 4 ♂♂, 05.-11.08., SL; ♂, 17.-23.06., SP; ♂, 24.-30.06., ♂, 15.-21.07., VK; 2 ♂♂, 15.-21.07., RS; ♂, 22.-28.07., KE; ♂, 30.09.-06.10., MI1.

Megaselia altifrons (Wood, 1909)

Material examined: ♂, 03.-09.06., KN; ♂, 07.-13.10., MI1.

Megaselia angusta (Wood, 1909)

Material examined: 3 ♂♂, 2 ♀♀, 17.-23.06., BB; ♀, 08.-14.07., BA; 2 ♂♂, ♀, 30.09.-06.10., MI1.

Megaselia brevicostalis (Wood, 1910)

Material examined: ♂, 24.-30.06., VK; ♂, 15.-21.07., RS.

Megaselia ciliata (Zetterstedt, 1848)

Material examined: ♂, 15.-21.07., MI1; ♀, 22.-28.07., KE; ♂, 22.-28.07., BA.

Megaselia cinereifrons (Strobl, 1910)

Material examined: ♂, 05.-11.08., SL.

Megaselia crassipes (Wood, 1909)

Material examined: ♂, 15.-21.07., MI1; ♂, 22.-28.07., KE.

Comments: The first record of this species in Slovakia was published by Grundmann et al. (2025).

Megaselia deltomera (Schmitz, 1924)

Material examined: ♂, 29.-31.07., SL; ♂, 02.-08.09., KN.

Comments: The first record of this species in Slovakia was published by Grundmann et al. (2025).

Megaselia diversa (Wood, 1909)

Material examined: ♂, 07.-13.10., MI1.

Comments: The first record of this species in Slovakia was published by Grundmann et al. (2024).

Megaselia elongata (Wood, 1914)

Material examined: ♂, 03.-09.06., RS.

Megaselia emarginata (Wood, 1908)

Material examined: ♂, 03.-09.06., RS.

Megaselia fenestralis (Schmitz, 1919)

Material examined: ♂, 03.-09.06., KN; ♂, 17.-23.06., BB; 2 ♂♂, 01.-07.07., 3 ♂♂, 22.-28.07., 2 ♂♂, 29.-31.07., 2 ♂♂, 01.-04.08., 2 ♂♂, 05.-11.08., 3 ♂♂, 12.-18.08., SL; 2 ♂♂, 08.-14.07., BA; ♂, 15.-21.07., RS.

Comments: The first record of this species in Slovakia was published by Grundmann et al. (2025).

Megaselia flavicans Schmitz, 1935

Material examined: ♂, 15.-21.07., VK; ♂, 23.-29.09., MI1.

Megaselia frameata Schmitz, 1927

Material examined: ♂, 30.09.-06.10., MI1.

Megaselia giraudii (Egger, 1862)

Material examined: 2 ♂♂, 03.-09.06., SL; ♂, 15.-21.07., VK; ♂, 23.-29.09., MI1.

Megaselia insons (Lundbeck, 1920)

Material examined: ♂, 17.-23.06., BB.

GBIF records. In Europe, this species is primarily recorded in northern regions and in European Russia. <https://www.gbif.org/species/1546492>.

Comments: New record for Slovakia.

Megaselia involuta (Wood, 1910)

Material examined: 10 ♂♂, 03.-09.06., ♂, 01.-07.07., ♂, 22.-28.07., 5 ♂♂, 05.-11.08, ♂, 12.-18.08., SL; ♂, 02.-08.09., KN.

Megaselia latipalpis (Schmitz, 1921)

Material examined: 2 ♂♂, 22.-28.07., KE.

Comments: The first record of this species in Slovakia was published by Grundmann et al. (2025).

Megaselia ledburyensis Brues, 1915

Material examined: ♂, 24.-30.06., VK; ♂, 29.-31.07., ♂, 01.-04.08., SL.

Megaselia major (Wood, 1912)

Material examined: ♂, 07.-13.10., MI1.

Megaselia manicata (Wood, 1910)

Material examined: ♂, 01.-07.07., SL.

Megaselia maura (Wood, 1910)

Material examined: ♂, 03.-09.06., KN.

Megaselia mimodensior Buck, 2001

Material examined: ♂, 03.-09.06., RS.

GBIF records. European records of this species are scarce, with only occasional findings in northern Europe and European Russia. <https://www.gbif.org/species/1548094>.

Comments: New record for Slovakia.

Megaselia pleuralis (Wood, 1909)

Material examined: ♂, 17.-23.06., SP; ♂, 22.-28.07., KE; 2 ♂♂, 30.09.-06.10., 4 ♂♂, 07.-13.10., MI1.

Megaselia plurispinulosa (Zetterstedt, 1860)

Material examined: ♂, 01.-07.07., ♂, 22.-28.07., SL; ♂, 15.-21.07., VK; ♂, 15.-21.07., MI1.

Megaselia propinqua (Wood, 1909)

Material examined: ♂, 22.-28.07., KE.

Megaselia pusilla (Meigen, 1830)

Material examined: ♂, 30.09.-06.10., MI1.

Megaselia quadriseta (Schmitz, 1918)

Material examined: ♂, 03.-09.06., SL.

Megaselia rubescens (Wood, 1912)

Material examined: ♂, 07.-13.10., MI1.

Megaselia ruficornis (Meigen, 1830)

Material examined: ♂, 24.-30.06., VK.

Megaselia rufipes (Meigen, 1804)

Material examined: ♂, 03.-09.06., RS.

Megaselia subcarpalis (Lundbeck, 1920)

Material examined: ♂, 17.-23.06., BB; 4 ♂♂, 22.-28.07., KE.

Comments: The first record of this species in Slovakia was published by Grundmann et al. (2025).

Megaselia sulphuripes (Meigen, 1830)

Material examined: ♂, 24.-30.06., VK.

Megaselia verralli (Wood, 1910)

Material examined: 3 ♂♂, 03.-09.06., 3 ♂♂, 29.-31.07., 10 ♂♂, 01.-04.08., 7 ♂♂, 05.-11.08., SL; ♂, 24.-30.06., 2 ♂♂, 08.-14.07., 6 ♂♂, 15.-21.07., VK; 2 ♂♂, 01.-07.07., ZA; ♂, 08.-14.07., BA; ♂, 15.-21.07., MI1.

Phalacrotophora spectabilis Schmitz, 1925

Material examined: ♂, 15.-21.07., MI1.

Pseudacteon formicarum (Verrall, 1877)

Material examined: 2 ♂♂, 03.-09.06., KN; 4 ♂♂, 03.-09.06., ♂, 05.-11.08., SL; ♂, 03.-09.08., NR; 2 ♂♂, 30.09.-06.10., MI1.

Pseudacteon lundbecki Schmitz, 1924

Material examined: ♀, 15.-21.07., RS; ♀, 12.-18.08., SL.

GBIF records. European records of this species are scarce, with only occasional findings in northern Europe and European Russia. <https://www.gbif.org/species/1549181>.

Comments: New record for Slovakia.

Spiniphora bergenstammi (Mik, 1864)

Material examined: ♂, 02.-08.09., ♂, 03.-09.06., KN; ♂, 23.-29.09., MI1.

Discussion

This study confirms the significant faunistic potential of CO₂-baited BG-Sentinel 2 traps, originally designed for mosquito surveillance, in revealing the diversity of non-target dipteran taxa – particularly scuttle flies (Phoridae). From a total of 414 samples collected across Slovakia in 2024, we identified 44 phorid species, including five new national records. Although the overall detection rate of phorids was relatively low (6.52 %), the observed species richness highlights the power of bycatch analysis in uncovering hidden biodiversity. These findings support recent calls to reevaluate the scientific value of non-target material collected during vector surveillance (Grundmann et al. 2025; Oboňa et al. 2025; Kurina et al. 2025).

Several species were frequently recorded across multiple localities and sampling periods, suggesting high local abundance or broad ecological tolerance. *Megaselia albocingulata* and *M. verralli* emerged as the most commonly encountered species, with the latter particularly dominant in Stará Ľubovňa (SL) and Lesenice (VK). *Megaselia involuta*, *M. fenestralis*, and *M. pleuralis* also exhibited broad spatial and seasonal distributions, indicating their potential as ecological generalists.

In contrast, many species were represented by single specimens or isolated occurrences. These include *Conicera similis*, *Diplonevra freyi*, *Pseudacteon lundbecki*, *Megaselia diversa*, *M. insons*, and *M. mimodensior* – almost all newly recorded for the Slovak fauna. Their detection reinforces the value of wide-ranging and long-term sampling, especially in underexplored habitats. This supports observations from earlier studies (e.g., Grundmann et al. 2025) that bycatch material often harbors rare or previously overlooked taxa with limited known distributions.

Seasonal patterns showed that the majority of specimens were collected between June and August, aligning with known phenology of many temperate Phoridae (Disney 1994). However, detections of *M. major*, *M. diversa*, and *M. pusilla* as late as October suggest that suitable microhabitats can support phorid activity well into autumn – an important consideration for biodiversity monitoring protocols.

A comparison with the study by Grundmann et al. (2025), conducted at the Košice Zoo using identical trap types, revealed substantial overlap in species composition: 26 species were shared between datasets. This congruence reinforces the robustness of CO₂-based sampling in detecting a consistent core of phorid diversity. However, detection rates differed markedly (82.76 % in Košice vs. 6.52 % in this study), likely reflecting differences in habitat complexity. As noted in the introduction, the Košice Zoo site includes a mosaic of microhabitats that favor higher insect diversity, whereas most sites in our regional survey were farms or semi-natural habitats dominated by one or few land-use types.

Interestingly, *Megaselia angusta* was the most abundant species in the Košice Zoo dataset but appeared only sporadically in our study. Conversely, *M. verralli*, common and widespread in our traps, was absent from the Košice sample. These differences likely reflect local variation in environmental conditions such as vegetation structure, substrate availability, and human disturbance.

Notably, although both studies recorded new additions to the Slovak fauna, there was minimal overlap in the newly documented species. This strongly suggests that expanding the

geographic scope of sampling is crucial for uncovering the full extent of regional biodiversity – a concept emphasized in recent studies on Diptera biodiversity using unconventional trapping methods (Kurina et al. 2025).

Taken together, our findings reaffirm the utility of CO₂-baited BG-Sentinel traps beyond their intended purpose. When paired with systematic bycatch analysis, these traps offer a low-cost, high-impact tool for biodiversity monitoring. The consistent detection of both widespread and rare species across diverse habitats highlights the method's versatility. Future faunistic and ecological surveys would benefit from integrating non-target analysis into standard entomological protocols, especially in regions where Diptera diversity remains poorly documented.

Conclusion

Our results underscore the significant, yet often overlooked, faunistic value of CO₂-baited BG-Sentinel 2 traps in capturing scuttle fly diversity across diverse habitats in Slovakia. Although designed for mosquito surveillance, these traps consistently yielded a rich assemblage of Phoridae, including both widespread taxa and five species newly recorded for the national fauna.

The comparison with previous findings from the Košice Zoo (Grundmann et al. 2025) highlights how localized and regional sampling efforts can complement one another, with minimal overlap in newly detected species. This emphasizes the importance of spatially and ecologically diverse sampling strategies in biodiversity research.

By incorporating systematic bycatch analysis into entomological protocols, researchers can unlock valuable faunistic information from material that would otherwise be discarded. Such integrative approaches enhance the cost-effectiveness and ecological relevance of insect monitoring, contributing to a more comprehensive understanding of Diptera diversity and supporting broader conservation goals.

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