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HIDDEN GUESTS OF CO_2 TRAPS: TRACKING *CLOGMIA ALBIPUNCTATA*, *DROSOPHILA SUZUKII*, AND OTHER DIPTERA ACROSS SLOVAKIA

TAJEMNICZY GOŚCIE W PUŁAPKACH NA CO_2: TROPIENIE *CLOGMIA ALBIPUNCTATA*, *DROSOPHILA SUZUKII*, I INNYCH MUCHÓWEK W SŁOWACJI

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Jozef Oboňa [1], Katarína Loziaková Peňazziová [2], Tomáš Csank[3], Zuzana Pačanská [4], Soňa Pivka [5]

[1] Department of Ecology, Faculty of Humanities and Natural Sciences, University of Prešov, 17. novembra 1, SK – 08116 Prešov, Slovakia; e-mail: jozef.obona@unipo.sk

[2] Department of Microbiology and Immunology, University of Veterinary Medicine and Pharmacy. Komenského 73, SK – 04181 Košice, Slovakia; e-mail: katarina.penazziova@uvlf.sk

[3] Department of Microbiology and Immunology, University of Veterinary Medicine and Pharmacy. Komenského 73, SK – 04181 Košice, Slovakia; e-mail: tomas.csank@uvlf.sk

[4] Department of Microbiology and Immunology, University of Veterinary Medicine and Pharmacy. Komenského 73, SK – 04181 Košice, Slovakia; e-mail: zuzana.pacanska@student.uvlf.sk

[5] Department of Microbiology and Immunology, University of Veterinary Medicine and Pharmacy. Komenského 73, SK – 04181 Košice, Slovakia; e-mail: sona.pivka@uvlf.sk

Corresponding author: Jozef Oboňa (jozef.obona@unipo.sk)

ABSTRACT: CO_2-baited BG-Sentinel 2 traps are widely used for mosquito surveillance; however, their non-target catches can also yield valuable insights into broader insect biodiversity. Building on previous research, we analyzed incidental captures collected from multiple sites across Slovakia, focusing on two invasive synanthropic species - the moth midge *Clogmia albipunctata* (Williston, 1893) (Psychodidae) and the spotted-wing drosophila *Drosophila suzukii* (Matsumura, 1931) (Drosophilidae). Using these traps, we successfully mapped their distribution across urban and semi-urban habitats, recording occurrences in several previously unreported localities. Our findings highlight the potential of CO_2 traps as practical tools for faunistic monitoring beyond mosquito targets, revealing patterns of distribution and spread of invasive Diptera. This study underscores the broader value of repurposing standard mosquito surveillance infrastructure for multi-taxa biodiversity assessments and early detection of invasive species in human-influenced environments.

KEY WORDS: bycatch, *Clogmia*, CO_2 trap, *Drosophila*, faunistics, invasive species, Slovakia, urban ecology

INTRODUCTION

Carbon dioxide (CO_2)-baited traps, such as the BG-Sentinel 2 (Biogents, Germany), have long been employed for targeted monitoring of hematophagous Diptera, particularly mosquitoes (e.g., Farajollahi *et al*., 2009; Cilek *et al*., 2024). Although these traps are optimized for host-seeking species, their non-target catches are often overlooked or discarded. However, recent studies have highlighted the considerable faunistic and ecological value of such incidental captures (Grootaert *et al*., 2025; Grundmann *et al*., 2025a,b; Kurina *et al*., 2025; Oboňa *et al*., 2025). By examining these non-target taxa, researchers have discovered previously undocumented species within families such as Phoridae, Bibionomorpha, and other Diptera groups, thereby broadening our understanding of insect biodiversity across Slovakia and illustrating the potential of CO_2 traps as complementary monitoring tools.

Building on these findings, the present study further explores non-target Diptera, focusing specifically on two synanthropic and invasive species: the moth midge *Clogmia albipunctata* (Williston, 1893) (Psychodidae) and the spotted-wing drosophila *Drosophila suzukii* (Matsumura, 1931) (Drosophilidae). Both species are of growing concern in Slovakia due to their expanding ranges, strong synanthropic tendencies, and, in the case of *D. suzukii*, significant economic impact on soft fruit crops (e.g., Oboňa *et al*., 2016; Oboňa *et al*., 2017).

In this study, we assess the effectiveness of CO_2-baited traps not only for detecting established mosquito populations but also for mapping the occurrence, distribution, and relative abundance of *C. albipunctata* and *D. suzukii* across semi-urban and urban landscapes. Through detailed analysis of incidental captures, we provide updated faunistic records and insights into the spatial dynamics of these species in Slovakia. Ultimately, our findings demonstrate the broader utility of CO_2-based surveillance systems for multi-taxa biodiversity monitoring in anthropogenically influenced environments.

MATERIAL AND METHODS

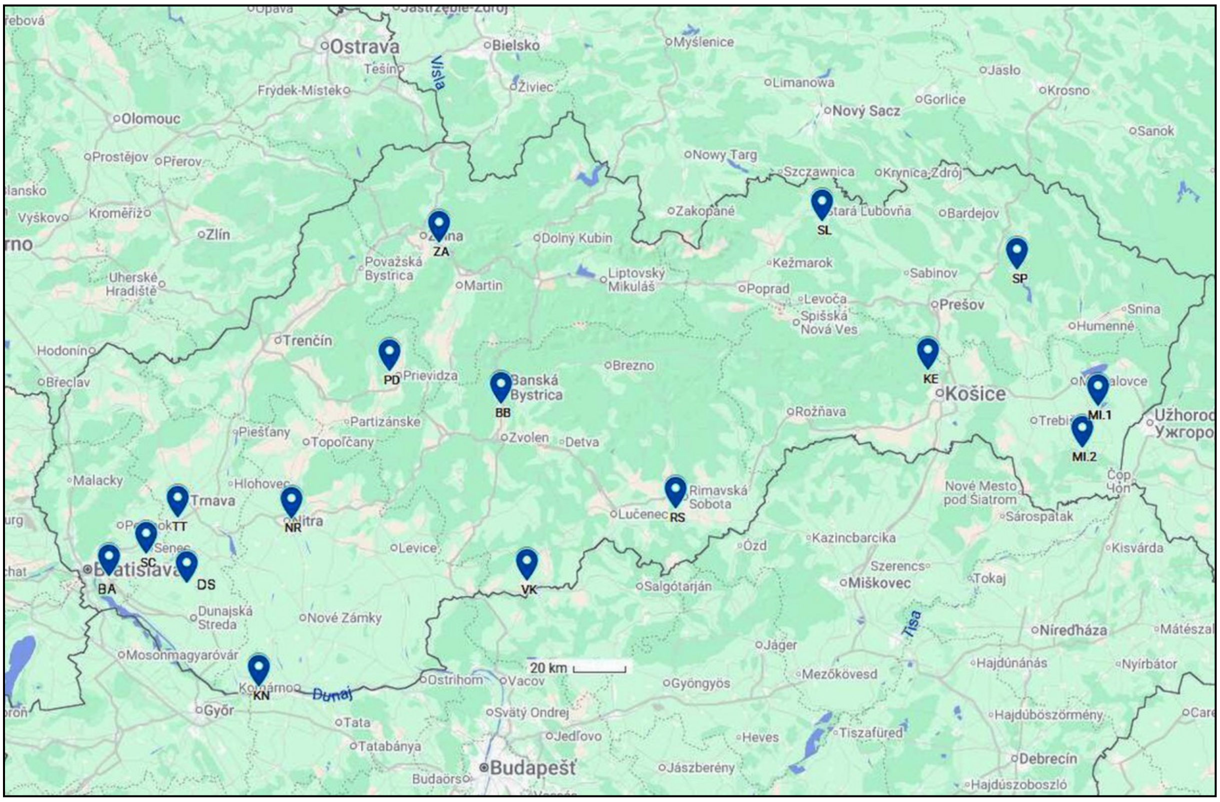
SAMPLING

The bycatch analyzed in this study was collected during mosquito surveillance using BG-Sentinel 2 traps (Biogents, Germany) baited with pressurized CO_2 cylinders. Traps were deployed across 16 localities in Slovakia throughout 2024 (Map 1). Collection nets were replaced weekly, and samples were first stored at −20 °C and later at −80 °C until laboratory processing.

After removing mosquitoes, the remaining material was preserved in 75% ethanol. The collected flies were then sorted to family level and subsequently identified to species level using the following keys: Limoniidae and Pediciidae – Podenas *et al.* (2006), Oosterbroek (2024); Psychodidae – Withers (1989), Ježek (1977, 1990), and Ježek and van Harten (2009); and Drosophilidae – Asplen *et al*. (2015).

LOCALITIES

Sampling was conducted at 16 sites representing a range of habitat types across Slovakia (for details, see Grundmann *et al*., 2025b; Grootaert *et al*., 2025, and Map 1).



Map 1. Sampling sites across Slovakia. Map created using Google Maps (https://www.google.com/maps).

For data interpretation, species were categorized according to their frequency of occurrence in traps (1 case = 1 qualitative presence; total = 396 samples): sporadic – < 1% of cases; not common – 1–5%; common – 5–10%; very common – > 10%. The number in parentheses () indicates the exact number of positive samples.

RESULTS

A total of 20 species were collected using BG-Sentinel 2 traps across Slovakia in 2024. These represent only selected taxa and do not constitute a complete overview of all Diptera species recorded. The families Limoniidae, Pediciidae, and Psychodidae are presented in full, while only one representative species is included from Drosophilidae.

Annotated list of recorded species

Drosophilidae Rondani, 1856

***Drosophila suzukii* (Matsumura, 1931)**

Note: common (22), present in 6% of all samples (see Map 2, Fig. 1)

Comments: The spotted wing drosophila has rapidly spread across Europe, establishing populations in several countries since its first detection (Calabria *et al*., 2012; Cini *et al*., 2012, 2014; Łabanowska *et al*., 2015; Kiss *et al*., 2016; Kenis *et al*., 2016; etc.). This invasive species poses a serious threat to agriculture, particularly to soft fruit production such as berries and cherries, where it causes substantial economic losses (De Ros *et al*., 2015; Kenis *et al*., 2016; Tait *et al*., 2021; Zhou *et al*., 2024; etc.).

Limoniidae Rondani, 1856

***Achyrolimonia coeiana* (Nielsen, 1959)**

Note: sporadic (1)

***Achyrolimonia decemmaculata* (Loew, 1873)**

Note: sporadic (2)

***Achyrolimonia neonebulosa* (Alexander, 1924)**

Note: sporadic (1)

***Atypophthalmus* (*Atypophthalmus*) *inustus* (Meigen, 1818)**

Note: very common (42)

***Dicranomyia* (*Dicranomyia*) *modesta* (Meigen, 1818)**

Note: sporadic (2)

***Erioptera* (*Erioptera*) *lutea* Meigen, 1804**

Note: sporadic (2)

***Gonempeda flava* (Schummel, 1829)**

Note sporadic (1)

***Helius* (*Helius*) *longirostris longirostris* (Meigen, 1818)**

Note: sporadic (1)

***Limonia nubeculosa* Meigen, 1804**

Note: very common (48)

***Limonia phragmitidis* (Schrank, 1781)**

Note: not common (3)

***Metalimnobia* (*Metalimnobia*) *bifasciata* (Schrank, 1781)**

Note: sporadic (2)

***Molophilus* (*Molophilus*) *griseus* (Meigen, 1804)**

Note: sporadic (1)

***Molophilus* (*Molophilus*) *ochraceus* (Meigen, 1818)**

Note: sporadic (1)

***Neolimonia dumetorum* (Meigen, 1804)**

Note: sporadic (1)

***Pseudolimnophila* (*Pseudolimnophila*) *lucorum* (Meigen, 1818)**

Note: not common (6)

Pediciidae Osten Sacken, 1860

***Ula* (*Ula*) *bolitophila* Loew, 1869**

Note: sporadic (1)

Psychodidae Bigot, 1854

***Clogmia albipunctata* (Williston, 1893)**

Note: very common (64); present in 16% of all samples (see Map 3, Fig. 1)

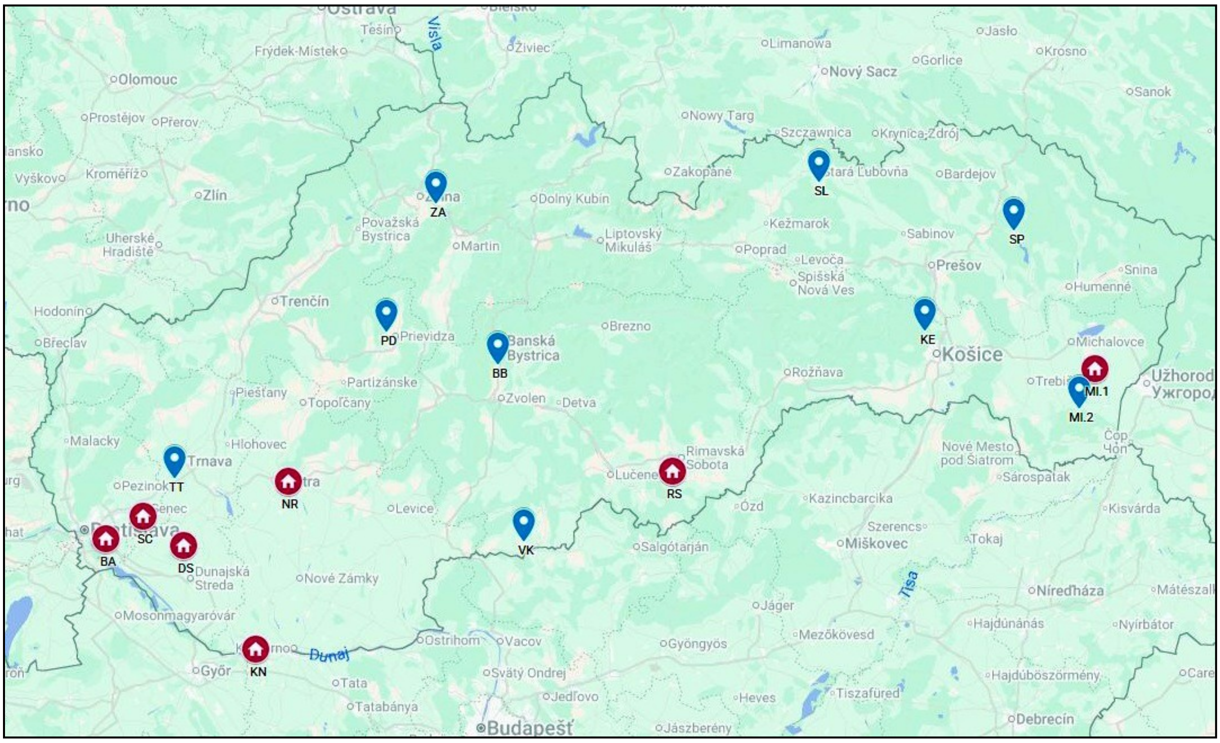
Comments: The cosmopolitan drain fly *C. albipunctata* is currently experiencing a notable expansion of its distribution range, with increasing records from diverse geographic regions (Oboňa *et al*., 2021, 2023; Kvifte, 2023; Marafi *et al*., 2025; etc.). While often considered a nuisance species, its presence in hospitals and domestic environments has raised significant public health concerns. *Clogmia albipunctata* has been implicated as a potential agent of facultative myiasis and as a passive carrier of bacteria and other pathogenic microorganisms, potentially facilitating their introduction into sterile or clinical settings (Akhoundi *et al*., 2022; Chen *et al*., 2022; Faulde *et al*., 2023; Mathison *et al*., 2024; Park *et al*., 2025; etc.).

***Psychodocha cinerea* (Banks, 1894)**

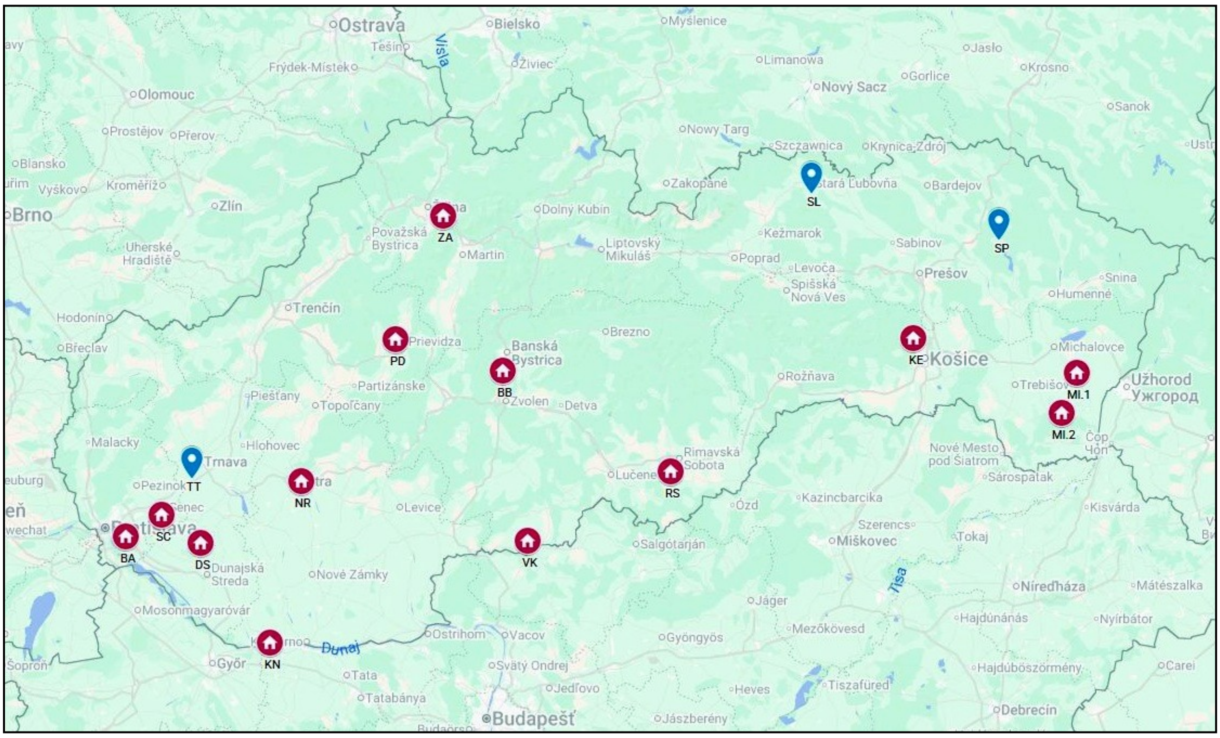
Note: common (19)

***Tinearia alternata* (Say, 1824)**

Note: very common (91)



Map 2. Sampling sites in Slovakia with positive localities (purple house symbols) for *Drosophila suzukii* (Matsumura, 1931). Map created using Google Maps (https://www.google.com/maps).



Map 3. Sampling sites in Slovakia with positive localities (purple house symbols) for *Clogmia albipunctata* (Williston, 1893). Map created using Google Maps (https://www.google.com/maps).

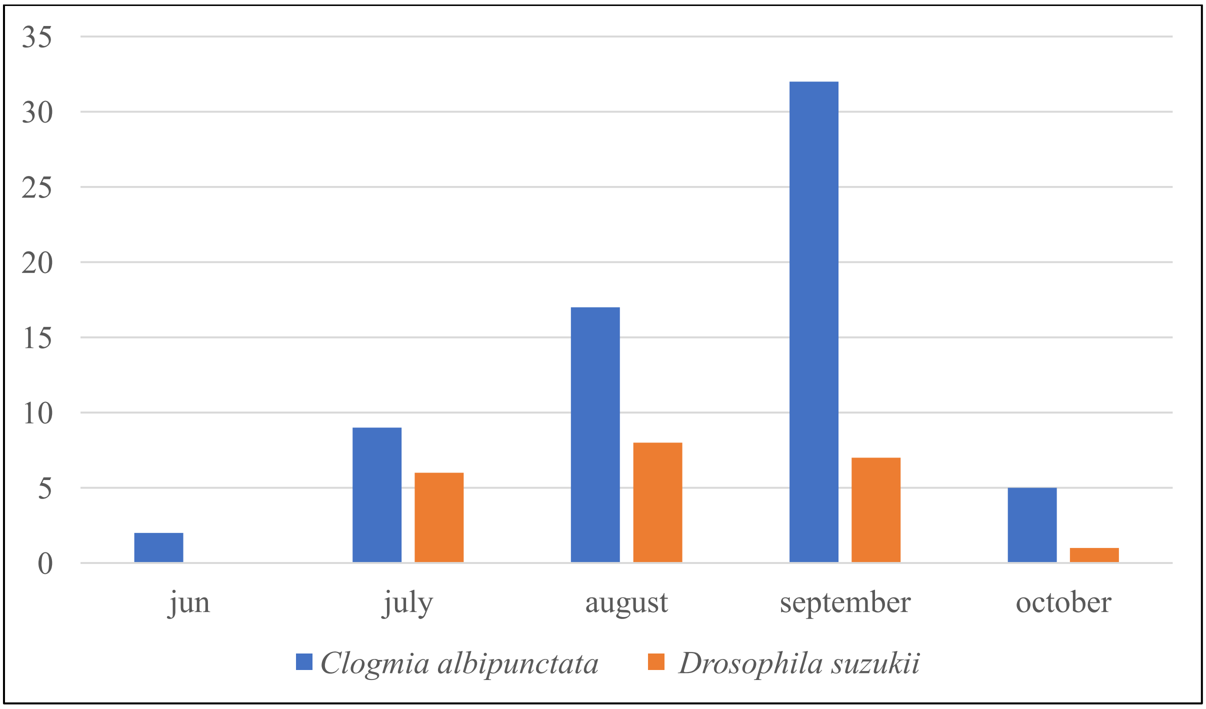


Fig. 1. Overview of the number of positive samples per month for both species.

DISCUSSION

The comparison of Diptera assemblages obtained from mosquito trap collections in Košice Zoo (see Oboňa *et al*., 2025) revealed both similarities and differences in species composition and relative abundance. Within the family Psychodidae, all three previously recorded species (*T. alternata*, *P. cinerea*, and *C. albipunctata*) were consistently captured. *Tinearia alternata* remained very common in both surveys. While *P. cinerea* was classified as very common in earlier study, it appeared only as common in the present dataset, suggesting minor fluctuations in local population density or differences in trap efficiency. The high frequency of *C. albipunctata* represents a new observation, possibly reflecting seasonal dynamics or microhabitat preferences within the zoo environment.

Among Limoniidae, several core species were repeatedly captured, confirming results from Oboňa *et al*. (2025). *Atypophthalmus inustus* and *L. nubeculosa* remained very common, confirming their widespread presence in the sampled habitats. Other species such as *A. decemmaculata* and *E. lutea* were only sporadically captured, indicating temporal variability or sensitivity to environmental factors such as humidity, vegetation structure, or larval substrate availability.

Newly recorded taxa (e.g., *A. coeiana*, *A. neonebulosa*, *D. modesta*, *P. lucorum*, and *U. bolitophila*) highlight the broader diversity of Diptera incidentally captured during mosquito monitoring. The sporadic occurrence of these species suggests that they are occasional visitors to trap sites rather than stable local residents, consistent with other European faunistic studies using CO_2-based traps.

The presence of *D. suzukii*, absent from previous datasets (Oboňa *et al*., 2025), underscores the potential of BG-Sentinel traps to collect a wider taxonomic spectrum beyond hematophagous Diptera. Its frequent occurrence supports the idea that CO_2-baited traps can attract species with diverse ecological niches, including frugivorous and saprophagous taxa.

Overall, the comparative analysis demonstrates that while core saprophagous and marshland-associated species such as *A. inustus*, *L. nubeculosa*, and *T. alternata* remain consistently abundant, the composition of non-target Diptera in mosquito traps varies temporally and ecologically. These findings reinforce the utility of BG-Sentinel traps not only for mosquito monitoring but also for documenting local dipteran biodiversity (see also Grootaert *et al*., 2025; Grundmann *et al*., 2025a,b; Kurina *et al*., 2025).

Our additional data confirm that CO_2 traps are effective not only for the originally targeted mosquito species but also for invasive and synanthropic taxa such as *C. albipunctata* and *D. suzukii*. *Clogmia albipunctata* was detected at multiple localities, including urban and peripheral areas where it had not previously been recorded (Map 3). Its occurrence even at higher altitudes suggests that urban microclimates may facilitate its expansion. Although the maximum altitude remains around 300 m a.s.l. (Oboňa *et al*., 2016), CO_2 traps can detect smaller peripheral populations outside the predicted range.

Similarly, *D. suzukii* was recorded mainly during late summer and autumn (Map 2, Fig. 1), consistent with its seasonal activity and polyphagous ecology (Asplen *et al*., 2015). These data enhance understanding of the species' spread in Slovakia and can help anticipate its potential impact on fruit crops.

In summary, CO_2-baited traps represent an efficient method for the simultaneous monitoring of multiple invasive and synanthropic Diptera species. They enable the creation of detailed distribution maps, assessment of seasonal dynamics, and detection of range limits. This approach is therefore well suited for long-term faunistic and ecological studies in Slovakia and the wider Central European region.

CONCLUSION

This study demonstrates that CO_2-baited BG-Sentinel 2 traps, although originally designed for mosquito monitoring, are highly effective for detecting and mapping non-target Diptera, including invasive synanthropic species such as *C. albipunctata* and *D. suzukii*. Analysis of bycatch allowed us to document these species across multiple urban and semi-urban sites in Slovakia, providing updated faunistic records and new insights into their current distribution and potential for further spread.

Our findings corroborate previous research showing that incidental captures from CO_2 traps hold substantial faunistic and ecological value. Incorporating non-target data into routine mosquito surveillance can enhance early detection of invasive species, contribute to urban biodiversity assessments, and inform management strategies for synanthropic Diptera.

Overall, CO_2-based monitoring represents a cost-effective, multi-taxa approach that strengthens our understanding of insect diversity and invasion dynamics in human-modified habitats.

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STRESZCZENIE

Pułapki BG-Sentinel 2 z przynętą CO_2, powszechnie stosowane w monitoringu komarów, mogą również dostarczać cennych informacji o różnorodności innych owadów. W niniejszym badaniu przeanalizowano przypadkowe odłowy uzyskane z różnych lokalizacji na Słowacji, koncentrując się na dwóch inwazyjnych gatunkach synantropijnych – muchówce *Clogmia albipunctata* (Psychodidae) i muszce plamoskrzydłej *Drosophila suzukii* (Drosophilidae). Za pomocą tych pułapek udało się sporządzić mapę rozmieszczenia obu gatunków w środowiskach miejskich i podmiejskich, odnotowując ich obecność w kilku wcześniej niezgłoszonych stanowiskach.

Wyniki potwierdzają, że dane uzyskane z odłowów niecelowych mają istotną wartość faunistyczną i ekologiczną. Włączenie takich informacji do rutynowego monitoringu komarów może wspierać wczesne wykrywanie gatunków inwazyjnych, ocenę bioróżnorodności miejskiej oraz opracowanie skuteczniejszych strategii zarządzania muchówkami synantropijnymi. Ogólnie rzecz biorąc, monitoring oparty na pułapkach CO_2 stanowi ekonomiczne i wielogatunkowe narzędzie, które poszerza wiedzę o różnorodności owadów i dynamice ich inwazji w środowiskach przekształconych przez człowieka.