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Original paper

Case report, citizen science reveals the occurrence of Botflies (Diptera: Oestridae) in the Czech Republic and Slovakia

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ABSTRACT. We present a case of a botfly larva, *Gasterophilus intestinalis* (De Geer, 1776) that was removed from a horse's stomach during gastroscopy. Additionally, we provide a detailed yet unconventional perspective on the research of botfly presence in the Czech Republic and Slovakia. Through citizen science, we confirm the occurrence of two species of Hypodermatinae, among which *Hypoderma diana* Brauer, 1858 is relatively common. In the subfamily Oestrinae, we confirmed the occurrence of three species. *Cephenemyia stimulator* (Clark, 1815) is very common, which suggests that this species could negatively impact deer populations and their vitality. On the other hand, species reproductively linked to livestock (cattle, sheep, and goats) are relatively rare, which may be associated with the transition to stable-based farming of these animals.

Keywords: parasite, Gasterophilinae, Oestrinae, Hypodermatinae, faunistics

Introduction

Citizen science is a powerful tool for biodiversity research [1]. It plays a crucial role in biodiversity monitoring, ecological research, and studying the expansion of invasive alien species [2–5]. In response to the growing interest in citizen science, numerous platforms have been developed to facilitate species recording. These platforms incorporate features such as mobile apps, enhancing the user experience by allowing to be recorded conveniently anytime and anywhere [1]. Botflies (Diptera: Oestridae) are obligate endoparasites of mammals, and their remarkable diversification plays a crucial role in understanding the evolution of parasitism. They are of significant economic, medical, and veterinary importance, as their larvae cause myiasis in both domestic and wild animals, as well as in humans [6].

In this study, we used citizen science to map the occurrence of botflies in the Czech Republic and Slovakia.

Materials and Methods

Data on the systematics, morphology, and biology of warble flies can be found in several monographs [7–9]. The Case report section provides basic information about the discovery of larvae in a horse's stomach.

The citizen science section is divided into the following subsection:

General note: contains fundamental data on the ecology and global distribution of the species. Occurrence: provides detailed information on localities in the Czech Republic and Slovakia, listed alphabetically.

Published references from the Czech Republic and Slovakia: presents relevant published data for the given species from these countries. References to the online resources from GBIF and iNaturalist.org are included for each species.

Records: summarizes new, unpublished data obtained from citizen science websites such as https://www.inaturalist.org/, https://fotonet.sk/, https://www.nahuby.sk, etc. Species occurrences were tracked by their scientific names. In case of a positive finding, data are provided in the following format: country (Czech Republic and Slovakia), location, date, name (or nickname) of the finder (Full web link is in Appendix). Individual findings are arranged chronologically.

Results and Discussion

Case report

Parasite: *Gasterophilus intestinalis* (De Geer, 1776) larva, 10 × 4 mm (Fig. 1); removed from the horse's stomach.

Host: 19-year-old gelding (*Equus ferus caballus* Linnaeus, 1758) named "Lorenzo" (Fig. 2).

Figure 1. *Gasterophilus intestinalis* (De Geer, 1776), larva removed from a horse's stomach (photo by Oldřich Sychra)

Figure 2. The host of *Gasterophilus intestinalis* – horse *Equus ferus caballus* Linnaeus, 1758 (photo by Marcela Adamcová)

Locality: Podzámčok (district Zvolen), 48°30′01.0″N 19°06′33.0″E.

Disease course: A 19-year-old gelding experienced colic of varying severity between June and November 2024. A gastroscopy performed in May revealed no abnormalities. However, in November, the horse was taken to the Clinic for Equine Diseases at University of Veterinary Sciences in Brno, where a second gastroscopy (on 20 November 2024) detected the presence of *Gasterophilus intestinalis* larvae.

Note: While we do not assume that the presence of the larva was the primary cause of the horse's gastroenterological issues (supportive gastric treatment was also initiated), it likely contributed to the animal's discomfort.

Citizen science

Family Oestridae

Subfamily Gasterophilinae

The larvae live as parasites in the stomach and intestine of horses and donkeys. The eggs are deposited directly on the host's skin, and the first larval instar penetrates the skin and works its way inside the animal. The larvae first migrate to the mouth and later to the stomach and intestine. Eventually, the larva leaves the host with the excrement and pupates in the soil. The adults have reduced mouthparts, do not feed, and are typically found near horses and stables [10].

Genus *Gasterophilus* Leach, 1817

Gasterophilus haemorrhoidalis (Linnaeus, 1758)

General note: The larvae parasitize the stomach and intestine of horses (*Equus ferus caballus*

Linnaeus, 1758) and zebras (*Hippotigris* spp.). This Palearctic species is also known from the Ethiopian region. It spread globally with horse breeding [7].

Occurrence: The species is known from Czech Republic (České Budejovice) and from Slovakia (Trenčín) [7,11].
https://www.gbif.org/species/1587230
https://www.inaturalist.org/taxa/408657-Gasterophilus-haemorrhoidalis

Published references from Czech Republic and Slovakia: Minář [7,11].

***Gasterophilus inermis* (Brauer, 1858)**

General note: The larvae parasitize the stomach and intestine of horses and zebras. This Palearctic species is also known from the Ethiopian region [7].

Occurrence: Eastern Slovakia [7,11].
https://www.gbif.org/species/1587248
https://www.inaturalist.org/taxa/666769-Gasterophilus-inermis

Published references from Czech Republic and Slovakia: Minář [7,11].

***Gasterophilus intestinalis* (De Geer, 1776)**

General note: The larvae parasitize the stomach and intestine of horses and donkeys (*Equus africanus asinus* Linnaeus, 1758). This original Palearctic species has spread globally with horse breeding [7].

Occurrence: The species is known from the Czech Republic (Kladruby nad Labem) and Slovakia (Humenné) [7]. Additional records from Humenné are cited in Minář [11]. In 2004, *G. intestinalis* was reported from horse imported form Netherlands [22].
https://www.gbif.org/species/1587209
https://www.inaturalist.org/taxa/666770-Gasterophilus-intestinalis

Published references from Czech Republic and Slovakia: Minář [7,11,22], Bezdekova et al. [21].

***Gasterophilus pecorum* (Fabricius, 1794)**

General note: The larvae parasitize the stomach and intestine of horses, donkeys, and zebras. This Palearctic species is also known from the Ethiopian region [7].

Occurrence: The species is known only from the Czech Republic (Vysoké Mýto) [11].
https://www.gbif.org/species/1587235
https://www.inaturalist.org/taxa/774896-Gasterophilus-pecorum

Published references from Czech Republic: Minář [7,11].

Subfamily Hypodermatinae

The larvae live as subcutaneous endoparasites in mammals, particularly in deer and cattle, but also occasionally in other mammals (e.g., horses, guinea pigs). Most species are specialised in one or only a few host species. The eggs are deposited on the skin of the host, and the first instar larva penetrates the skin. The second and third instar larvae accumulate on the host's back, forming large warbles. Just prior to pupation, the fully grown larva leaves exits the host through the skin and pupates in the soil. The adults have reduced mouthparts and do not feed. They are often resting on walls, plants, etc., or near their host. Species of economic importance to cattle breeding were virtually exterminated during the second half of the 20th century [10].

Genus *Oestromyia* Brauer, 1860
***Oestromyia leporina* (Pallas, 1778)**

General note: The species inhabits the temperate zone of the Palearctic region, from Central Europe to Eastern Siberia, in hilly and mountainous areas [8].

Occurrence: Recorded from *Microtus arvalis* Pallas, 1778 and *Microtus agrestis* Linnaeus, 1761 at several locations in the Hercynian and Carpathian regions. A relatively rare species [8]. In Slovakia, it is known from Dolný Kubín, Oravice, Ruské Pekľany (Prešov) [12].
https://www.gbif.org/species/1587343
https://www.inaturalist.org/taxa/626981-Oestromyia-leporina

Published references from Czech Republic and Slovakia: Minář [8,12], Klimková et al [23].

Genus *Hypoderma* Latreille, 1818
***Hypoderma actaeon* Brauser, 1858**

General note: The larvae parasitize under the skin of the European deer (*Cervus elaphus* Linné, 1758), which is their specific host. It is a central and common species in southeaster Europe [8].

Occurrence: The species is known from the Czech Republic (Lány) and Slovakia (Kováčovské kopce Hill and Zlaté Moravce). It is a rare species [8]. Minář [12] added records from Chľaba (Slovakia).
https://www.gbif.org/species/1587285
https://www.inaturalist.org/taxa/626997-Hypoderma-actaeon

Published references from Czech Republic and Slovakia: Minář [8,12].

***Hypoderma bovis* (De Geer, 1776)**

General note: It is primarily found in mountainous and foothill areas where cattle graze. It also develops on bison, buffalo, and yak. Additionally, it has also been found on other types of domestic animals and hunted game. The species is distributed in the temperate zone of the Northern Hemisphere, in Eurasia, South Africa, and North America [8].

Occurrence: It is an economically extremely significant ectoparasite of cattle. It is now found only on the Moravian-Slovak border and in central Slovakia [8]. Minář [12] provides a detailed occurrence in Slovakia.
https://www.gbif.org/species/1587301
https://www.inaturalist.org/taxa/390876-Hypoderma-bovis

Published references from Czech Republic and Slovakia: Minář [8,12–14], Minář & Breev [15].

Records: **Czech Republic**: Neratov, near pond Skříň, 16.4.2020, Miroslav Polášek (Fig. 3).

Figure 3. *Hypoderma bovis* (De Geer, 1776) from the locality Neratov, near pond Skříň, 16.4.2020 (photo by Miroslav Polášek)

***Hypoderma diana* Brauer, 1858**

General note: The species parasitizes under the skin of the roe deer (*Capreolus capreolus* (Linnaeus, 1758)), which is the primary host of this species, and also on the European deer (*C. elaphus*). It has also been detected in reindeer, sika deer, elk, chamois and mouflon. It can be found in the temperate zone of the Palearctic region [8].

Occurrence: A relatively common species in the Czech Republic and Slovakia [8]. In Slovakia, it is known from Burda, Chľaba, Horné Lefantovce, Hrušov, Jelenec, Košice, Modrý Kameň, Nové Zámky, Oponice, Párovské Háje, Žibrica – vrchol, Zlatá Idka, Zlatovce, Zobor – prameň (spring) [12].
https://www.gbif.org/species/1587290
https://www.inaturalist.org/taxa/626998-Hypoderma-diana

Published references from Czech Republic and Slovakia: Minář [8,12], Jahn et al [24], Salaba et al. [16], Kudrnáčová et al. [17], Pavlásek & Minář [25, 26, 27].

Records: **Czech Republic**: Hnanice, 1.4.–30.6.2001, Miroslav Barták, Štěpán Kubík; Havraníky, 1.4.–30.6.2001, Miroslav Barták, Štěpán Kubík; Braitava Letohrádek, 1.4.–30.6. 2002, Miroslav Barták, Štěpán Kubík; Terasy, 1.4.–30.6.2003, Miroslav Barták, Štěpán Kubík; Liščí Skála, 1.4.–30.6.2004, Miroslav Barták, Štěpán Kubík; Rochov, 7.5.2016, Karel Filip; Jeseníky – Karlovice, 22.5.2018, Jiří Kuča; Česko (Jihomoravský kraj, Bučovice-Nesovice), May 2019, Milan Kudlička; Údolí Bubovického potoka brook, 19.5.2019, Ivo Carvan; Valtice, 30.4.2023, Jakub Široký.

Slovakia: Košická kotlina basin, Košice, Vyšné Opátske, 22.4.2015, Karol Ox (Fig. 4); Strážovské vrchy hills, Chvojnica, behind the sawmill, 15.6.2017, Braňo Ivčič; Strážovské vrchy hills, Chvojnica, 15.6.2017, Laco Tábi; Zvolenská kotlina basin, Banská Bystrica, near Fončorda, 26.4.2019, Matej Schwarz; Stropkov – Bokša, 23.4.2020, Jozef Šeršeň; Považský Inovec, Banka, district Piešťany, 23.4.2020, Laco Tábi.

Figure 4. *Hypoderma diana* Brauer, 1858 from the locality Vyšné Opátske near Košice, 22.4.2015 (photo by Karol Ox)

***Hypoderma lineatum* (De Villers, 1798)**

General note: The main host of this species is cattle. It also parasites buffalo, bison, and yak. Additionally, it has been found on other types of domestic animals and hunted game. The species is present in the temperate zone of the Northern Hemisphere [8].

Occurrence: It occurs mainly in grazing areas with a drier climate. In Slovakia, it is known from Humenné, Martin, Prešov, Ruská Porubá, Šamorín, and Zlaté Moravce [8], Minář [12] adds records from Bánovce nad Bebravou, Klokoč, Lučenec, Námestovo, Nitra, Pohronský Ruskov, Považská Bystrica, Rožňava, Sečovce, Šurany, Sládkovičovo, Trebišov, Trstená, Zádiel, and Zvolen.
https://www.gbif.org/species/1587295
https://www.inaturalist.org/taxa/626994-Hypoderma-lineatum

Published references from Czech Republic and Slovakia: Minář [8,12–14], Minář & Hojsík [18].

Subfamily Oestrinae

The larvae are parasites in the nostrils or nasal cavities of mammals, especially sheep and goats, but occasionally also antelopes, deer, camels and horses. The host relationship is rather specific. Oestrinae are larviparous, meaning that larvae (instead of eggs) are deposited into the nostrils of the host, usually from a distance. The female hovers just in front of the host and ejects the larvae into its nostrils. The larvae migrate to the nasal cavities and, in most cases, later into the pharynx. Fully grown larvae leave their host through the nostrils or mouth and pupate in the soil. The adults have reduced mouthparts and do not feed. They are relatively inactive insects and are rarely observed. A conspicuous phenomenon in this family is hilltopping, i.e., the habit of adults seeking out high places or landmarks in order to increase the chances of males and females meeting each other [10].

Genus *Cephenemyia* Latreille, 1818

***Cephenemyia auribarbis* (Meigen, 1824)**

General note: The larvae parasitize in the nasopharynx of European deer. They are also rarely found in European fallow deer (*Dama dama* (Linnaeus, 1758)). It is a predominantly Central and Western European species [9].

Occurrence: In the Czech Republic, it is known from the Krušné hory Hills, and in Slovakia, from the Kováčovské kopce Hills [9], as well as from

Figure 5. *Cephenemyia auribarbis* (Meigen, 1824) from Husárik near Čadca, 19.5.2020 (photo by Matej Schwarz)

Biela skala rock (Oponice), Burda, Holíč (Nimnica), Hunták (Žirany), Jelenec, Kamenica nad Hronom, Plavečský Mikuláš, Tríbeč – brook, and Zobor – hill [19].
https://www.gbif.org/species/1587331
https://www.inaturalist.org/taxa/774895-Cephenemyia-auribarbis

Published references from Czech Republic and Slovakia: Minář [9,19].

Records: **Slovakia**: Javorníky, Čadca, Husárik, 19.5.2020, Matej Schwarz (Fig. 5).

***Cephenemyia stimulator* (Clark, 1815)**

General note: The larvae parasitize in the nasopharynx of roe deer, often in large numbers. The species can be found in the temperate zone of the Palearctic region [9].

Occurrence: A widely distributed and relatively abundant species [9]. In Slovakia, it is known from Banská Bystrica, Bezovec, Burda, Čadca, Chopok, Dolný Kubín, Ilava, Lučenec, Malý a Veľký Fatranský Kriváň, Martin, Nitra, Nitrianska Magura, Nové Zámky, Oravský Podzámok, Ostredok, Poľana, Prievidza, Rimavská Sobota, Sitno, Stratenec, Veľký Inovec, Žiar nad Hronom, Žibrica, Žilina, and Zobor [19].
https://www.gbif.org/species/1587317
https://www.inaturalist.org/taxa/626816-Cephenemyia-stimulator

Published references from Czech Republic and Slovakia: Minář [9,19], Salaba et al. [16], Kudrnáčová et al. [17], [28–35].

Records: **Czech Republic:** Kolínsko, 8.1.2007, Fery; Nové Město pod Smrkem, 3.8.2008, Ivan Motlík; Vysoké kolo, 10.8.2009, Jan Vaněk; Kolín,

7.7.2010, Milan.K; Česko, Šumava, na kopci Boubín, July 2010, Jiří Švábík; Jižní Čechy, April 2011, Lukáš Jurek; Kamenná rozhledna v obci Úvalno, 8.7.2012, Ing. Miroslav Hudeček; Jeseníky, 18.7.2015, Milena Vořechovská; Svatá, 26.7.2018, Michaela Tajovská; Biskupská kupa, 8.8.2018, Petr Krampl; Mutěnice, 16.6.2019, Michal Hýl; Klapý, 29.5.2020, Kaferano; Nový Bor, 25.6.2020, Anyvalay; Tachov, 6.7.2020, Jan Mach; Židlochovice, 25.7.2020, Kamcatka; Podhradí, Třemošnice, 2.8.2020, Martin Mecerod; Kokořín, 5.8.2020, Oldřich Sychra; Loučná nad Desnou, 10.8.2020, Kateřina Kolárová; Beroun, České Švýcarsko, 16.8.2020, Branwen; Hejnice, 20.8.2020, Václav Koďousek; Brno, 1.7.2021, Pavel Zverina; Klapý, 13.7.2021, Kathem; Jiřetín pod Jedlovou, 21.7.2021, Enrico Tomschke; Jílové, 31.7.2021, Karel184; Klapý, 6.8.2021, Hana Tykalová; Židlochovice, 9.8.2021, Wlazlo; Raná, 12.8.2021, Karel Chobot; Hejnice, 21.8.2021, Hanka Sokolová; Jílové, 10.6.2022, Martin Vašina; Rozhledna Krásno, 3.7.2022, Karel Randák; Rajnochovice, Zlínský, 6.7.2022, Ondřej Hanák; Svor, 18.7.2022, Cyril Matyáš; Skuhrov nad Bělou, Jul 2022, Misalaj; Staré Město, 28.7.2022, Martin Onačila; Český Krumlov, 31.7.2022, Madeliefje; Louny, 1.8.2022, Leonie; Losiná, 2.8.2022, Jana Machaňová; Hudice, 7.8.2022, Emma Vriezen; Rozhledna Velký Lopeník, 9.8.2022, Ondřej Šimůnek; Jílové, 10.8.2022, Pioliska; Bezděz, 24.6.2023, Tesarik; Bučovice, 3.6.2023, Vojtěch Baláž; Deštné v Orlických horách, 4.7.2023, Petr Matyáš; Ústí nad Labem, 17.7.2023, Agnija Fedukovičiūtė; Vernířovice, 2.8.2023, Vojtěch Vyskočil; Lhota, Dolní Břežany, 3.8.2023, Farmarjezek; Losiná, 6.9.2023, iwo2022; Lužické hory, 23.6.2024, Klara; Velký a Malý Bezděz, 20.7.2024, Andrea Aulicka; Kaplice, 25.7.2024, Lukáš Valecký; Sněžník, Jílové-Děčín, 25.7.2024, Kamila Hellerová; Velké Vrbno, 30.7.2024, Filip Blokker; Deštné v Orlických horách, 1.8.2024, Brizard; Vrch Hazmburk, 11.8.2024, Theo; Rychnov nad Kněžnou, 12.8.2024, Matlinka; Lázně Libverda, 14.8.2024, Hanka Sokolová; Židlochovice, 17.8.2024, Janninnka; Deštné v Orlických horách, 18.8.2024, Dan L.; Stezka Valaška, Trojanovice, 18.8.2024, Nikola Šůstková.

Slovakia: Malá Fatra, Malý Rozsutec, August 2010, Jiří Švábík; Malá Fatra, near Malý Kriváň, 16.7.2015, Romana Plačková (Fig. 6); Spišský hrad, 24.8.2018, Oldřich Sychra; Žehra, 17.8.2018, Fero Bednar; Malacky, 30.8.2020, lauxania; Veľký Lopeník, env. Nová Bošaca, 9.8.2022, Ondřej Šimůnek; Siná, Nízke Tatry, 27.8.2022, Dave; Važecká dolina valley, Vysoké Tatry, 16.8.2023, manumea2000; Veľký Choč, Vyšný Kubín, 2.9.2023, Zdenko Bardon; Veľký Šariš, 15.8.2024, Jan Kapr; Bratislava, Staré Mesto, 21.9.2024, Michal Vrsanský.

Figure 6. *Cephenemyia stimulator* (Clark, 1815) from Malá Fatra, near Malý Kriváň, 16.7.2015 (photo by Romana Plačková)

Genus *Pharyngomyia* Schiner, 1861

Pharyngomyia picta (Meigen, 1824)

General note: Larvae parasitize in the nasopharynx of roe deer. The species can be found in the temperate zone of the Palearctic region [9].

Occurrence: Found only in areas whit larger forest stands; in the Czech Republic, it is known from Heřmanův Městec and Lány, and in Slovakia from the Kováčovské kopce hills and Považský Inovec [9], as well as from Bratislava and potok (stream) Hunták [19].

Figure 7. *Pharyngomyia picta* (Meigen, 1824) from locality Břeclav, 30.5.2020 (photo by Tomáš Vrána)

https://www.gbif.org/species/1587603
https://www.inaturalist.org/taxa/506514-Pharyngomyia-picta

Published references from Czech Republic and Slovakia: Minář [9,19].

Records: **Czech Republic**: PR Libochovka, 1.1.1991–31.12.1992, Máca Jan; Břeclav, 30.5.2020, Tomáš Vrána (Fig. 7), Morávka, 29.7.2023, Miroslav Deml.

Genus *Oestrus* Linnaeus, 1758
***Oestrus ovis* Linnaeus, 1758**

General note: The larvae parasitize in the nasal and head cavities of domestic sheep (*Ovis aries* Linnaeus, 1758), less so in domestic goats (*Capra hircus* Linnaeus, 1758), but they have also been detected in some wild species. Originally a Palaearctic species, with sheep breeding spreading to all parts of the world [9].

Occurrence: This species is known from southern Bohemia around Třeboň and also occurs in some districts of central and eastern Slovakia (Liptovský Mikuláš, Prešov, Velký Krtíš, Žilina, etc.) [9] (Minář 1980b), as well as from Zádiel [19].
https://www.gbif.org/species/1587401
https://www.inaturalist.org/taxa/362512-Oestrus-ovis

Published references from Czech Republic and Slovakia: Minář [9,19] Import from Greece [36].

Genus *Rhinoestrus* Brauer, 1886
***Rhinoestrus purpureus* (Brauer, 1858)**

General note: The larvae parasitize in the nasal cavities and nasopharynx of horses and donkeys. The species is known throughout the entire Palearctic realm [9].

Occurrence: It is known only from eastern Slovakia [20].
https://www.gbif.org/species/1587455
https://www.inaturalist.org/taxa/627000-Rhinoestrus-purpureus

Published references from Czech Republic and Slovakia: Minář [9,19].

In conclusion, botflies represent an interesting and economically significant group of parasitic insects that deserves our attention. From the territory of the Czech Republic and Slovakia, four species from the subfamily Gasterophilinae, five species from the subfamily Hypodermatinae and five species from the subfamily Oestrinae have been recorded [7–9]. Thanks to citizen science, the occurrence of two species from the Hypodermatinae subfamily has been confirmed, with *Hypoderma diana* Brauer, 1858 being relatively common. From the subfamily Oestrinae, three species were recorded. *Cephenemyia stimulator* (Clark, 1815) is particularly common, which could suggest that this species may cause problems in the near future, potentially affecting the population and vitality of deer. On the other hand, species that are reproductively linked to livestock (cows, sheep, goats) are relatively rare, possibly due to the shift toward more stable farming practise of these animals.

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References

[1] Díaz-Calafat J., Jaume-Ramis S., Soacha K., Álvarez A., Piera J. 2024. Revealing biases in insect observations: a comparative analysis between academic and citizen science data. *Plos one* 19(7): p.e0305757. doi:10.1371/journal.pone.0305757

[2] Chandler M., See L., Copas K., Bonde A.M., López B.C., Danielsen F., Legind J.K., Masinde S., Miller-Rushing A.J., Newman G., Rosemartin A. 2017. Contribution of citizen science towards international biodiversity monitoring. *Biological Conservation* 213: 280–294. doi:10.1016/j.biocon.2016.09.004

[3] Webb C., Clancy J., Doggett S.L., McAlister E., Williams C., Fricker S., van den Hurk A., Lessard B., Lenagan J., Walter M. 2022. First record of the mosquito *Aedes* (*Downsiomyia*) *shehzadae* (Diptera: Culicidae) in Australia: a unique discovery aided by citizen science. *Journal of Vector Ecology* 47(1): 133–137. doi:10.52707/1081-1710-47.1.133

[4] Kvifte G.M. 2023. Citizen science reveals the establishment of the invasive container breeder *Clogmia albipunctata* in Sweden and Denmark (Diptera: Psychodidae). *Management of Biological Invasions* 14(2): 239–244. doi:10.3391/mbi.2023.14.2.04

[5] Marchante E., López-Núñez F.A., Duarte L.N., Marchante H. 2024. The role of citizen science in biodiversity monitoring: when invasive species and insects meet. In: Biological invasions and global insect decline. (Eds. J. Rodriguez, A. Novoa, P. Pyšek), Elsevier: 291–314. doi:10.1016/B978-0-323-99918-2.00011-2

[6] Li X.Y., Yan L.P., Pape T., Gao Y.Y., Zhang D. 2020. Evolutionary insights into botflies (Insecta: Diptera: Oestridae) from comparative analysis of the mitochondrial genomes. *International Journal of Biological Macromolecules* 149: 371–380. doi:10.1016/j.ijbiomac.2020.01.249

[7] Minár J. 1980. Gasterophilidae. In: Krevsající mouchy a střečci – Diptera. (Ed. M. Chvála). Fauna ČSSR vol. 22, Academia, Praha: 430–466 (in Czech).

[8] Minár J. 1980. Hypodermatidae. In: Krevsající mouchy a střečci – Diptera. (Ed. M. Chvála). Fauna ČSSR vol. 22, Academia, Praha: 391–411 (in Czech).

[9] Minár J. 1980. Oestridae. In: Krevsající mouchy a střečci – Diptera. (Ed. M. Chvála). Fauna ČSSR vol. 22, Academia, Praha: 412–429 (in Czech).

[10] Oosterbroek P. 2006. The European families of the Diptera: identification–diagnosis–biology. KNNV Publishing, Utrecht.

[11] Minár J. 1986. Gasterophilidae. In: Diptera Slovenska 2. (Ed. J. Čepelák). Veda, Bratislava: 251–253.

[12] Minár J. 1986. Hypodermatidae. In: Diptera Slovenska 2. (Ed. J. Čepelák), Veda, Bratislava: 254–256.

[13] Minár J. 1992. Hypodermosis in Central and East Europe. In: Improvements in the control methods for warble-fly in cattle and goats. (Eds. A. Gasca, S. Hernandez, J. Martinez, K. Pithan). Workshops, Cordoba 1991, ECSC Brussels–Luxembourg: 85–92.

[14] Minár J. 1992. Warble fly invasion in cattle of Czechoslovakia. In: Improvements in the control methods for warble-fly in cattle and goats. (Eds. A. Gasca, S. Hernandez, J. Martinez, K. Pithan). Workshops, Cordoba 1991, ECSC Brussels–Luxembourg: 37–44.

[15] Minár J., Breev K.A. 1982. Laboratory and field rearing of the warble fly *Hypoderma bovis* (de Geer) (Diptera, hypodermatidae) in the research of its population ecology. *Folia Parasitologica* 29(4): 351–360.

[16] Salaba O., Vadlejch J., Petrtyl M., Valek P., Kudrnacova M., Jankovska I., Bartak M., Sulakova H., Langrova I. 2013. *Cephenemyia stimulator* and *Hypoderma diana* infection of roe deer in the Czech Republic over an 8-year period. *Parasitology Research* 112: 1661–1666. doi:10.1007/s00436-013-3322-6

[17] Kudrnáčová M., Langrová I., Maršálek M., Jankovská I., Scháňková Š., Brožová A., Truněčková J. 2014. A 4-years monitoring of *Hypoderma diana* in horses from the Czech Republic. *Parasitology Research* 113: 1735–1738. doi:10.1007/s00436-014-3818-8

[18] Minár J., Hojsík J. 1994. Súčasný stav strečkovitosti hovädzieho dobytka na Slovensku [The present status of hypodermosis in cattle in Slovakia]. *Slovenský Veterinársky Časopis* 19: 170–174.

[19] Minár J. 1986. Oestroidea. In: Diptera Slovenska 2. (Ed. J. Čepelák). Veda, Bratislava: 251–253.

[20] Kramář J. 1954. Podivní cizopasníci člověka. *Vesmir* 33: 105 (in Czech).

[21] Bezdekova B., Jahn P., Vyskocil M. 2007. Pathomorphological study on gastroduodenal ulceration in horses: localisation of lesions. *Acta Veterinaria Hungarica* 55(2): 241–249. doi:10.1556/AVet.55.2007.2.10

[22] Bdeček Š., Koudela B., Jahn P., Bezděková P. 2004. Nález žaludečních střečků u importovaného koně. *Veterinářství* 54: 628–631 (in Czech).

[23] Klimková Z., Loudová D., Cadková Z. 2020. The first record of *Oestromyia leporina* (Pallas, 1778) larvae (Diptera: *Hypodermatinae*) on *Microtus arvalis* (Pallas, 1778), (Rodentia) in North-Western Bohemia. In: 12th Workshop on Biodiversity, Jevany. (Eds. S. Kubik, M. Bartak): 38–47.

[24] Jahn P., Minár J., Gelbič I. 2022. Napadení koní larvami střečka srnčího (*Hypoderma diana*). *Veterinářství* 52: 476–477 (in Czech).

[25] Pavlásek I., Minár J. 2014. New host and the extend of the host range of warble fly *Hypoderma diana* (Diptera, Hypodermatidae). *Acta Musei Silesiae Scientiae Naturales* 63(1): 61–64. doi:10.2478/cszma-2014-0008

[26] Kačmař V. 2008. Podkožní střečkovitost u srnčí zvěře. https://xn—poovnctvo-k5a10g.com/spravy/119-spravy/801-podkozni-streckovitost-u-srnci-zvere

[27] Wedlich E. 2013. Střečkovitost spárkaté zvěře [Botflies of cloven-hoofeld animals in Czech]. Bakalářská práce, ČZÚ, Praha (in Czech).

[28] Hera A. 2020. Léčba střečkovitosti srnčí zvěře [Treatment of botflies in roe deers]. *Myslivost* 3: 27–31 (in Czech).

[29] Hera A. 2023. Léčení střečkovitosti spárkaté zvěře v roce 2022 [Treatment of botflies of ungulates in 2022]. *Myslivost* 1: 32–35 (in Czech).

[30] Hera A. 2023. Léčení střečkovitosti srnčí zvěře [Treatment of ungulate game]. *Veterinářství* 73(6): 327–333 (in Czech).

[31] Kučera J., Buršík O. 2007. Zdravotní problematika kamzíka v Lužických horách [Health issues of chamois in the Lusatian Mountains]. *Myslivost* 8: 23–25 (in Czech).

[32] Minár J. 1999. Oestridae, Hypodermatidae. In: Diptera of the Palava Biosphere Reserve of UNESCO. (Eds. R. Rozkosny, J. Vanhara). II. *Folia Facultatis Scientiarium Naturalium Universitatis Masarykianae Brunensis, Biol*. 100: 437–439.

[33] Scherer P. 2020. Střečkovitost srnčí zvěře [Botflies in roe deers]. *Myslivost* 12: 60–63 (in Czech).
[34] Sýkora I. 2012. Střeček hltanový u srnčí zvěře [Botflies in roe deers]. *Myslivost* 11: 54–63 (in Czech).
[35] Vaca D. 2000. Biology of nasopharyngeal bot fly *Cephenemyia stimulator* Cl. (Diptera, Oestridae) and its distribution in the Czech Republic In: Mange and myiasis of livestock. (Eds. M. Good, B. Hall, B. Losson). COST Action: 189–194.
[36] Hartmannová L., Mach R., Záruba R., Pavlovský M. 2020. Zevní oftalmomyiáza způsobená larvou atřečka *Oestrus ovis*. *Czech and Slovak Ophthalmology* 76: 130–134 (in Czech).

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Appendix

Full text of citizen science records for individual species in alphabetical order

***Hypoderma bovis* (De Geer, 1776)**

Czech Republic:
Neratov, near pond Skříň, 16.04.2020, Miroslav Polášek, https://www.fotonet.sk/?idp=159604&page=1; https://www.fotonet.sk/?idp=159605&page=1.

***Hypoderma diana* Brauer, 1858**

Czech Republic:
Braitava Letohrádek, 1.4.–30.6.2002, Miroslav Barták, Štěpán Kubík, https://portal23.nature.cz/nd/find.php?akce=view&akce2=stopValidaci&karta_id=32980128&karta_vztazne_id=0&ndtoken=7a6ca4c619f23fff37a715ca674c7f35;
Česko (Jihomoravský kraj, Bučovice-Nesovice), May 2019, Milan Kudlička, https://www.biolib.cz/cz/taxonimage/id378649/?taxonid=432374&type=1;
Havraníky, 1.4.–30.6.2001, Miroslav Barták, Štěpán Kubík, https://portal23.nature.cz/nd/find.php?akce=view&akce2=stopValidaci&karta_id=32978519&karta_vztazne_id=0&ndtoken=7a6ca4c619f23fff37a715ca674c7f35;
Hnanice, 1.4.–30.6.2001, Miroslav Barták, Štěpán Kubík, https://portal23.nature.cz/nd/find.php?akce=view&akce2=stopValidaci&karta_id=32975066&karta_vztazne_id=0&ndtoken=7a6ca4c619f23fff37a715ca674c7f35;
Jeseníky – Karlovice, 22.05.2018, Jiří Kuča, https://www.fotonet.sk/?idp=146096&page=1;
Liščí Skála, 1.4.–30.6. 2004, Miroslav Barták, Štěpán Kubík, https://portal23.nature.cz/nd/find.php?akce=view&akce2=stopValidaci&karta_id=32985200&karta_vztazne_id=0&ndtoken=7a6ca4c619f23fff37a715ca674c7f35;
Rochov, 7.5.2016, Karel Filip, https://www.youtube.com/watch?v=2PsAwXJK7vk;
Terasy, 1.4.–30.6.2003, Miroslav Barták, Štěpán Kubík, https://portal23.nature.cz/nd/find.php?akce=view&akce2=stopValidaci&karta_id=32982250&karta_vztazne_id=0&ndtoken=7a6ca4c619f23fff37a715ca674c7f35;
Údolí Bubovického potoka, 19.5.2019, Ivo Carvan, https://www.biolib.cz/cz/taxonimage/id375377/?taxonid=432374&type=1;
Valtice, 30.4.2023, Jakub Široký, https://www.biolib.cz/cz/taxonimage/id469342/?taxonid=432374&type=1.

Slovakia:
Košická kotlina basin, Košice, Vyšné Opátske, 22.4.2015, Karol Ox, https://www.nahuby.sk/obrazok_detail.php?obrazok_id=517869 (Fig. 4);
Považský Inovec, Banka, district Piešťany, 23.04.2020, Laco Tábi, https://www.fotonet.sk/?idp=159767&page=1;
Strážovské vrchy hills, Chvojnica, 15.6.2017, Laco Tábi, https://www.fotonet.sk/?idp=138896&page=1;
Strážovské vrchy hills, Chvojnica, behind the sawmill, 15.6.2017, Braňo Ivčič, https://www.fotonet.sk/?idp=138805&page=1;

Stropkov – Bokša, 23.4.2020, Jozef Šeršeň, https://www.nahuby.sk/obrazok_detail.php?obrazok_id=745244; https://www.nahuby.sk/obrazok_detail.php?obrazok_id=745243;
Zvolenská kotlina basin, Banská Bystrica, near Fončorda, 26.4.2019, Matej Schwarz, https://www.fotonet.sk/?idp=153313&page=1; https://www.fotonet.sk/?idp=153314&page=1.

Cephenemyia auribarbis (Meigen, 1824)

Slovakia:
Javorníky, Čadca, Husárik, 19.5.2020, Matej Schwarz, https://www.fotonet.sk/?idp=160565&page=1 (Fig. 5).

Cephenemyia stimulator (Clark, 1815)

Czech Republic:
Beroun, České Švýcarsko, 16.8.2020, Branwen, https://www.inaturalist.org/observations/56641680;
Bezděz, 20.7.2024, Andrea Aulicka, https://www.inaturalist.org/observations/230496139;
Bezděz, 24.6.2023, Tesarik, https://www.inaturalist.org/observations/169422059;
Biskupská kupa, 8.8.2018, Petr Krampl, https://www.biolib.cz/cz/taxonimage/id349234/?taxonid=122319&type=1;
Brno, 1.6.2021, Pavel Zverina, https://www.inaturalist.org/observations/125416162;
Brno, 1.7.2021, Pavel Zverina, https://www.inaturalist.org/observations?taxon_id=626816;
Bučovice, 3.6.2023, Vojtěch Baláž, https://www.inaturalist.org/observations/187996685;
Česko, July 2010, Šumava, na kopci Boubín, Jiří Švábík, https://svabblog.wordpress.com/2011/02/05/strecek-2/;
Český Krumlov, 31.7.2022, Madeliefje, https://observation.org/observation/250932158/;
Deštné v Orlických horách, 1.8.2024, Brizard, https://www.inaturalist.org/observations/233166185;
Deštné v Orlických horách, 18.8.2024, Dan L., https://www.inaturalist.org/observations/236491546;
Deštné v Orlických horách, 4.7.2023, Petr Matyáš, https://www.inaturalist.org/observations/170996706;
Dolní Břežany, 3.8.2023, Farmarjezek, https://www.inaturalist.org/observations/176483837;
Hejnice, 20.8.2020, Václav Koďousek, https://www.inaturalist.org/observations/57353086;
Hejnice, 21.8.2021, Hanka Sokolová, https://www.inaturalist.org/observations/91989142;
Hudice, 7.8.2022, Emma Vriezen, https://observation.org/observation/251648193/;
Jeseníky, 18.7.2015, Milena Vořechovská, https://www.biolib.cz/cz/taxonimage/id321160/?taxonid=122319&type=1;
Jílové, 10.6.2022, Martin Vašina, https://www.inaturalist.org/observations/122044871;
Jílové, 10.8.2022, Pioliska, https://www.inaturalist.org/observations/130224098;
Jílové, 25.7.2024, Kamila Hellerová, https://www.inaturalist.org/observations/231983617;
Jílové, 31.7.2021, Karel184, https://www.inaturalist.org/observations/89791214;
Jiřetín pod Jedlovou, 21.7.2021, Enrico Tomschke, https://www.inaturalist.org/observations/87979914;
Jižní Čechy, Duben 2011, Lukáš Jurek, https://www.biolib.cz/cz/taxonimage/id153859/?taxonid=122319&type=1;
Kamenná rozhledna v obci Úvalno, 8.7.2012, Ing. Miroslav Hudeček, https://www.biolib.cz/cz/taxonimage/id202652/?taxonid=122319&type=1;
Kaplice, 25.07.2024, Lukáš Valecký, https://www.inaturalist.org/observations/231593234;
Klapý, 13.7.2021, Kathem, https://www.inaturalist.org/observations/86887860;
Klapý, 29.5.2020, Kaferano, https://www.inaturalist.org/observations/47753738;
Klapý, 6.8.2021, Hana Tykalová, https://www.inaturalist.org/observations/90417899;
Kokořín, 5.8.2020, Oldřich Sychra, own observation – photo in private archive;
Kolín, 7. 7. 2010, Milan.K, https://www.loveckeforum.info/viewtopic.php?t=283;
Kolínsko, 8. 1. 2007, Fery, https://www.loveckeforum.info/viewtopic.php?t=283;
Lázně Libverda, 14.8.2024, Hanka Sokolová, https://www.inaturalist.org/observations/235713167;
Lhota, Dolní Břežany, 3.8.2023, farmarjezek, https://www.inaturalist.org/observations/176483837;
Losiná, 6.9.2023, iwo2022, https://www.inaturalist.org/observations/129123426;
Loučná nad Desnou, 10.8.2020, katerina_kolarova, https://www.inaturalist.org/observations/56150689;
Louny, 1.8.2022, Leonie, https://observation.org/observation/251045382/;
Lužické hills, 23.6.2024, Klara, https://www.inaturalist.org/observations/224600825;
Mutěnice, 16.6.2019, Michal Hýl, https://www.inaturalist.org/observations/27088548;
Nové Město pod Smrkem, 3.8.2008, Ivan Motlik, https://www.biolib.cz/cz/taxonimage/id77583/?taxonid=122319&type=1;
Nový Bor, Liberecký, 25.6.2020, anyvalay, https://www.inaturalist.org/observations/50877872;
Podhradí, Třemošnice, 2.8.2020, Martin Mecerod, https://www.inaturalist.org/observations/55141427;
Rajnochovice, 6.7.2022, Ondřej Hanák, https://www.inaturalist.org/observations/125017361;

Raná, 12.8.2021, Karel Chobot,
https://portal23.nature.cz/nd/find.php?akce=view&akce2=stopValidaci&karta_id=51305225&karta_vztazne_id=0&ndtoken=174c8e1ff10467ab4e4ca5baf0b7a682;
Rozhledna Krásno, 3.7.2022, Karel Randák, https://www.biolib.cz/cz/taxonimage/id463217/?taxonid=122319&type=1;
Rozhledna Velký Lopeník, 9.8.2022, Ondřej Šimůnek, https://www.inaturalist.org/observations/140479107;
Rychnov nad Kněžnou, 12.8.2024, matlinka, https://www.inaturalist.org/observations/236808590;
Skuhrov nad Bělou, Červen 2022, Misalaj, https://www.inaturalist.org/observations/127978699;
Sněžník, Jílové-Děčín, 25.7.2024, Kamila Hellerová, https://www.inaturalist.org/observations/231983617;
Staré Město, 28.7.2022, Martin Onačila, https://www.inaturalist.org/observations/128280743;
Svatá, 26.7.2018, Michaela Tajovská, https://www.inaturalist.org/observations/23984325;
Svor, 18.7.2022, Cyril Matyáš, https://www.inaturalist.org/observations/126789210;
Tachov, 6.7.2020, Jan Mach, https://www.inaturalist.org/observations/52597017;
Třemošnice, 2.8.2020, Martin Mecerod, https://www.inaturalist.org/observations/55141427;
Trojanovice, 18.8.2024, Nikola Šůstková, https://www.inaturalist.org/observations/236741493;
Ústí nad Labem, 17.7.2023, Agnija Fedukovičiūtė, https://www.inaturalist.org/observations/173431009;
Velké Vrbno, 30.7.2024, Filip Blokker, https://observation.org/observation/321957030;
Velký a Malý Bezděz, 20.7.2024, Andrea Aulicka, https://www.inaturalist.org/observations/230496139;
Vernířovice, 2.8.2023, Vojtěch Vyskočil, https://www.inaturalist.org/observations/176857128;
Vrch Hazmburk, 11.8.2024, Theo, https://observation.org/observation/323714465;
Vysoké kolo, 10.8.2009, Jan Vaněk, https://www.biolib.cz/cz/taxonimage/id196074/?taxonid=122319&type=1;
Stezka Valaška, Trojanovice, 18.8.2024, Nikola Šůstková, https://www.inaturalist.org/observations/236741493;
Židlochovice, 25.7.2020, Kamcatka, https://www.inaturalist.org/observations/54541564;
Židlochovice, 9.8.2021, Wlazlo, https://www.inaturalist.org/observations/90528104;
Židlochovice, 17.8.2024, janninnka, https://www.inaturalist.org/observations/236252185.

Slovakia:
Bratislava, Staré Mesto, 21.9.2024, Michal Vrsansky, https://www.inaturalist.org/observations/243066283;
Malá Fatra, Malý Rozsutec, Augus 2010, Jiří Švábík, https://svabblog.wordpress.com/2011/02/05/strecek-2/;
Malá Fatra, near Malý Kriváň, 16.7.2015, Romana Plačková, https://www.fotonet.sk/?idp=124094&page=1;
Malacky, 30.8.2020, lauxania, https://www.inaturalist.org/observations/191947642;
Siná, Nízke Tatry, 27.8.2022, Dave, https://www.inaturalist.org/observations/236568320;
Spišský hrad, 24.8.2018, Oldřich Sychra, own observation – photo in private archive;
Važecká dolina valley, Vysoké Tatry, 16. 8.2023, manumea2000, https://www.inaturalist.org/observations/178858824;
Veľký Choč, Vyšný Kubín, 2.9.2023, Zdenko Bardon, https://www.inaturalist.org/observations/181360752;
Veľký Lopeník, env. nová Bošaca, 9.8.2022, Ondřej Šimůnek, https://www.inaturalist.org/observations/140479107;
Veľký Šariš, 15.8.2024, Jan Kapr, https://www.inaturalist.org/observations/235964356;
Žehra, 17.8.2018, Fero Bednar, https://www.inaturalist.org/observations/15587290.

Pharyngomyia picta (Meigen, 1824)

Czech Republic:
Břeclav, 30.5.2020, Tomáš Vrána, https://www.inaturalist.org/observations/178722396;
Morávka, 29.7.2023, Miroslav Deml, https://www.biolib.cz/cz/taxonimage/id475082/?taxonid=122321&type=1;
PR Libochovka, 1.1.1991–31.12.1992, Máca Jan,
https://portal23.nature.cz/nd/find.php?akce=view&akce2=stopValidaci&karta_id=3280301&karta_vztazne_id=0&ndtoken=cae459f46066306f8d25510f752ae565.