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Historical overview of research on butterflies in Prešov city and its surroundings (Slovakia)

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Abstract
The aim of the study was to summarize data on the distribution of butterflies (Lepidoptera: Papilionoidea) in Prešov city (Košická kotlina basin, Slovakia). Although sufficient attention was paid in the past to butterfly research in this area, data are currently scarce. Therefore, intensive research on butterfly biodiversity is currently being carried out by the first author of this study. It will serve as a basis for further research in this area, i.e., confirm, refute or add new knowledge to the species list. Several faunistic data from this area have been presented in "*Prodromus Lepidopterorum Slovaciae*" (Hrubý 1964) and its supplements (Reiprich 1977; Reiprich & Okáli 1988, 1989a, b; Okáli 1997; Endel & Panigaj 2022), mainly due to several authors (e.g., Husz A., Abafi-Aigner L., Dahlström Gy.). The earliest records from Prešov city were found in 1876 in the study "*Enumeratio Macrolepidopterorum Hungariae*" (Horváth & Pável 1876). In total, for the older period, 151 (or 148) species belonging to 6 families were reported for Prešov city. In contrast, 42 species belonging to 5 families were confirmed for the more recent period (after 1990). This number represents 28.4% of the total number of species reported before 1990.

Keywords: Lepidoptera, historical data, urban areas

Introduction

In study "*Fauna Regni Hungariae*" (Abafi-Aigner et al. 1896), authors summarized data on the occurrence of butterflies from the Eastern Carpathians, without more precise localization (usually as Ung County). Among the first more comprehensive study summarizing the state of knowledge on the butterfly's fauna in Slovakia was "*Prodromus Lepidopterorum Slovaciae*", published by Hrubý (1964). In this study, the author lists all published and unpublished data, with known localities at that time, for all registered species of Slovak butterflies from 1772 to 1959. Later, this review was expanded with occurrence data from 1959 to 1972 in the studies "*Additions to the Prodrome Lepidoptera of Slovakia*" (Reiprich 1977) and "*Supplements to the Prodrome Lepidoptera of Slovakia*" which were published in 3 volumes (Reiprich & Okáli 1988, 1989a, b). In these supplements new data on butterflies of Slovakia for the period 1973 – 1984 were added. At the same time missing data at localities were filled in and corrections to previous works were given. In them, the authors list only those species in combination with locality that were not listed in the Prodrome. This is the reason why we do not find data in the appendices that could confirm some very interesting older records from the past. The missing bibliography for the years 1985 – 1995 has been added by Okáli (1997). Finally, literature from 1996 to 2000 were completed by Endel & Panigaj (2022).

The oldest records from Prešov city were found in 1876 in the study "*Magyarország nagypikkelyröpűinek rendszeres névjegyzéke* (*Enumeratio Macrolepidopterorum Hungariae*)" (Horváth & Pável 1876). Several faunistic data from this area were listed in above-mentioned studies by (Hrubý 1964; Reiprich 1977; Reiprich & Okáli 1988, 1989a, b), mainly due to several authors (e.g., Husz A., Abafi-Aigner L., Dahlström G. etc.). Moreover, the study (Hrubý 1964) also includes collection data mainly from the Hungarian National Museum in Budapest (see Moucha 1961) and the Podtatra Museum in Poprad as well as private collections. Later, several authors, when mentioning the butterfly fauna of Prešov, only took over already published older data (cf. in our overview the citations are given in square brackets).

Data on butterflies of the urban environment of Prešov city can be found in the bachelor's theses (Mošková 2015). Two species were also listed by Csanády (2019). The last mentioned author, started in 2020 more intensive research on the fauna of butterflies in the urban and suburban environment of Prešov city and the data are presented in the overview as unpublished (cf. as „Csanády A. unpubl."). In view of the mentioned lack of data, the idea to comprehensively summarize old and new knowledge about the butterfly fauna from the territory of Prešov arose. In addition, we considered the effort to summarize the existing information in one place to be beneficial, which will simplify the work with older literature in the future.

Material and methods

Study area

The Prešov city is located in eastern Slovakia, between 49°00' north latitude and 21°15' east longitude. It is part of the Košická kotlina basin and is surrounded by the Slanské vrchy Mts. to the east and the Šarišská vrchovina highland to the west. Its altitude is approximately 255 m above sea level. The Sekčov River flows through the town and flows into the Torysa River. Between 1970 – 1990 it also included

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Haniska village, Ľubotice village and Šarišské lúky meadows (Ištok 1998), but at present they do not belong to the cadastral territory of the city of Prešov. Moreover, Šarišské lúky meadows are since 1990 part of the village Ľubotice. Therefore, the city currently it consists of four districts: Prešov, Solivar, Šalgovík and Nižná Šebastová. There are large green areas in Prešov made up of forests, but also urban greenery.

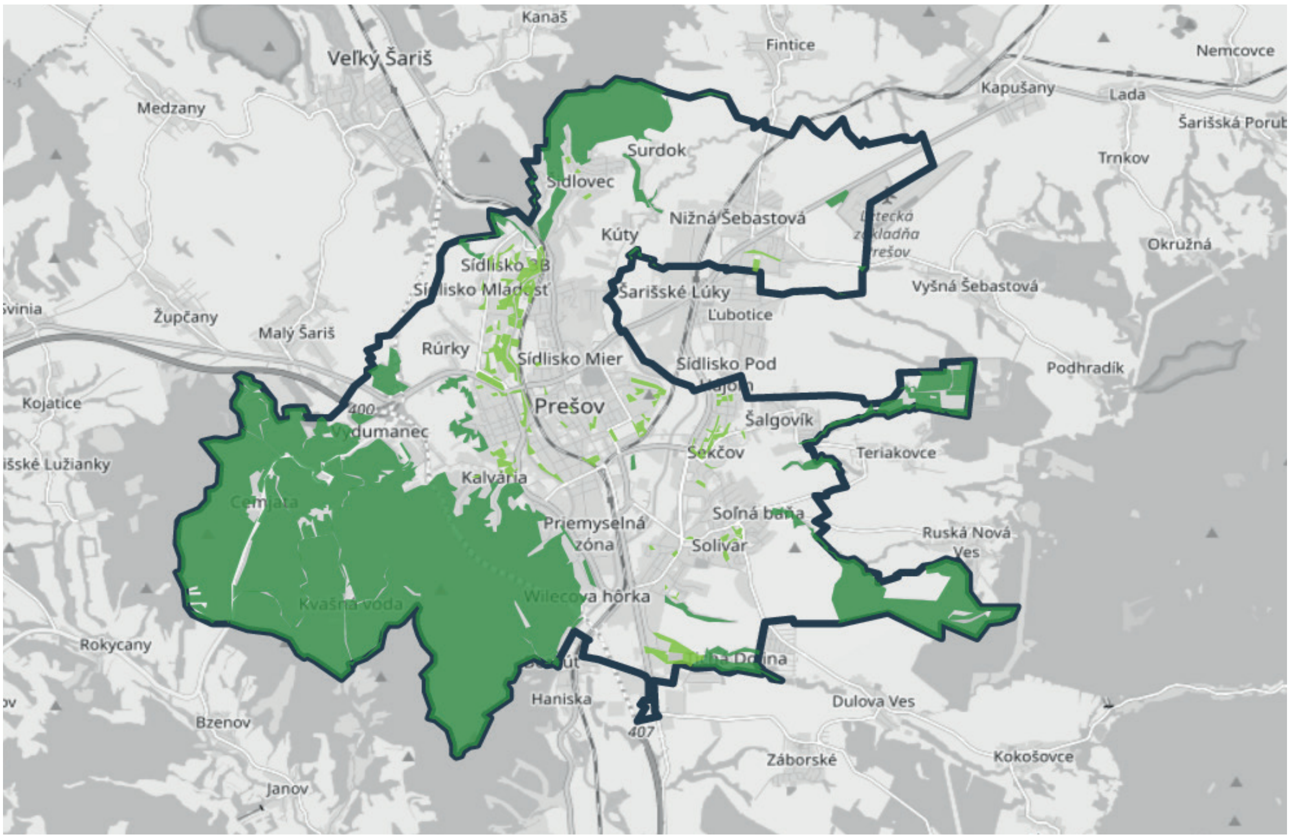

Figure 1. Current boundary of Prešov city with marked urban greenery (Source: https://a-static.projektn.sk/2015/07/presov.html).

woodland: suggesting an area with tree canopies that are taller than 5m. They do not show areas smaller than 1 ha and narrower than 10m.

urban green zones: include parks and gardens. They do not include cemeteries, private gardens and areas smaller than 0.25 ha or narrower than 10m.

It should be noted, that Hrubý (1964) in his summary lists the following localities of Prešov city and its surroundings: Prešov city, Solivar village, Prešovské hory Mts., Šalgovík village and the Torysa River valley. By studying the original study by Husz (1881a), it is evident that the following localities can also be distinguished. Prešov included the territory of the Prešov mountains (mainly Calvary and Wilec hôrka, the Haligrund mountains and their numerous valleys (mainly Cemjata, Kvašná voda, Veľký and Malý Borkut). Šalgovík village and Solivar village were originally independent municipalities, which were later annexed to Prešov. For the valley of the Torysa River the author mentioned three parts, with the upper part (from Šarišské Michaľany village to Prešov city) and the middle part (from Prešov city to Drienov village) being of particular importance for our overview.

Bibliographic research methodology

The bibliographic overview presents published and unpublished data on the occurrence of butterflies in the area of the Prešov city until 2022, classified not alphabetically, but according to the systematics presented by Pastorális et al. (2013) and Pastorális (2022). In its elaboration, the several literary sources were used (e.g., Horváth & Pável 1876; Husz 1881a, b; Abafi-Aigner et al. 1896; Dahlström 1897, 1900; Moucha 1961; Hrubý 1964; Reiprich 1977; Reiprich & Okáli 1988, 1989a, b; Mošková 2015; Csanády 2019; Gáborová 2021).

A very valuable source of data as well documentary specimens from Prešov city and its surroundings were also the collections deposited in the Hungarian National Museum in Budapest (cf. Moucha 1961; Hrubý 1964), the Podtatra Museum in Poprad (cf. Hrubý 1964), and finally, the East Slovak Museum in Košice (cf. Hogyová & Krišovský 2011; Krišovský & Panigaj 2017; Krišovský 2020). The

East Slovak Museum in Košice deposits an entomological collection of butterflies. A large part of the collections came from the territory of Prešov and its surroundings. In particular, these are the private collections by Jozef Petrašovič, Slavomír Bacher (see Hogyová & Krišovský 2011) and Milan Mihok (see Krišovský & Panigaj 2017; Krišovský 2020).

The collection of J. Petrašovič, concerning the group of butterflies, dates from the period 1958 – 1989. The butterflies (17 spp.) come from the city extravilan (Kvašná voda – Vydumanec i.e., urban part of Prešov, Borkut, Delňa and Šalgovík).

The collection of S. Bacher, dates from the period 1971 – 1985. The butterflies (18 spp.) come from the urban environment as well as the city's extravilan (Vydumanec, Borkut, Delňa, Cemjata and Solivar).

Finally, the collection of M. Mihok, dates from the period 1964 – 1997, while for the diurnal butterflies of Prešov city and its surroundings it is mainly the period 1968 – 1978. The butterflies (34 spp.) come from the urban environment of the city and extravilan (Kvašná voda – Vydumanec).

It should also be mentioned that other amateur collectors active in Prešov and its surroundings included Mr. Jozef Kyselý, Mr. Žembera and Mr. Belovodský (Panigaj Ľ. and Jászay T. in verb.). However, data on the whereabouts of butterflies from their private collections are currently unknown.

For each species, the locality of occurrence is given, and authors who recorded each butterfly species, or a reference to the collection material. In cases where the listed authors have merely adopted a previously published record, the source of the citation is given in square brackets. For unpublished data, the author and the source of the citation is given (e.g., Reiprich A. in Hrubý (1964) – private collection; Csanády A. unpubl., Dahlström Gy., Hámori J. in coll. Hungarian National Museum in Budapest; Petrašovič J. in coll. East Slovak Museum in Košice). The scientific nomenclature of butterflies and comments are given by Pastorális et al. (2013) and Pastorális (2022).

Bibliographic overview of butterflies and localities of occurrence in Prešov city

Summarization of published and unpublished older (until 1990) and new (after 1990) data showed that 152 species of butterflies belonging to 62 genera from 6 families were reported in the monitored area of Prešov. However, the existence of three species of the genus *Erebia* (*E. epiphron* Knoch, *E. pandrose* Borkh. and *E. oeme* Hübner) is doubtful, as they are high-altitude species and were probably poorly determined (see Hrubý 1964). In that case, the total number of butterflies was 149 species. For the families Papilionidae (5 species from 4 genera), Hesperiidae (16 species from 8 genera), Pieridae (17 species from 7 genera), Riodinidae (1 species from 1 genus), Lycaenidae (45 species from 20 genera) and for the family Nymphalidae (68 or 65) species from 29 genera).

In total, for the older period, 151 (or 148) species belonging to 6 families were reported for Prešov city. In contrast, 42 species belonging to 5 families were confirmed for the more recent period (after 1990). This number represents 28.4% of the total number of species reported before 1990.

During period 1876 – 2022, five species of butterflies belonging to the family Papilionidae, belonging to four genera, were confirmed in the territory of Prešov city and its vicinity (cf. the locality "Prešovské hory Mts.", Torysa River vallue). However, the occurrence of three species (*Zerynthia polyxena* Den. & Schiff., *Parnassius apollo* L. and *P. mnemosyne* L.) is currently questionable to unlikely. It should be noted that there are two specimens of *P. mnemosyne* L. from years 1968 and 1978 (leg. et det. Ing. Milan Mihok) in the collections of the East Slovak Museum in Košice. The remaining two species (*Iphiclides podalirius* L. and *Papilio machaon* L.) were also confirmed at present (Mošková 2015; Csanády A. unpubl.).

Until 2022, the family Hesperiidae was recorded with 16 species of butterflies belonging to eight genera. It should be noted that for most species only older data (until 1990) are known. From the more recent period after 1990, occurrence has only been confirmed for the more common species, such as *Erynnis tages* L., *Pyrgus malvae* L., *Thymelicus lineola* Ochs., and *Ochlodes sylvanus* Esp. Therefore, intensive research in urban and suburban localities of Prešov city will be necessary to confirm the occurrence of other species.

Family Pieridae was represented by 17 species of butterflies belonging to seven genera. In the present period, only eight species have been confirmed, but the occurrence of several species is more than probable as they belong to relatively common species (e.g., *Pontia edusa* F., *Gonepteryx rhamni* L.). On the other hand, several listed species of the genus *Colias* are doubtful (cf. Hrubý 1964). Moreover, the occurrence of several species, such as *Leptidea sinapis* L., *L. juvernica* Will., *Colias hyale* L. and *C. alfacariensis* Rib. are also questionable and requires more detailed investigation with regard to the problematic determination.

One species of the family Riodinidae belonging to the genus *Hamearis* occurred on the territory of Prešov city between years 1876 – 2022. Nevertheless, in the current period it has not yet been confirmed.

During evaluated period (from 1876 to 2022), 45 species of Lycaenidae butterflies belonging to 16 genera were recorded. Pastorális et al. (2013) showed the species *Lycaena helle* Den. & Schiff. as a protected species of European importance and also as an extinct or missing species in Slovakia. They point out that the species *Plebejus optilete* Knoch and *Polyommatus damon* Den. & Schiff. are protected species of national importance and the species *P. damon* Den. & Schiff. is also, together with *Iolana iolas* Ochs. an extinct or missing species. The occurrence of several species, such as *Plebejus idas* L. and *P. argyrognomon* Brgstr. are also questionable and requires more detailed investigation with regard to the problematic determination.

In total, 68 (or 65) species of butterflies from the Nymphalidae family belonging to 26 genera were recorded in the territory of Prešov during evaluated period (1876 – 2022). Pastorális et al. (2013) noted the species *Boloria aquilonaris* Stich. as extinct or missing. *Nymphalis vaualbum* Den. & Schiff. as both a protected species of European importance and an extinct or missing species. *Neptis sappho* Pall. as a protected species of national importance, *Coenonympha oedippus* Fab. as a protected species of European importance. According to the authors, the occurrence of a permanent population of *Pyronia tithonus* L. in Slovakia is also very unlikely at present. In the current period, 18 species were confirmed. In conclusion, the presence of several species in evaluated area is questionable and validation of older data is very difficult (see Moucha 1961; Hrubý 1964; Pastorális et al. 2013).

These inconsistencies are already pointed out by Moucha (1961), who critically evaluates the butterfly collections stored in the Hungarian National Museum in Budapest, and concern in particular Dahlström's collection. The author stresses that clarification of this fact is very important for the understanding of the faunistics of Slovak research, because most of these erroneous data were reported in older literature (before 1960) and for many years were only passively cited.

He divided the erroneous data into two groups:

(a) unreliable are those species that actually occur in Slovakia, but the recorded localities do not correspond to their ecological conditions (e.g., several species of the genus *Erebia*).

b) erroneous records are those relating to species that do not occur in Slovakia.

For these reasons, it should be considered with reserve all other records from this author as well from further author (Husz A.). Their older data are often doubtful, because in addition to the alpine species they also mention other species, e.g. *Pyronia tithonus* L., *Coenonympha oedippus* Fab. and others occurring in the vicinity of Prešov (see below for several species in the overview).

The current confirmation of the occurrence of several notable species of the Red List of the Slovak Republic, as well as species of national or European importance (Kulfan & Kulfan 2001; van Swaay et al. 2010; Pastorális et al. 2013), only highlights the further need for intensive mapping, especially for the purposes of conservation of the species themselves and their habitats.

Familia: Papilionidae

***Iphiclides podalirius* (Linnaeus, 1758) – the Scarce Swallowtail**

Localities: Prešov (Horváth & Pável 1876; Husz 1881a; [Abafi-Aigner et al. 1896]; Abafi-Aigner 1897, 1898, [1907c]; Dahlström 1897, 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice).

***Papilio machaon* (Linnaeus, 1758) – the Swallowtail**

Localities: Prešov (Horváth & Pável 1876; Husz 1881a; Dahlström 1900; Abafi-Aigner 1906b; Mošková 2015; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice).

***Parnassius mnemosyne* (Linnaeus, 1758) – the clouded Apollo**

Localities: Prešov (Husz 1881a; Dahlström 1900; Dahlström Gy., Hámori J., Issekutz. L. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice).

***Parnassius apollo* (Linnaeus, 1758) – the Apollo**

Localities: Prešov (Husz 1881a; Rebel & Rogenhoffer 1893; Vángel 1893, 1911; Abafi-Aigner et al. 1896; Stichel 1899, 1907, 1909; Abafi-Aigner 1900; Dahlström 1900; Pagenstecher 1909; Bryk 1914, 1915, 1918, 1922, 1935; Kertész 1922; Eisenhardt 1931; Bryk & Eisner 1932, 1934, 1939; Issekutz 1952; Pekarsky 1953; Eisner 1955; [Kríž 2011]; Dahlström Gy., Sándor A. in coll. Hungarian National Museum in Budapest); Solivar – Prešov (Husz 1881a; Rebel & Rogenhoffer 1893; Abafi-Aigner 1906b; Szent-Ivány 1938; Pekarsky 1953); Prešovské hory (Pax 1915; Fruhstorfer 1921; Slabý 1954); Šalgovík* (Szent-Ivány 1938).

Note: *We mentioned the locality Šalgovík in the list of localities, even though it was a separate village at the time of publication of the paper. Currently, Šalgovík village is part of the city of Prešov.

***Zerynthia polyxena* ([Denis & Schiffermüller], 1775) – the southern festoon**

Localities: Prešov (Abafi-Aigner 1907c).

Familia: Hesperiidae

***Carterocephalus palaemon* (Pallas, 1771) – the Chequered Skipper**

Localities: Prešov (Husz 1881a; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Ochlodes sylvanus* (Esper, [1777]) – the Large Skipper**

Localities: Prešov (Husz 1881a; Dahlström 1900; Csanády A. unpubl.; Hámori J. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice).

Note: in older literature referred to as *Ochlodes venatus* (Bremer & Grey, 1852), but according to recent research taxa *O. venatus* and *O. sylvanus* are two separate species, with *O. venatus* occurs only in the Far East in Asia (Devyatkin 1997; Pastorális et al. 2013).

***Hesperia comma* (Linnaeus, 1758) – the Silver-spotted Skipper**

Localities: Prešov (Husz 1881a; [Abafi-Aigner et al.

1896]; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest); Solivar – Prešov (Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Thymelicus acteon* (Rottemburg, 1775) – the Lulworth Skipper**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900).
Note: in older literature referred to as *Adopaea acteon* (Rottemburg, 1775).

***Thymelicus sylvestris* (Poda, 1761) – the Small Skipper**
Localities: Prešov (Husz 1881a; Dahlström 1900; Hámori J. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice).
Note: in older literature referred to as *Adopaea sylvestris* (Poda, 1761).

***Thymelicus lineola* (Ochsenheimer, 1808) – the Essex Skipper**
Localities: Prešov (Husz 1881a; Dahlström 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J., Mihok M. in coll. East Slovak Museum in Košice).
Note: in older literature referred to as *Adopaea lineola* (Ochsenheimer, 1808).

***Spialia sertorius* (Hoffmannsegg, 1804) – the Red-underwing Skipper**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest); Torysa River valley* (Husz 1881).
Note: in older literature referred to as *Pyrgus sertorius* (Hoffmannsegg, 1804). *Although the site is defined as the valley of the Torysa River, the captures were probably made near Prešov (cf. Husz 1881).

***Spialia orbifer* (Hübner, [1823]) – the Orbed Red-underwing Skipper**
Localities: Prešov (Abafi-Aigner et al. 1896; [Paclt & Šmelhaus 1948]).
Note: in older literature referred to as *Pyrgus orbifer* (Hübner, 1823).

***Carcharodus alceae* (Esper, [1780]) – the Mallow Skipper**
Localities: Prešov (Husz 1881a; Dahlström 1900; Reiprich A. in Hrubý (1964) – private collection; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Carcharodus floccifera* (Zeller, 1847) – the Tufted Skipper**
Localities: Prešov (Abafi-Aigner et al. 1896; Dahlström 1900; [Paclt & Šmelhaus 1948]).
Note: in older literature referred to as *Carcharodus flocciferus* (Zeller, 1847)

***Erynnis tages* (Linnaeus, 1758) – the Dingy Skipper**
Localities: Prešov (Husz 1881a; Dahlström 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J., Mihok M. in coll. coll. East Slovak Museum in Košice).

***Pyrgus malvae* (Linnaeus, 1758) – the Grizzled Skipper**
Localities: Prešov (Husz 1881; Dahlström 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Bacher S., Mihok M. in coll. coll. East Slovak Museum in Košice).

***Pyrgus carthami* (Hübner, [1813]) – the Safflower Skipper**
Localities: Prešov (Husz 1881a; Dahlström 1900).

***Pyrgus serratulae* (Rambur, 1839) – the Olives Skipper**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Pyrgus armoricanus* (Oberthür, 1910) – the Oberthür's Grizzled Skipper**
Localities: Prešov (Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Pyrgus alveus* (Hübner, [1803]) – the Large Grizzled Skipper**
Localities: Prešov (Husz 1881a; Abafi-Aigner et al. 1896; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

Familia: Pieridae
***Leptidea morsei* (Fenton, 1882) – Fenton's Wood White**
Localities: Prešov (Lorković 1930, 1931; Moucha 1953a, 1959; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Leptidea juvernica* Williams, 1946 – the Cryptic Wood White**
Localities: Prešov (Csanády A. unpubl.).

***Leptidea sinapis* (Linnaeus, 1758) – the Wood White**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1897, 1900; Mošková 2015; Dahlström Gy., Hámori J. in coll. Hungarian National Museum in Budapest; Petrašovič J. in coll. East Slovak Museum in Košice).
Note: on the basis of genetic analyses the occurrence of cryptic species in *Leptidea sinapis*/*reali* complex. The range of *L. reali* is restricted to the southern part of Western Europe. The taxon *L. juvernica* has been assigned a new status as a valid taxon occurring together with *L. sinapis* also in the territory of Slovakia (Dincă et al. 2011; Pastorális et al. 2013).

***Gonepteryx rhamni* (Linnaeus, 1758) – the common brimstone**

Localities: Prešov (Horváth & Pável 1876; Husz 1881a; Dahlström 1900; Bacher S., Mihok M. in coll. East Slovak Museum in Košice).

Colias hyale **(Linnaeus, 1758) – the Pale Clouded Yellow**
Localities: Prešov (Husz 1881a, 1883; [Abafi-Aigner et al. 1896]; Dahlström 1897, 1900; [Abafi-Aigner 1906b; Berger & Fontaine 1948; Reissinger 1959]; Csanády A. unpubl.; Dahlström Gy., Tomala N. in coll. Hungarian National Museum in Budapest; Bacher S., Mihok M. in coll. East Slovak Museum in Košice).

Colias alfacariensis **Ribbe, 1905 – the Berger's Clouded Yellow**
Localities: Prešov (Kovács 1954; coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Colias australis* (Verity, 1911). Moreover, *C. alfacariensis* together with *C. hyale* forms a kind of complex. Since the butterflies of both species develop many variations, the two species cannot be differentiated by morphology or on the basis of a genital examination. Information about the habitat and the geographical distribution provide only an indication of which of the two species may be involved. A safe distinction is possible only on the completely different caterpillars.

Colias chrysotheme **(Esper, [1781]) – the Lesser Clouded Yellow**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900); Torysa River valley* (Husz 1881a).
Note: *Although the site is defined as the valley of the Torysa River, the captures were probably made near Prešov (cf. Husz 1881a).

Colias crocea **(Geoffroy in Fourcroy, 1758) – the Clouded Yellow**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Bacher S., Mihok M. in coll. East Slovak Museum in Košice); Torysa River valley* (Husz 1881a).
Note: *Although the site is defined as the valley of the Torysa River, the captures were probably made near Prešov (cf. Husz 1881a).

Colias myrmidone **(Esper, [1781]) – the Danube Clouded Yellow**
Localities: Prešov (Husz 1881a; Abafi-Aigner et al. 1896; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest; coll. Drnec M. in Hrubý (1964) – private collection); Torysa River valley* (Husz 1881a).
Note: *Although the site is defined as the valley of the Torysa River, the captures were probably made near Prešov (cf. Husz 1881a).

Colias phicomone **(Esper, 1780) – the Mountain Clouded Yellow**
Localities: Prešov (Abafi-Aigner et al. 1896; Dahlström 1900; [Abafi-Aigner 1905, Megyesi 1935]).
Note: Hrubý (1964) lists all these data as doubtful, later unconfirmed („*Omnia istaindiciadubiosa, posteriorusanemine confirmata*"). In view of the above comment, it is included in our review only to supplement the historical records of the species' occurrence in the territory of Prešov city and its surroundings.

Aporia crataegi **(Linnaeus, 1758) – the Black-veined White**
Localities: Prešov (Horváth & Pável 1876; Fritsch 1878; Husz 1881a; Dahlström 1900; Mihok M. in coll. East Slovak Museum in Košice).

Pontia edusa **(Fabricius, [1777]) – the Eastern Bath White**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Reiprich A., Bacher S., Mihok M. in coll. East Slovak Museum in Košice).
Note: in older literature referred to as *Pontia daplidicae* (Linnaeus, 1758). However, studies showed that the species of *P. daplidicae* and *P. edusa* are habitually identical and their distinction is only possible at the gene level (Geiger & Scholl 1982). However, they have different ranges *P. daplidice* is distributed in south-western and southern Europe, Southwest Asia to Afghanistan and Kazakhstan, whereas *P. edusa* is found in central, south-eastern and eastern Europe and in northern parts of Iran and Iraq through Siberia to the Sea of Japan (Pastorális et al. 2013).

Pieris brassicae **(Linnaeus, 1758) – the Large White**
Localities: Prešov (Horváth & Pável 1876; Husz 1881a; Dahlström 1900; Csanády A. unpubl.; Hámori J., Sándor A. in coll. Hungarian National Museum in Budapest; Bacher S., Mihok M. in coll. East Slovak Museum in Košice).

Pieris rapae **(Linnaeus, 1758) – the Small Shite**
Localities: Prešov (Husz 1881a; Dahlström 1900; Mošková 2015; Csanády A. unpubl.; Hámori J., Sándor A. in coll. Hungarian National Museum in Budapest; Bacher S., Mihok M. in coll. East Slovak Museum in Košice).

Pieris bryoniae **(Hübner, [1806]) – the Dark-veined White**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Moucha 1958; Dahlström Gy., Hámori J. in coll. Hungarian National Museum in Budapest).
Note: in older literature referred to as *Pieris bryoniae* (Ochsenheimer, 1808).

Pieris napi **(Linnaeus, 1758) – the Green-veined White**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Mošková 2015; Csanády A.

unpubl.; Sándor A. in coll. Hungarian National Museum in Budapest; Bacher S., Mihok M. in coll. East Slovak Museum in Košice); Torysa River valley* (Husz 1881a).
Note: *Although the site is defined as the valley of the Torysa River, the captures were probably made near Prešov (cf. Husz 1881a).

***Anthocharis cardamines* (Linnaeus, 1758) – the Orange Tip**
Localities: Prešov (Horváth & Pável 1876; Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Abafi-Aigner 1903; Mošková 2015; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Bacher S., Mihok M. in coll. East Slovak Museum in Košice).

Familia: Riodinidae
***Hamearis lucina* (Linnaeus, 1758) – the Duke of Burgundy**
Localities: Prešov (Husz 1881a; Dahlström 1900; Abafi-Aigner 1906b, 1907c; [Stichel 1928]; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

Familia: Lycaenidae
***Lycaena phlaeas* (Linnaeus, 1761) – the Small Copper**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; [Abafi-Aigner 1909]; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J. in coll. East Slovak Museum in Košice).

***Lycaena dispar* ([Haworth], 1802) – the Large Copper**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Lycaena virgaureae* (Linnaeus, 1758) – the Scarce Copper**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; [Abafi-Aigner 1909]; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J. in coll. East Slovak Museum in Košice).

***Lycaena tityrus* (Poda, 1761) – the Sooty Copper**
Localities: Prešov (Husz 1881a; Dahlström 1900; [Abafi-Aigner 1909]; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice).

***Lycaena alciphron* (Rottemburg, 1775) – the Purple-shot Copper**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Abafi-Aigner 1902; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Lycaena hippothoe* (Linnaeus, 1761) – the Purple-edged Copper**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Lycaena thersamon* ([Esper, 1784]) – the Lesser Fiery Copper**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900).

***Lycaena helle* (Denis & Schiffermüller, 1775) – the Violet Copper**
Localities: Prešov (Husz 1881a; Abafi-Aigner et al. 1896; Dahlström 1900; Megyesi 1935).
Note: in older studies it is referred to as *Lycaena amphidamas* (Esper, 1870). It is a species that had its population in Slovakia, but its presence has not been confirmed in recent decades. Therefore we consider it extinct or missing (see Pastorális et al. 2013).

***Thecla betulae* (Linnaeus, 1758) – the Brown Hairstreak**
Localities: Prešov (Husz 1881a; Dahlström 1897, 1899a, 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice).

***Favonius quercus* (Linnaeus, 1758) – the Purple Hairstreak**
Localities: Prešov (Husz 1881a; Dahlström 1899a, 1900; Husz A. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Neozephyrus quercus* L. or *Thecla quercus* L. (cf. Hrubý 1964; Patočka & Kulfan 2009).

***Callophrys rubi* (Linnaeus, 1758) – the Green Hairstreak**
Localities: Prešov (Husz 1881a; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Satyrium w-album* (Knoch, 1782) – the White-letter Hairstreak**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Dahlström Gy., Tomala N. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Strymon w-album* (Knoch, 1782).

***Satyrium pruni* (Linnaeus, 1758) – the Black Hairstreak**
Localities: Prešov (Husz 1881a; Dahlström 1900; Csanády A. unpubl.; Dahlström Gy., Tomala N. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Strymon pruni* (Linnaeus, 1758).

***Satyrium spini* ([Denis & Schiffermüller, 1775]) – the Blue Spot Hairstreak**
Localities: Prešov (Husz 1881a; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest; coll. Podtatra Museum in Poprad*).
Note: in older studies it is referred to as *Strymon spini*

(Fabricius, 1787).
[*]as District Museum of Local History in Poprad (cf. Hrubý 1964).

***Satyrium ilicis* (Esper, [1779]) – the Ilex Hairstreak**
Localities: Prešov (Husz 1881a; Dahlström 1900; Dahlström Gy., Piso K. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Strymon ilicis* (Esper, 1779).

***Satyrium acaciae* (Fabricius, 1787) – the Sloe Hairstreak**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest); Torysa River valley[*] (Husz 1881a).
Note: [*]Although the site is defined as the valley of the Torysa River, the captures were probably made near Prešov (cf. Husz 1881a).
Note: in older studies it is referred to as *Strymon acaciae* (Fabricius, 1787).

***Cupido minimus* (Fuessly, 1775) –the Small Blue**
Localities: Prešov (Husz 1881a; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Cupido osiris* (Meigen, [1829]) – the Osiris Blue**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; [Megyesi 1935]).
Note: in older studies it is referred to as *Cupido serbus* (Boisduval, 1832).

***Cupido argiades* (Pallas, 1771) – the Short-tailed Blue**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Abafi-Aigner 1907c, [1910]; Csanády unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice).

***Cupido decolorata* (Staudinger, 1886) – the Eastern Short-tailed Blue**
Localities: Prešov (Dahlström 1897, 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Cupido alcetas* (Hoffmannsegg, 1804) – the Provençal Short-tailed Blue**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1897, 1900).

***Celastrina argiolus* (Linnaeus, 1758) – the Holly blue**
Localities: Prešov (Husz 1881a; Dahlström 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Pseudophilotes vicrama* (Moore, 1865) – the Eastern Baton Blue**
Localities: Prešov (Husz 1881a; Dahlström 1900; [Abafi-Aigner 1910]; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Philotes vicrama* (Moore, 1865).

***Scoliantides orion* (Pallas, 1771) – the Chequered Blue**
Localities: Prešov (Husz 1881a; Dahlström 1900; [Abafi-Aigner 1910]).

***Glaucopsyche alexis* (Poda, 1761) – the Green-underside Blue**
Localities: Prešov (Husz 1881a; Dahlström 1897, 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Phengaris arion* (Linnaeus, 1758) – the Large Blue**
Localities: Prešov (Husz 1881a; Dahlström 1899a, 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Maculinea arion* (Linnaeus, 1758).

***Phengaris teleius* (Bergsträsser, 1779) – the Scarce Large Blue**
Localities: Prešov (Husz 1881a; Abafi-Aigner et al. 1896; Dahlström 1900; Ulbrich E. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice).
Note: in older studies it is referred to as *Maculinea teleius* (Bergsträsser, 1779).

***Phengaris nausithous* (Bergsträsser, 1779) – the Dusky Large Blue**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; [Szent-Ivány 1940]; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Maculinea nausithous* (Fabricius, 1787).

***Phengaris alcon* ([Denis & Schiffermüller], 1775) – the Alcon Large Blue**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Dahlström in Moucha 1961; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Maculinea alcon* Den. & Schiff. (cf. Hrubý 1964). In addition, Dahlström in Moucha (1961) lists as *Maculinea rebeli* Hirsch. Moreover, according to Fric et al. (2007), there are no morphological or genetic differences between the species *P. rebeli* Hirsch. and *P. alcon* Den. & Schiff.

***Plebejus argus* (Linnaeus, 1758) – the Silver-studded Blue**
Localities: Prešov (Husz 1881a; Dahlström 1897, 1900; [Abafi-Aigner 1910]; Mošková 2015; Csanády 2019;

Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

Plebejus idas **(Linnaeus, 1761) – the Idas Blue**
Localities: Šalgovík (Petrašovič J. in coll. East Slovak Museum in Košice).

Plebejus argyrognomon **(Bergsträsser, 1779) – Reverdin's Blue**
Localities: Prešov (Dahlström 1900; [Abafi-Aigner 1910]; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

Aricia agestis **([Denis et Schiffermüller], 1775) – the Brown Argus**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; [Abafi-Aigner 1910]; Mošková 2015; Csanády A. unpubl.).
Note: in older studies it is referred to as *Aricia astrarche* (Bergsträsser, 1779).

Eumedonia eumedon **(Esper, [1780]) – the Geranium Argus**
Localities: Prešov (Husz 1881a, b; [Biró 1885; Abafi-Aigner et al. 1896]; Dahlström 1897, 1900; [Abafi-Aigner 1910; Megyesi 1935]; Petrašovič J. in coll. East Slovak Museum in Košice).
Note: in older studies it is referred to as *Eumedonia chiron* (Rottemburg, 1775), *Aricia eumedon* (Esper, 1780).

Cyaniris semiargus **(Rottemburg, 1775) – the Mazarine Blue**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1899a, 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Polyommatus semiargus* (Rottemburg, 1775).

Agriades optilete **(Knoch, 1781) – the Cranberry Blue**
Localities: Prešov (Abafi-Aigner et al. 1896; [Megyesi 1935]).
Note: in older studies it is referred to as *Vacciniina optilete* (Knoch, 1781), *Plebejus optilete* (Knoch, 1781).

Lysandra bellargus **(Rottemburg, 1775) – the Adonis Blue**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Polyommatus bellargus* (Rottemburg, 1775).

Lysandra coridon **(Poda, 1761) – the Chalkhill Blue**
Localities: Prešov (Husz 1881a; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Polyommatus coridon* (Poda, 1761).

Polyommatus dorylas **([Denis & Schiffermüller], 1775) – the Turquoise Blue**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; [Abafi-Aigner 1910]; Dahlström Gy., Husz A. in coll. Hungarian National Museum in Budapest; coll. Podtatra Museum in Poprad*).
Note: *as District Museum of Local History in Poprad (cf. Hrubý 1964).

Polyommatus thersites **(Cantener, [1835]) – the Chapman's Blue**
Localities: Prešov (Dahlström Gy. in coll. Hungarian National Museum in Budapest).

Polyommatus icarus **(Rottemburg, 1775) – the Common Blue Butterfly**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1897, 1900; [Abafi-Aigner 1910]; Mošková 2015; Csanády 2019, Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J., Mihok M. in coll. East Slovak Museum in Košice); Torysa River valley* (Husz 1881a).
Note: *Although the site is defined as the valley of the Torysa River, the captures were probably made near Prešov (cf. Husz 1881a).

Polyommatus daphnis **([Denis & Schiffermüller], 1775) – the Meleager's Blue**
Localities: Prešov (Husz 1881a; Dahlström 1900; [Abafi-Aigner 1910]; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Meleageria daphnis* (Denis & Schiffermüller, 1775).

Polyommatus damon **(Denis & Schiffermüller, 1775) – the Damon Blue**
Localities: Prešov (Husz 1881a; Dahlström 1900).
Note: It is a species that has had its population in Slovakia, but its presence has not been confirmed in recent decades. Therefore we consider it extinct or missing (see Pastorális et al. 2013).

Iolana iolas **(Ochsenheimer, 1816) – the Iolas Blue**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900).
Note: It is a species that has had its population in Slovakia, but its presence has not been confirmed in recent decades. Therefore we consider it extinct or missing (see Pastorális et al. 2013).

Lampides boeticus **(Linnaeus, 1767) – the Pea Blue**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Uhryk 1903; [Warnecke 1933]).
Note: Pastorális et al. (2013) list this species as an "isolated, unrecorded record far from its range of permanent occurrence". In view of the above comments, it is included in our review only to supplement the historical records of

the species' occurrence in the territory of the city of Prešov and its surroundings.

Familia: Nymphalidae

***Pararge aegeria* (Linnaeus, 1758) – the Speckled Wood**
Localities: Prešov (Husz 1881a; Dahlström 1900; Csanády A. unpubl.; Petrašovič J. in coll. East Slovak Museum in Košice).

***Lasiommata megera* (Linnaeus, 1767) – the Wall Brown**
Localities: Prešov (Husz 1881a; Dahlström 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Lasiommata petropolitana* (Fabricius, 1787) – the Northern Wall Brown**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900).

***Lasiommata maera* (Linnaeus, 1758) – the Large Wall Brown**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest); Solivar – Prešov (Husz A. in coll. Hungarian National Museum in Budapest).

***Lopinga achine* (Scopoli, 1763) – the Woodland Brown**
Localities: Prešov (Husz 1881a; Dahlström 1900).

***Coenonympha pamphilus* (Linnaeus, 1758) – the Small Heath**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Mošková 2015; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice).

***Coenonympha tullia* (Müller, 1764) – the Large Heath**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; [Megyesi 1935]).

***Coenonympha glycerion* (Borkhausen, 1788) – the Chestnut Heath**
Localities: Prešov (Husz 1881a; Dahlström 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J. in coll. East Slovak Museum in Košice).
Note: the first records from Slovakia were published as *Coenonympha amyntas* (cf. Hrubý 1964), which is nowadays a synonym of *C. arcania* (Pastorális et al. 2013). In older studies it is referred to also as *Coenonympha iphis* (Denis & Schiffermüller, 1775).

***Coenonympha hero* (Linnaeus, 1761) – the Scarce Heath**
Localities: Prešov (Abafi-Aigner et al. 1896; [Baudis 1907; Megyesi 1935]).

***Coenonympha arcania* (Linnaeus, 1761) – the Pearly Heath**
Localities: Prešov (Husz 1881a; Dahlström 1900; Schwarz 1948; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J. in coll. East Slovak Museum in Košice).

***Coenonympha oedippus* (Fabricius, 1771) – the False Ringlet**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; [Megyesi 1935; Troníček 1936]).
Note: Pastorális et al. (2013) state that the occurrence of a permanent population of the species in Slovakia is currently very unlikely.

***Erebia ligea* (Linnaeus, 1758) – the Arran Brown**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1899a, b, 1900; Sándor A. in coll. Hungarian National Museum in Budapest).

***Erebia euryale* (Esper, 1805) – the Large Ringlet**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1899a, b, 1900).

***Erebia epiphron* (Knoch, 1783) – the Small Mountain Ringlet**
Localities: Prešov (Abafi-Aigner et al. 1896; Dahlström 1900; [Megyesi 1935]).
Note: Hrubý (1964) states as quite doubtful (*omnino dubiosum!*). In view of the above comments, it is included in our review only to supplement the historical records of the species' occurrence in the territory of the city of Prešov and its surroundings.

***Erebia aethiops* (Esper, 1777) – the Scotch Argus**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Dahlström Gy., Piso K., Tomala N. in coll. Hungarian National Museum in Budapest; Petrašovič J. in coll. East Slovak Museum in Košice).
Note: in older studies it is referred to as *Erebia aethiops* (Esper, 1779).

***Erebia medusa* ([Denis & Schiffermüller], 1775) – the Woodland Ringlet**
Localities: Prešov (Husz 1881a; Elwes 1889; [Abafi-Aigner et al. 1896]; Dahlström 1900; Abafi-Aigner 1907b; Slabý 1950; Csanády A. unpubl.; coll. Hungarian National Museum in Budapest); Solivar – Prešov (Husz 1881a; Dahlström 1900; Dahlström Gy., Parlay Gy., Piso K. in coll. Hungarian National Museum in Budapest); Prešovské hory Mts. (Slabý 1950).

***Erebia pandrose* (Borkhausen, 1788) – the Dewy Ringlet**
Localities: Solivar – Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900).
Note: Hrubý (1964) states as impossible (*impossible!*). In view of the above comments, it is included in our

review only to supplement the historical records of the species' occurrence in the territory of Prešov city and its surroundings.

Erebia oeme **(Hübner, 1804) – the Bright Eyed Ringlet**
Localities: Prešov (Abafi-Aigner et al. 1896; Dahlström 1900; Fruhstorfer 1917).
Note: Hrubý (1964) states as doubtful (*dubiosum!*). Pastorális et al. (2013) state that the published data for this species were based on an incorrect determination. In view of the above comments, it is included in our review only to supplement the historical records of the species' occurrence in the territory of Prešov city and its surroundings.

Aphantopus hyperanthus **(Linnaeus, 1758) – the Ringlet**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

Hyponephele lycaon **(Rottemburg, 1775) – the Dusky Meadow Brown**
Localities: Prešov (Husz 1881a; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Maniola lycaon* (Rottemburg, 1775).

Maniola jurtina **(Linnaeus, 1758) – the Meadow Brown**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1897, 1900; Mošková 2015; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J., Mihok M. in coll. East Slovak Museum in Košice).

Melanargia galathea **(Linnaeus, 1758) – the Marbled White**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest); Solivar – Prešov (Dahlström Gy. in coll. Hungarian National Museum in Budapest).

Minois dryas **(Scopoli, 1763) – the Dryad**
Localities: Prešov (Husz 1881a; Dahlström 1900; Abafi-Aigner 1906b, 1907a; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice).
Note: in older studies it is referred to as *Satyrus dryas* (Scopoli, 1763).

Brintesia circe **(Fabricius, 1775) – the Great Banded Grayling**
Localities: Prešov (Husz 1881a; Dahlström 1900); Solivar – Prešov (Husz 1881a; Dahlström 1900).
Note: in older studies it is referred to as *Hipparchia circe* (Fabricius, 1775).

Chazara briseis **(Linnaeus, 1764) – the Hermit**
Localities: Prešov (Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Hipparchia briseis* (Linnaeus, 1764).

Hipparchia statilinus **(Hufnagel, 1766) – the Tree Grayling**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900).
Note: in older studies it is referred to as *Satyrus statilinus* (Hufnagel, 1766).

Hipparchia semele **(Linnaeus, 1758) – the Grayling**
Localities: Prešov (Husz 1881a; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Eumenis semele* (Linnaeus, 1758).

Hipparchia fagi **(Scopoli, 1763) – the Woodland Grayling**
Localities: Prešov (Husz 1881a; Dahlström 1900).

Hipparchia hermione **(Linnaeus, 1764) – the Rock Grayling**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; [Abafi-Aigner 1908; Megyesi 1935]).
Note: in older studies it is referred to as *Hipparchia aelia* (Hoffmannsegg, 1804).

Pyronia tithonus **(Linnaeus, 1767) – the Gatekeeper**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900).
Note: The occurence of a permanent population of this species in Slovakia is currently considered highly unlikely (see Pastoralis et al. 2013).

Argynnis paphia **(Linnaeus, 1758) – the Silver-washed Fritillary**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; [Abafi-Aigner 1907b]; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Bacher S. in coll. East Slovak Museum in Košice).
Note: in older studies it is referred to as *Argyronome paphia* (Linnaeus, 1758).

Argynnis pandora **([Denis & Schiffermüller], 1775) – the Cardinal**
Localities: Prešov (Husz 1881a; Dahlström 1900; [Megyesi 1935; Moucha 1952, 1959]).
Note: in older studies it is referred to as *Pandoriana pandora* (Denis & Schiffermüller, 1775).

Speyeria aglaja **(Linnaeus, 1758) – the dark green fritillary**
Localities: Prešov (Husz 1881a; Dahlström 1899a, 1900; Abafi-Aigner 1906b, 1907b, c; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Fabriciana aglaia* (Linnaeus, 1758), *Brenthis aglaia* (Linnaeus, 1758), *Argynnis aglaja* (Linnaeus, 1758).

Fabriciana adippe **([Denis & Schiffermüller], 1775) – the High Brown Fritillary**
Localities: Prešov (Husz 1881a; Dahlström 1900; Hámori J. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Fabriciana adippe* (Denis & Schiffermüller, 1775), *Brenthis adippe* (Denis & Schiffermüller, 1775), *Argynnis adippe* (Denis & Schiffermüller, 1775).

Fabriciana niobe **(Linnaeus, 1758) – the Niobe Fritillary**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Abafi-Aigner 1906b; Szent-Ivány 1939; Dahlström Gy. in coll. Hungarian National Museum in Budapest); Torysa River valley* (Husz 1881a).
Note: *Although the site is defined as the valley of the Torysa River, the captures were probably made near Prešov (cf. Husz 1881a). In older studies it is referred to as *Fabriciana niobe* (Linnaeus, 1758), *Brenthis niobe* (Linnaeus, 1758), *Argynnis niobe* (Linnaeus, 1758).

Issoria lathonia **(Linnaeus, 1758) – the Queen of Spain Fritillary**
Localities: Prešov (Horváth & Pável 1876; Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1899a, 1900; [Abafi-Aigner 1907b]; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice).

Brenthis ino **(Rottemburg, 1775) – the Lesser Marbled Fritillary**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900).

Brenthis daphne **([Denis & Schiffermüller], 1775) – the Marbled Fritillary**
Localities: Prešov (Csanády A. unpubl.).

Brenthis hecate **([Denis & Schiffermüller], 1775) – the Twin-spot Fritillary**
Localities: Prešov (Husz 1881a; Dahlström 1900).

Boloria aquilonaris **(Stichel, 1908) – the Cranberry Fritillary**
Localities: Prešov (Abafi-Aigner et al. 1896; Abafi-Aigner 1907b).
Note: in older studies it is referred to as *Boloria alethea* (Hemming, 1934). According to Pastorális et al. (2013), *B. alethea* Hemm. is synonymous with *B. aquilonaris* Stich. in the older litterature, whereas it is now at the subspecies level – *B. aquilonaris alethea* Hemm.

Boloria euphrosyne **(Linnaeus, 1758) – the Pearl-bordered Fritillary**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1899a, 1900; [Abafi-Aigner 1907c]; Dahlström Gy., Parlay Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Clossiana euphrosyne* (Linnaeus, 1758).

Boloria selene **([Denis & Schiffermüller], 1775) – the Small Pearl-bordered Fritillary**
Localities: Prešov (Husz 1881a; Dahlström 1900; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest); Solivar – Prešov (Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J. in coll. East Slovak Museum in Košice).
Note: in older studies it is referred to as *Clossiana selene* (Denis et Schiffermüller, 1775).

Boloria dia **(Linnaeus, 1767) – the Weaver's Fritillary**
Localities: Prešov (Husz 1881a; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J. in coll. East Slovak Museum in Košice).
Note: in older studies it is referred to as *Boloria dia* (Linnaeus, 1767).

Boloria titania **(Esper, 1793) – the Titania's Fritillary**
Localities: Prešov (Abafi-Aigner et al. 1896; [Abafi-Aigner 1907b; Matějková 1942]).
Note: Hrubý (1964) states as later unconfirmed (*posterius non confirmatum*). Pastorális et al. (2013) state that no documented specimens are available. In view of the above comments, it is included in our review only to supplement the historical records of the species' occurrence in the territory of Prešov city and its surroundings.

Limenitis populi **(Linnaeus, 1758) – the Poplar Admiral**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900, 1901; Dahlström Gy., Parlay Gy., Ulbrich E. in coll. Hungarian National Museum in Budapest; Mihok M. in coll. East Slovak Museum in Košice East Slovak Museum in Košice).

Limenitis camilla **(Linnaeus, 1764) – the White Admiral**
Localities: Prešov (Husz 1881a; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Bacher S. in coll. East Slovak Museum in Košice).
Note: in older studies it is referred to as *Limenitis camilla* (Linnaeus, 1758).

Limenitis reducta **Staudinger, 1901 – the Southern White Admiral**
Localities: Prešov (Mihok M. in coll. East Slovak Museum in Košice)
Note: According to Pastorális et al. (2013), recent data are lacking, but the occurrence of the species in Slovakia is not excluded.

Neptis sappho **(Pallas, 1771) – the Pallas' Sailer**
Localities: Prešov (Husz 1881a; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: Hrubý (1964) referred to as *Neptis hylas* (Linnaeus,

1758). *N. hylas* L. represents a distinct taxon that occurs in Southeast Asia (see Pastorális et al. 2013).

***Apatura ilia* ([Denis & Schiffermüller], 1775) – the Lesser Purple Emperor**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1897, 1901; Abafi-Aigner 1906a; Dahlström Gy., Parlay Gy., Szurdoky R. in coll. Hungarian National Museum in Budapest).

***Apatura iris* (Linnaeus, 1758) – the Purple Emperor**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1897, 1900; Abafi-Aigner 1906b; Parlay Gy., Simon A., Szurdoky R., Ulbrich E. in coll. Hungarian National Museum in Budapest; Petrašovič J., Bacher S. in coll. East Slovak Museum in Košice).

***Nymphalis antiopa* (Linnaeus, 1758) – the Mourning Cloak**
Localities: Prešov (Horváth & Pável 1876; Husz 1881a; Dahlström 1897, 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Bacher S., Mihok M. in coll. East Slovak Museum in Košice).

***Nymphalis polychloros* (Linnaeus, 1758) – the Large Tortoiseshell**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J., Bacher S., Mihok M., leg. "?" in coll. East Slovak Museum in Košice).

***Nymphalis xanthomelas* ([Denis & Schiffermüller], 1775) – the Scarce Tortoiseshell**
Localities: Prešov (Husz 1881a; Dahlström 1897, 1900; Abafi-Aigner 1900; Dahlström Gy., Ulbrich in coll. Hungarian National Museum in Budapest; coll. Podtatra Museum in Poprad*); Torysa River valley** (Husz 1881a).
Note: in older studies it is referred to as *Nymphalis xanthomelas* (Esper, 1781).
* as District Museum of Local History in Poprad (cf. Hrubý 1964).
**Although the site is defined as the valley of the Torysa River, the captures were probably made near Prešov (cf. Husz 1881a).

***Nymphalis vaualbum* (Denis & Schiffermüller, 1775) – the Compton tortoiseshell**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1900).
Note: in older studies it is referred to as *Nymphalis L-album* (Esper, 1781). It is a species that has had its population in Slovakia, but its presence has not been confirmed in recent decades. Therefore we consider it extinct or missing (see Pastorális et al. 2013).

***Aglais urticae* (Linnaeus, 1758) – the Small Tortoiseshell**
Localities: Prešov (Husz 1881a; Dahlström 1900; Csanády A. unpubl.; Hámori J. in coll. Hungarian National Museum in Budapest; Bacher S., Mihok M. in coll. East Slovak Museum in Košice).

***Aglais io* (Linnaeus, 1758) – the European Peacock**
Localities: Prešov (Husz 1881a; Hutten-Klingestein 1882*; [Abafi-Aigner et al. 1896]; Dahlström 1899a, 1900; Mošková 2015; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Bacher S., Mihok M. in coll. East Slovak Museum in Košice).
Note: in older studies it is referred to as *Nymphalis io* L. (Hrubý 1964). *Hrubý (1964) stated this literature with "?".

***Vanessa atalanta* (Linnaeus, 1758) – the Red Admiral**
Localities: Prešov (Horváth & Pável 1876; Fritsch 1878; Husz 1881a; Dahlström 1900; [Pillich 1922]; Mošková 2015; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Vanessa cardui* (Linnaeus, 1758) – the Painted Lady**
Localities: Prešov (Husz 1881a; Speyer 1881; Dahlström 1900; Mošková 2015; Csanády unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Bacher S., Mihok M. in coll. East Slovak Museum in Košice).

***Polygonia c-album* (Linnaeus, 1758) – the Comma**
Localities: Prešov (Husz 1881a, Dahlström 1900; Csanády A. nepubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J., Bacher S., Mihok M. in coll. East Slovak Museum in Košice).
Note: in older studies it is referred to as *Nymphalis c-album* (Linnaeus, 1758).

***Araschnia levana* (Linnaeus, 1758) – the Map**
Localities: Prešov (Husz 1881a; Dahlström 1899a, 1900; Abafi-Aigner 1906b, 1907c; Csanády A. nepubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Bacher S., Mihok M. in coll. East Slovak Museum in Košice).

***Melitaea cinxia* (Linnaeus, 1758) – the Glanville Fritillary**
Localities: Prešov (Husz 1881a; Dahlström 1900).

***Melitaea diamina* (Lang, 1789) – the False Heath Fritillary**
Localities: Prešov (Husz 1881a; Dahlström 1900; Tomala N. in coll. Hungarian National Museum in Budapest); Solivar – Prešov (Husz 1881a; Dahlström 1900).
Note: in older studies it is referred to as *Melitaea dictynna* (Esper, 1777).

***Melitaea phoebe* ([Denis & Schiffermüller], 1775) – the Knapweed Fritillary**
Localities: Prešov (Husz 1881a; Dahlström 1899a, 1900; Csanády A. unpubl.; Dahlström Gy., Tomala N. in coll.

Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Melitaea paedotrophos* (Bergsträsser, 1780).

***Melitaea didyma* (Esper, 1779) – the Spotted Fritillary**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1899a, 1900; Abafi-Aigner 1906b, 1907c; Dahlström Gy., Husz A. in coll. Hungarian National Museum in Budapest).

***Melitaea trivia* ([Denis & Schiffermüller], 1775) – the Lesser Spotted Fritillary**
Localities: Prešov (Husz 1881a; Dahlström 1899a, 1900; Abafi-Aigner 1906b; Dahlström Gy. in coll. Hungarian National Museum in Budapest).
Note: in older studies it is referred to as *Melitaea fascelis* (Esper, 1784).

***Melitaea athalia* (Rottemburg, 1775) – the Heath Fritillary**
Localities: Prešov (Husz 1881a; [Abafi-Aigner et al. 1896]; Dahlström 1899a, 1900; Abafi-Aigner 1906b; Csanády A. unpubl.; Dahlström Gy. in coll. Hungarian National Museum in Budapest; Petrašovič J. in coll. East Slovak Museum in Košice).

***Melitaea aurelia* Nickerl, 1850 – the Nickerl's Fritillary**
Localities: Prešov (Husz 1881a; Dahlström Gy. in coll. Hungarian National Museum in Budapest); Solivar – Prešov (Dahlström Gy. in coll. Hungarian National Museum in Budapest).

***Melitaea britomartis* (Assmann, 1847) – the Assmann's Fritillary**
Localities: Prešov (Abafi-Aigner et al. 1896; Dahlström 1899a; [Weiss 1959]).

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Original paper

Contribution to the knowledge of fleas (Siphonaptera) in the nests of *Micromys minutus* and *Muscardinus avellanarius* in north-eastern Slovakia

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Abstract

Associations of fleas that live in nests and burrows of small mammals are relatively well explored. In this study we try to expand the knowledge about flea communities of two small mammals, namely *Micromys minutus* (Pallas, 1771) and *Muscardinus avellanarius* (Linnaeus, 1758) in Slovakia. Part of the research into the nesting biology and ecology of both rodent species in north-eastern Slovakia was also research into parasites in their nests. In nests of *M. minutus* three flea species (*Megabothris turbidus* (Rothschild, 1909), *Ctenophthalmus assimilis* (Taschenberg, 1880), *C. solutus* Jordan & Rothschild, 1920), while in hazel dormouse nest five species were found – *M. turbidus*, *C. assimilis*, *C. solutus*, *Ceratophyllus* (*Monopsyllus*) *sciutorum* (Schrank, 1803) and *Doratopsylla dasycnema* (Rothschild, 1897).

Key words: Eurasian Harvest Mouse, Hazel Dormouse, Ondavská vrchovina highlands, parasites

Introduction

Parasitic and non-parasitic groups of invertebrates inhabit nests that provide suitable habitat for their survival and reproduction. Important factors that affect the species and trophic composition of arthropods in nests are the character of the surrounding habitat, the structure of the nest, food remains in nests, and also the nest position, it means if the nests are located above or below the soil surface (e.g., Cyprich & Krumpál 1996, 2007; Cyprich et al. 1992; Tryjanowski et al. 2001; Büchner et al. 2003; Mašán & Stanko 2005; Bajerlein et al. 2006; Błoszyk et al. 2006, 2011; Gwiazdowicz et al. 2006; Šustek & Stanko 2012; Krawczyk et al. 2015; Roháček et al. 2022).

The flea fauna (Siphonaptera) of rodents in Slovakia is relatively well described. Information about fleas on *Micromys minutus* (Pallas, 1771) can be found in several works (Rosický 1957; Dudich 1984, 1986; Cyprich et al. 1987; Stanko 1987a). A total of seven species of fleas have been confirmed from this host in Slovakia. Similarly, data on the flea fauna on *Muscardinus avellanarius* (Linnaeus, 1758) can be found in several publications too (Rosický 1957; Dudich 1983, 1987, 1988, 1991; Dudich & Matoušek 1985; Stanko 1987b; Stanko & Fričová 2001), four flea species have been recorded on this rodent species from our territory. On the other hand, there are few published works on the flea fauna in the nests of both species of rodents from the territory of Slovakia (Cyprich & Kiefer 1981; Cyprich et al. 1992), and at the same time it should be noted that numerous nests were examined in these publications. This is reflected in the relatively high number of flea species found in the nests of both rodent species.

The main aim of our study was to describe the flea's fauna living in the Eurasian harvest mouse and the hazel dormouse nests in north-eastern Slovakia. Data on the fleas of these hosts, as well as their nests, are missing from the study territory.

Material and methods

The field margins and woodland edges were systematically searched by hand for nests of *M. minutus* and *M. avellanarius*. All evaluated nests were obtained between July and November of 2011. The study sites were in predominantly arable landscapes in the vicinity of Duplín village (49°14‘08“N, 21°38‘11“E, 260 m a.s.l.) and Stropkov city (49°11‘36“N, 21°39‘35“E, 216 m a.s.l.) all in north-eastern Slovakia (Ondavská vrchovina highlands). Nests of *M. minutus* were identified and distinguished from similar grassland nests of *M. avellanarius* according to studies by Čanády (2012, 2013, 2015) and Csanády (2022). A total of six nests of *M. minutus* and 12 nests of *M. avellanarius* were evaluated.

Each nest was placed in a plastic bag, the top of which was sealed to prevent arthropod escape. Under laboratory conditions, each nest was placed in modified Berlese-Tullgren funnels for 72 hours. Arthropods were collected in 70% ethyl alcohol in a catch bottle that was attached to the bottom of the funnel. The extracted arthropods were then sorted according to taxonomic affiliation (see Roháček et al. 2022) and fleas (Siphonaptera) were identified according to the key of Rosický (1957).

These materials in alcohol are deposited in the collection of the Institute of Parasitology, Slovak Academy of Sciences in Košice, Slovakia.

Results and Discussion

Micromys minutus (Pallas, 1771) – Eurasian Harvest Mouse

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In previous studies (e.g., Bence et al. 2003; Čanády 2013; Csanády 2022) were showed that harvest mice spend most of their life above the soil surface, in tall, dense vegetation, where they build their woven ball-shaped nests anchored above the ground. Nests are used for breeding and resting, and most nests are damaged within one month. The mice abandon old nests and build new ones during their reproductive period (Čanády 2013). The spherical nests, 4.5 – 14 cm in diameter, are usually located at a height of 8 – 115 cm above the ground and attached to vegetation.

Flea communities recorded from Eurasian harvest mouse nests in Slovakia

Together, six *M. minutus* nests were examined, and 29 fleas of three species we confirmed in four positive nests: *Megabothris turbidus* (Rothschild, 1909), *Ctenophthalmus assimilis* (Taschenberg, 1880), *C. solutus* (Jordan & Rothschild, 1920).

While two flea species (*C. assimilis*, *C. solutus*) were recorded with only one specimen each, the third registered species – *M. turbidus* was more numerous and we found it in four nests in both localities (Table 1).

***Megabothris turbidus* (Rothschild, 1909)**

Fleas occur in equal proportions in the fur and in the nests of hosts (Skuratowicz 1967; Baláž & Ševčík 2021; Baláž & Košša 2022). It is a typical representative of the small mammals such as *Apodemus agrarius* (Pallas, 1771), *A. flavicollis* (Melchior, 1834), *A. sylvaticus* (Linnaeus, 1758), *Clethrionomys glareolus* (Schreber, 1780), *Microtus agrestis* (Linnaeus, 1761), *M. arvalis* (Pallas, 1778), *M. subterraneus* (de Selys-Longchamps, 1836), *Sorex araneus* Linnaeus, 1758 and, *S. minutus* Linnaeus, 1766. In forest habitats of lower altitudes, it is their second most abundant flea species (the first is *Ctenophthalmus agyrtes* (Heller, 1896). It prefers mainly floodplain forests and does not avoid secondary tree formations. It also penetrates from forests into adjacent open areas of fields and meadows. It also occurs in mountain environments up to the alpine zone. It is most abundant in the warm part of the year, peaking in summer and autumn. In winter, it mainly stays in nests. According to Baláž & Ševčík (2021), the host spectrum is very broad, attacking mainly members of the genera *Microtus* and *Clethrionomys*, quite often also *Apodemus* (Brinck-Lindroth & Smit 2007). It has also been recorded on other species of small mammals, squirrels, dormice, some carnivores (*Mustela*) and also birds. *C. glareolus* is considered to be the most common host (Rosický 1957; Skuratowicz 1967; Dudich 1995; Baláž & Ševčík 2021).

Table 1. The fleas found in the nest of the Eurasian harvest mouse (*Micromys minutus*) in Slovakia.

Species	Nest no.	N/Sex	Site	Date
Megabothris turbidus	H9	2 M, 2 F	Stropkov	25.VIII.2011
	H9[a]	1 M, 2 F	Duplín	16.IX.2011
	H4[b]	1 M, 2 F	Duplín	16.IX.2011
	H6	1 M	Duplín	16.IX.2011
	H16	2 F	Duplín	17.IX.2011
	H20	5 M, 9 F	Duplín	18.XI.2011
Ctenophthalmus assimilis	H9[a]	1 M	Duplín	16.IX.2011
Ctenophthalmus solutus	H4[b]	1 M	Duplín	16.IX.2011

[a, b] – species and individuals recorded in the same nest.

M – male.

F – female.

***Ctenophthalmus assimilis* (Taschenberg, 1880)**

It is a predominantly nest-dwelling species (Beaucournu & Launay 1990), but often occurs on hosts, originally restricted to the forest-steppe of Eurasia (Rosický 1957). Several authors (Baláž & Ševčík 2021; Baláž & Košša 2022) state that it prefers open habitats, especially fields, meadows, clearings, where it is the dominant species of small mammal flea. Although its main host is the field rodent species – *Microtus arvalis*, it sometimes invades into forest habitats together with its host. Conversely, it is absent in high mountains where its main host is also absent. Flea is present on hosts during all seasons. On the other hand, apart from its main host, *C. assimilis* has been recorded on various species of other small mammals – other voles, mice, and shrews such as (*Apodemus agrarius*, *A. flavicollis*, *A. sylvaticus*, *Clethrionomys glareolus*, *Microtus agrestis*, *M. subterraneus*, *Sorex araneus*, and *S. minutus*) and also on species of *Spermophilus citellus* (Linnaeus, 1766) or *Cricetus cricetus* (Linnaeus, 1758), and on the mole (*Talpa europaea* Linnaeus, 1758) it tends to be the most abundant flea species (Rosický 1957; Skuratowicz 1967; Dudich 1995; Brinck-Lindroth & Smit 2007).

***Ctenophthalmus solutus* Jordan & Rothschild, 1920**

According to review papers by Baláž & Ševčík (2021) and Baláž & Košša (2022), the species is found primarily in the fur of the host. The ecological optimum of the species is in forest habitats of the upland stage; on the northern edge of the Pannonian Plain it ascends to the fir-beech vegetation stage (Dudich 1986). It is especially abundant in thermophilous oak woods, over-wooded groves and in their close vicinity. It is less common in open areas and spruce forests, completely avoiding floodplain forests. Rosický (1957) and Skuratowicz (1967) state that it can be recorded during all seasons, but reaches its maximum especially in spring. The main hosts are members of the genus *Apodemus*, especially *A. flavicollis*, *A. sylvaticus* and *A. agrarius*. A common secondary host is *Mus musculus*, and it also parasitizes microtid rodents and insectivores more sporadically (*Clethrionomys glareolus*, *Microtus agrestis*, *M. arvalis*, *M. subterraneus*, *Sorex araneus*, *S. minutus*; Rosický 1957).

Cyprich & Kiefer (1981), who so far examined the most voluminous material of nests of *M. minutus* (100 nests in total) from the territory near Bratislava, during the population expansion of the Eurasian harvest mouse in 1966, recorded fleas in 75% of nests. The average number of fleas in their research was approximately 10 fleas per examined nest. They registered 5 flea species in the nests, while the species *M. turbidus* significantly dominated (97.5%). In addition to the three species that we also confirmed in our research, the authors mention 2 more species – *Ctenophthalmus agyrtes* (Heller, 1896) (10 specimens) and *Nosopsyllus fasciatus* (Bosc, 1800) (1 specimen).

***Muscardinus avellanarius* (Linnaeus, 1758) – Hazel Dormouse**

In previous studies (cf. Čanády 2012, 2015; Csanády 2022) were showed that the hazel dormouse occupies woodland habitats, shrub stands, clearings and other ecotone habitats mostly in deciduous or mixed deciduous-coniferous forests with a well-developed understorey. Arboreal nests are important for predator avoidance, protection from weather conditions and security for offspring.

Spherical nests, mostly 5 – 15 cm in diameter (depending on the nest type), were usually located 20 – 140 cm above the ground attached to vegetation (Čanády 2015; Csanády 2022).

Table 2. The fleas (Siphonaptera) found in nest of the hazel dormouse, *Muscardinus avellanarius* in Slovakia.

Species	Nest no.	N/Sex	Site	Date
Megabothris turbidus	H6[a]	1 M, 4 F	Duplín	21.VII.2011
	H4[b]	6 M, 7 F	Duplín	24.VIII.2011
	H12	1 F	Duplín	26.VIII.2011
	H16[c]	1 M, 3 F	Duplín	26.VIII.2011
	H17	3 F	Duplín	26.VIII.2011
	H7	1 F	Duplín	16.IX.2011
	H14	2 F	Duplín	17.IX.2011
	H13	6 M, 8 F	Duplín	18.XI.2011
	H6	8 M, 8 F	Duplín	18.XI.2011
	H15	3 M, 5 F	Duplín	18.XI.2011
	H25[d]	15 M 14 F	Duplín	19.XI.2011
Ctenophthalmus assimilis	H16[c]	2 F	Duplín	26.VIII.2011
Ctenophthalmus solutus	H4[b]	1 M	Duplín	16.IX.2011
Ceratophyllus sciurorum	H6[a]	1 M	Duplín	21.VII.2011
	H16[c]	1 F	Duplín	26.VIII.2011
	H25[d]	1 M, 1 F	Duplín	19.XI.2011
Doratopsylla dasycnema	H3	1 F	Duplín	21.VII.2011

[a, b, c, d] species and individuals recorded in the same nest.
M – male.
F – female.

Flea communities recorded from Hazel Dormouse nests

Twelve nests of *M. avellanarius* were examined from the Duplín locality, from which we recorded 96 fleas belonging to five species: *M. turbidus*, *C. assimilis*, *C. solutus*, *Ceratophyllus sciurorum* and *Doratopsylla dasycnema* (Table 2).

M. turbidus flea in the hazel dormouse nests dominated. We recorded 96 fleas, it means 40 males and 56 females in 11 nests. Two *C. assimilis* females were recorded in one nest, together with two other species – *M. turbidus* and *C. sciurorum*. Similarly, one *C. solutus* male was confirmed with several individuals of *M. turbidus* (Table 2).

Data on the ecology of the three-flea species – *M. turbidus*, *C. assimilis* and *C. solutus* were presented above (see *M. minutus*).

Ceratophyllus (Monopsyllus) sciurorum **(Schrank, 1803)**
It is a nest-dwelling flea species (Skuratowicz 1967) associated with arboreal mammals and cavity-nesting bird species (Rosický 1957; Skuratowicz 1967; Dudich 1986; Baláž & Ševčík 2021; Baláž & Košša 2022). According to the mentioned authors, its main host is *Sciurus vulgaris* Linnaeus, 1758. Together with its host, it occurs in forest habitats from lowlands to the montane zone. Typically, this species can also be captured in the wild (e.g., on a flag), where it actively seeks out its host. It occurs throughout the year, but is more abundant in the warmer months. In autumn and winter, its abundance decreases. In addition to the squirrel, it is a common parasite of dormice (e.g., *Muscardinus avellanarius*, *Glis glis*) and sporadically attacks small mammals (*Apodemus agrarius*, *A. flavicollis*, *Clethrionomys glareolus*, *Microtus subterraneus*). It has also been recorded on the species *Erinaceus europaeus* Linnaeus, 1758, on some carnivores, such as *Martes martes* Linnaeus, 1758, *Vulpes vulpes* Linnaeus, 1758, also *Canis lupus* forma *familiaris* Linnaeus, 1758 (see Baláž & Ševčík 2021) and on human (Rosický 1957; Skuratowicz 1967; Bartkowska 1973; Brinck-Lindroth & Smit 2007).
Four fleas (two males, and two females) were recorded in three nests, together with two species of *M. turbidus* and *C. assimilis* obtained from Duplín village (Table 2).

Doratopsylla dasycnema **(Rothschild, 1897)**
It belongs to the species parasitizing in the fur of the host (Brinck-Lindroth & Smit 2007; Baláž & Ševčík 2021; Baláž & Košša 2022). It is a common parasite of shrews (Soricidae) such as *Sorex*, *Neomys* and *Crocidura* (Dudich & Ambros 1985). It is a widespread and dominant species that is associated with forest formations (Dudich 1991), avoiding areas of large river floodplains that are periodically flooded (Dudich 1995). The species is especially abundant in the upland, foothill and mountain grades. The most common host is *Sorex araneus* and, together with it, can reach up to the alpine stage. In lowland areas, its occurrence is more sporadic. It reaches its highest abundance in the warm months. In addition to the insectivores mentioned above, it has also been recorded on a wide range of other small mammal species (*Apodemus agrarius*, *A. flavicollis*, *A. sylvaticus*, *Micromys minutus*, *Mus musculus, Clethrionomys glareolus, Microtus agrestis, M. arvalis, M. subterraneus*, *M. tatricus*, *Crocidura leucodon*, *C. suaveolens*, *Neomys anomalus*, *N. fodiens*, *Sorex alpinus*, *S. araneus*, *S. minutus*, *Talpa europaea*) (Rosický 1957; Skuratowicz 1967; Baláž & Ševčík 2021; Baláž & Košša 2022). However, Brinck-Lindroth & Smit (2007) consider its occurrence on voles and murid rodents to be coincidental. One female was recorded in a nest (Table 2).

A representative and so far, the largest number of *M. avellanarius* nests in Slovakia were investigated by Cyprich et al. (1992). They examined 163 nests in the many localities of Slovakia, of which 141 were located in birdhouses. The authors registered a total of 2099 fleas belonging to 16 species in the nests, *C. sciurorum* absolutely dominated (51%), i.e., a species associated with arboreal mammals (dormouse, squirrels). Another seven species represented fleas associated with parasitation on birds and made up a total of 38.6% of fleas in nests. The remaining eight species of fleas were created by flea communities, which are mostly associated with small mammals, and made up 10.4% of the flea material in *M. avellanarius* nests. Within this mammal´s flea species, the authors mention the species *M. turbidus*, *C. solutus* and *C. assimilis*. The flea *D. dasycnema* was missing in their collections.
The number of investigated nests of both rodent species is not large, therefore the range of detected flea taxa in the given region is not complete. At the same time, we can state that although both species of rodents are taxonomically quite distant, they still have very ecologically similar trophic and topical requirements due to some characteristics of nidobiology and ecology. This was reflected in similar coenoses of fleas in both species, which points to strong contacts and common parasitofauna with other species of small mammals (genera *Ctenophthalmus*, *Megabothris*, *Doratopsylla*). *Ceratophyllus sciurorum* is an important flea species for the hazel dormouse (both in nests and on hosts), which is typical for the parasitofauna of dormouse and squirrels and some species of birds nesting on trees (Rosický 1957; Stanko 1987b; Dudich 1988, Cyprich et al. 1992).

Conclusion
During 2011, there were examined nests of *Micromys minutus* and *Muscardinus avellanarius* in the surroundings of Duplín village and Stropkov city (north-eastern Slovakia). In twelve hazel mouse nests, five flea's species were recorded. In six Eurasian harvest mouse nests, three flea species were recorded. In nests of both rodent species, *Megabothris turbidus* dominates in flea communities. The occurrence of *Doratopsylla dasycnema* flea in hazel mouse nest, according to the author's knowledge, is new data from this territory of Slovakia.

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Vplyv invázie pohánkovca japonského (*Fallopia japonica* (Houtt.) Ronse Decr.) (Polygonaceae) na pôdne organizmy – prehľadový článok

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Abstract. Effect of *Fallopia japonica* invasion on soil biota – a review.
Invasion of alien plant species is considered one of the most severe threats to natural ecosystems, with varying degrees of impact. Their occurrence in an ecosystem can lead to environmental changes, reduce native biodiversity, increase the homogenization of the world's biota, and cause economic damage. Some invaders can also produce toxic allergens dangerous to humans. We provide an overview of the current knowledge of the impact of the invasive plant *Fallopia japonica* on soil fauna. Our results indicated that the presence of *F. japonica* invaders in soil ecosystems often decreased the abundance and diversity of soil organisms, e.g., mites, springtails, and most beetles, but that other soil organisms, especially decomposers such as saprophytic fungi and some arthropods, were less affected. *Fallopia* invasion also negatively affected the abundance of herbivorous species, e.g., nematodes and some beetles, probably because nearly homogeneous stands of *Fallopia* produce inappropriate and low-diversity plant food upon which herbivorous species can feed. The overall conclusions indicated that more soil organisms were negatively affected than benefited from the presence of *F. japonica*, suggesting that the invaders were a threat to biodiversity and ecological integrity, especially for coastal but also other invaded ecosystems. There is a lack of ecohydrological work even though *F. japonica* is usually found on riverbanks. Our results also suggested that research on the impact of invasive plants, including *F. japonica*, on soil organisms remains insufficient despite the importance of *F. japonica* in ecosystem processes and/or the potential possibility of using soil organisms in mitigating invasion. These gaps in our knowledge can lead to scepticism about the damage caused by invasive plants if not sufficiently supported by scientific research.

Key words: Biological invasion, *Fallopia japonica*, soil biota

Úvod

Invázia nepôvodných druhov rastlín je spoločne s klimatickými zmenami, nadmerným využívaním prírodných zdrojov a znečistením životného prostredia považovaná za najvážnejšiu hrozbu pre pôvodné ekosystémy (Pergl 2008). Výskyt inváznych druhov rastlín v ekosystéme je globálnym problémom, ktorý často vedie k environmentálnym zmenám. Lone et al. 2019 Invázne rastliny sú vysoko konkurencieschopné, vitálne a odolné voči stresu a nepriaznivým podmienkam, dokážu rásť na typovo odlišných lokalitách, často sa rozšíria v narušených biotopoch, kde dokážu vytvoriť homogénne monocenózy. Rýchlo sa rozmnožujú vegetatívne aj generatívne, vytvárajú množstvo semien, ktoré dobre klíčia. Kvety inváznych rastlín sa vyznačujú pestrejšou farbou, atraktívnejšou pre hmyz, čo taktiež napomáha k ich rozmnožovaniu (Vila et al. 2009). Vyskytujú sa vo väčších vzdialenostiach od materských rastlín, v novom prostredí majú zriedkavo a málo prirodzených nepriateľov, parazitov a sú odolné voči väčšine chorôb (Ružek & Noga 2015). Sú vážnym a narastajúcim celospoločenským problémom, pretože ich nekontrolované šírenie i zámerne rozširovanie prináša so sebou nielen environmentálne riziká spojené napr. so stratou biodiverzity, ale aj zdravotné riziká napr. alergie, popáleniny či ekonomické straty v poľnohospodárstve, lesnom hospodárstve, vodohospodárstve a podobne. Okrem toho, že invázne rastliny produkujú látky s alelopatickým účinkom vytvárajú aj veľké množstvo odumretej biomasy, ktorá často ostáva na napadnutých lokalitách. Pri rozklade tejto biomasy sa do pôdy uvoľňujú látky, ktoré menia fyzikálne a chemické vlastnosti pôdneho prostredia čo sa následne odráža na zmenách v zložení a zastúpení pôdnych organizmov (Lone et al. 2019).

Rod pohánkovec alebo krídlatka (*Fallopia* spp.) patrí do čeľade stavikrvovitých (Polygonaceae). Zahŕňa 12 druhov, pričom na Slovensku boli zaznamenané tri druhy: pohánkovec japonský (*Fallopia japonica* (Houtt.) Ronse Decr.) pohánkovec český (*F. x bohemica* (Chrtek et Chrtková) J. P. Bailey) a pohánkovec sachalínsky (*F. sachalinensis* (F. Schmidt) Ronse Decr.).

Fallopia japonica (Houtt.) Ronse Decraene syn. *Reynoutria japonica, Polygonum cuspidatum, Polygonum zyccarinii* (Weston et al. 2005) bola v roku 1999 označená za jednu zo 100 celosvetovo najnebezpečnejších inváznych druhov rastlín (International Union for the Conservation of Nature) pričom bol zohľadnený jej vplyv najmä na biodiverzitu a ľudské aktivity (Luque et al. 2014). *F. japonica* pochádza pôvodne z východnej Ázie (Japonsko, Južná Kórea, Čína a Taiwan). V čínskej medicíne sa odvar z jej koreňa a listov dodnes využíva pri liečbe zápalových ochorení, kardiovaskulárnych a cievnych chorôb (Stefanowicz et al. 2016; Patočka et al. 2017). Do Európy bola introdukovaná v 19. storočí ako medonosná a okrasná rastlina. Vyrastá do výšky 1,5 až 3,6 m. Má silnú, vzpriamenú a rozvetvenú stonku s 1 – 3 cm dlhými stopkami, na ktorých vyrastajú 5 – 12 cm dlhé a 5 – 8 cm široké vajcovité a na báze zrezané listy. Kvety sú v paklasoch usporiadané do zelenožltých metlín a kvitnú od augusta do septembra. Plodom je okrídlená, lesklá nažka tmavohnedej farby (Beerling et al. 1994;

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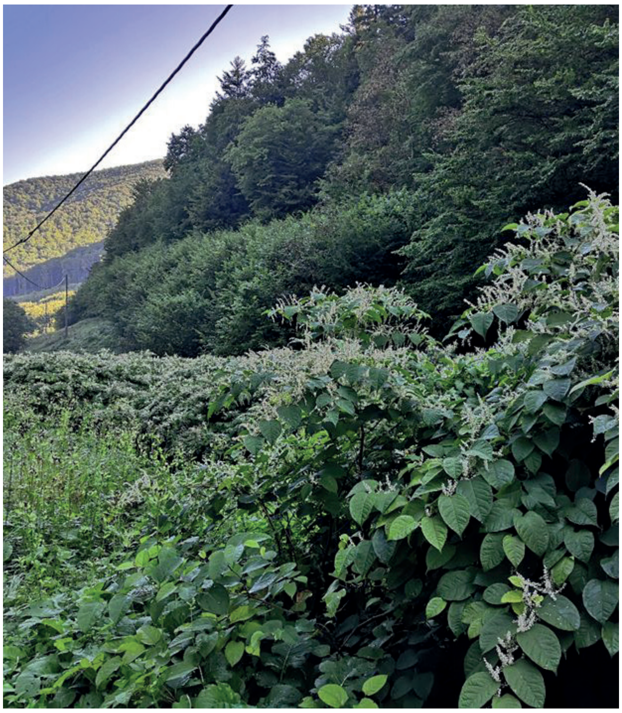

Obrázok 1. Súvislý porast pohánkovca japonského (*Fallopia japonica* (Houtt.) Ronse Decr.) na okraji lesa pri obci Opátka (Foto: Andrea Čerevková).

Obrázok 2. Rozšírenie pohánkovca japonského (*Fallopia japonica* (Houtt.) Ronse Decr.) v blízkosti ľudských sídiel v centre Košíc (Foto: Andrea Čerevková).

Prather et al. 2009), ktorá sa rýchlo šíri vetrom, vodou, prípadne ľudskou aktivitou. Najčastejšie sa rozmnožuje vegetatívne, pričom aj 1 cm úlomok koreňa je schopný prenosom napríklad vodou zakoreniť na brehu rieky a založiť nové husté porasty, ktoré dosahujú aj viac ako sto štvorcových metrov (Duquette et al. 2016). Často sa vyskytuje aj pozdĺž ciest a železničných tratí, ale aj v urbánnych oblastiach v centrách miest (Obrázok 1 a 2). Preferuje kyslé až neutrálne (pH = 4,0 – 7,4), hlinité alebo piesčité pôdy, ale všeobecne toleruje pomerne širokú škálu podmienok prostredia. Jej rozsiahly koreňový systém môže prerážaním asfaltu na cestách, chodníkoch a stenách spôsobiť vážne ekonomické škody (Prather et al. 2009; Sarajlić et al. 2016; Stefanowicz et al. 2016). Okrem toho monokultúry *F. japonica* menia úrodnosť pôdy a znižujú kvalitu ekosystémov, čím ovplyvňujú diverzitu pôvodných druhov rastlín a živočíchov (Gerber et al. 2008; Prather et al. 2009; Sarajlić et al. 2016). V tomto prehľadovom článku sumarizujeme poznatky o vplyve *F. japonica* na vybrané organizmy pôdnej mikro-, mezo- a makrofauny.

Vplyv *F. japonica* na pôdne mikroorganizmy

Medzi pôdne mikroorganizmy sa zaraďujú všetky organizmy, ktoré sa nachádzajú v pôde a sú menšie ako 0,2 mm. Patria sem baktérie vrátane aktinomycét, mikroskopické huby, riasy, bičíkovce, koreňonožce, nálevníky (Šimek et al. 2019). Ich primárnou funkciou je rozklad a mineralizácia organických látok, produkcia látok primárneho a sekundárneho metabolizmu, tvorba a odbúravanie humusových látok a fixácia vzdušného N_2. Pri štúdiu literárnych zdrojov bola v porastoch s *F. japonica* väčšinou pozorovaná vyššia abundancia, biomasa a druhová diverzita húb a prvokov na úkor abundancie a biomasy baktérií (Stefanowicz et al. 2016; Zubek et al. 2016). Keďže *F. japonica* vytvára nekvalitnú organickú hmotu, ktorá je chudobná na živiny a bohatá na lignín, jej rozklad je 3 až 4-krát pomalší ako rozklad rastlinnej biomasy pôvodných rastlín, čím sa spomaľuje cyklus organických látok v pôdnom prostredí. Takáto pomaly rozkladajúca sa mŕtva rastlinná biomasa akú vytvára *F. japonica* je uprednostňovaná pôdnymi hubami pred baktériami z dôvodu ich väčšej schopnosti mineralizovať rastlinné heteropolyméry a ich vyššej schopnosti využívať pôdny uhlík (Mincheva et al. 2014; Stefanowicz et al. 2016). Taníny, ktoré sú považované za antimikrobiálne látky a v podstielke *F. japonica* sa vyskytujú vo veľkom množstve, sú menej toxické pre huby ako pre pôdne baktérie. Suseela et al. (2016) uvádzajú, že rozklad organickej hmoty, ktorú produkuje *F. japonica* vo veľkom množstve si vyžaduje *špeciálne* enzýmy, ktoré produkujú iba niektoré pôdne huby. Autori zároveň naznačujú že pri obnove ekosystému okrem odstránenia invázneho druhu je pravdepodobne potrebná aj chemická úprava pôdy. Na druhej strane Stefanowicz et al. (2016) a Zubek et al. (2016) zistili, že aj niektoré mykorízne huby sú negatívne ovplyvňované prítomnosťou *F. japonica.* Pokles celkovej biomasy pôdnych mikroorganizmov, ktorý pravdepodobne súvisí s vysokým obsahom antimikrobiálnych látok v mŕtvej biomase pohánkovca uvádzajú aj autori Kumagai et al. (2005) a Stefanowicz et al. (2019).

Vplyv *F. japonica* na pôdnu mezofaunu

Do pôdnej mezofauny sa zaraďujú živočíchy s veľkosťou tela od 0,2 až 10 mm. Medzi najpočetnejšie skupiny patria vírniky, hlístovce, roztoče, chvostoskoky, ale patria tu aj šutky, vidličiarky, šťúriky a niektoré viacnôžky (Pauropoda, Symphyla) (Šimek et al. 2019). Živia sa pôdnymi mikroorganizmami, pletivami živých rastlín alebo živočíšnymi tkanivami, prípadne pôdnym detritom. Svojou trofickou aktivitou v pôdnom prostredí ovplyvňujú biomasu a aktivitu pôdnych mikroorganizmov, kolobeh živín a rozklad organickej hmoty. Tým, že sa živia mikroorganizmami a zároveň sú korisťou pre ostatné organizmy, tvoria významnú zložku pôdnej potravnej siete (Eisenhauer 2010). Prítomnosť porastov *F. japonica* na lokalitách znížila druhovú diverzitu a abundanciu bezstavovcov, napríklad roztočov a chvostoskokov (Gerber et al. 2008; Hapca 2013). Skubala & Mierny (2009) pozorovali na lokalitách s výskytom *F. japonica* o 22 % nižšiu abundanciu chvostoskokov a o viac ako 50 % nižšiu abundanciu roztočov skupín Oribatida a Astigmatina. Podľa autorov môže byť znížená abundancia fytofágnych druhov v porastoch s výskytom *F. japonica* spôsobená fenolovými zlúčeninami (tanínmi), ktoré obsahuje organická hmota produkovaná *F. japonica* vo veľkom množstve (Kawasakiho et al. 1986). Podľa Gulvik (2007) a Manu et al. (2021) práve roztoče radu Oribatida rýchlo a citlivo reagujú na zmenu vegetačného zloženia a sú dobrými ukazovateľmi narušeného a ochudobneného stavu pôdneho prostredia, ktoré je zároveň pod vplyvom stresu. Zníženie diverzity a abundancie fytofágnych a fyto-mykofágnych druhov hlístovcov vplyvom *F. japonica* a iba malý alebo žiaden vplyv na abundanciu bakteriofágnych, omnifágnych a dravých hlístovcov uvádzajú autori Čerevková et al. (2019) a Renčo et al. (2021). Pri experimentálnom sledovaní vplyvu pridaných vyšších koncentrácií sekundárnych metabolitov *F. japonica* na hlístovce, roztoče a chvostoskoky bola zistená vyššia abundancia najmä baktériofágnych druhov hlístovcov, roztočov a chvostoskov. Abundancia omnifágnych a dravých hlístice a podobne aj dravých roztočov (napr. Gamasida) nebola bez ohľadu na pridané koncentrácie sekundárnych metabolitov *F. japonica* ovplyvnená (Abgrall et al. 2018).

Vplyv *F. japonica* na pôdnu makrofaunu

Pôdna makrofauna je zastúpená živočíchmi s veľkosťou tela väčšou ako 10 mm. Patria tu mäkkýše, dážďovky, rovnakonôžky, mnohonôžky, stonôžky a iné stonôžkovce, pavúky, chrobáky, dvojkrídlovce, a ostatný hmyz. Tieto organizmy sa živia časťami rastlín a húb, drobnými živočíchmi alebo odumretými organizmami (Šimek et al. 2019). Svojou činnosťou drvia a rozkladajú organické látky, stimulujú mineralizáciu v pôde a ovplyvňujú humifikáciu a úrodnosť pôdy, čím podporujú pôdnu mikroflóru, aktivitu mikroorganizmov a tok energie v pôde (Szyszko-Podgórska et al. 2018). Ich rozmanitosť a početnosť pomáha zvyšovať pôdnu heterogenitu, čo napríklad zvyšuje odolnosť rastlín voči škodcom a odolnosť pôdneho prostredia voči narušeniu a nerovnováhe (Brown et al. 2001). Negatívny vplyv *F. japonica* na organizmy pôdnej makrofauny bol zaznamenaný napríklad v zníženej abundancii a diverzite dravých aj fytofágnych chrobákov. Naopak abundancia dravých koscov, bola na lokalitách s výskytom *F. japonica* vyššia ako na kontrolných lokalitách, a to pravdepodobne z dôvodu zjednodušenia vegetačného spoločenstva, ktoré vzniklo vplyvom invázie (Topp et al. 2008). Na invadovaných lokalitách sa pozorovala aj vyššia abundancia detrivorných mnohonôžok a rovnakonôžok ako na kontrolných lokalitách (Kappes et al. 2007). Johnson et al. (2019) uvádzajú, že *F. japonica* produkuje na začiatku vegetačného obdobia nektár, ktorý je bohatý na fruktózu a glukózu, a tým priťahuje dravé mravce (napr. druh *Myrmica rubra* (Linnaeus, 1758)), ktoré následne konkurujú herbivorným chrobákom. Prítomnosť *F. japonica* v porastoch spôsobuje aj zníženie abundancie herbivorných ulitníkov (Kappes et al. 2007). Negatívne ovplyvnené sú najmä veľké a dlho žijúce druhy slimákov (napr. slimák záhradný - *Helix pomatia* Linnaeus 1758) alebo baculka obyčajná - *Bradybaena fruticum* Müller, 1774) (Stoll et al. 2012).

Záver

F. japonica vytvára husté porasty s bohatým koreňovým systémom, čím lokálne znižuje druhovú diverzitu rastlín. Vytvára tiež odumretú biomasu, z ktorej sa pri rozklade uvoľňujú látky spôsobujúce zníženie pôdneho pH, čím sa menia nielen chemické vlastnosti pôdy, ale aj zastúpenie živých organizmov. Účinok *F. japonica* na pôdnu faunu závisí ako od sledovaného druhu pôdneho organizmu, tak aj od ďalších faktorov napríklad od chemických a fyzikálnych vlastností pôdneho prostredia, typu ekosystému, klímy, veku porastov a pod. Aj keď väčšina sledovaných pôdnych organizmov reagovala na prítomnosť *F. japonica* negatívne, poklesom abundancie a diverzity (roztoče, chvostoskoky, väčšina chrobákov), niektoré, najmä detritvorné druhy (napr. pôdne huby, niektoré článkonožce) boli ovplyvnené menej. Znížená diverzita rastlín, a teda aj potenciálnej potravy má vplyv na abundanciu a druhovú diverzitu fytofágnych druhov živočíchov (napr. fytofágnych hlístovcov a chrobákov). Následne nižšia abundancia koristi vedie k zníženej abundancii predátorov, aj keď v prípade dravých koscov to neplatilo.

Celkové závery ale naznačujú, že negatívne ovplyvnených pôdnych organizmov je viac ako tých ktorým prítomnosť *F. japonica* prospieva, a preto sa domnievame, že *F. japonica* je hrozbou pre biodiverzitu a ekologickú integritu, pobrežných, ale aj iných invadovaných ekosystémov. Môže spôsobovať vyhynutie pôvodných druhov a viesť k zmenám v štruktúre spoločenstiev pôdnych organizmov. Tento prehľad sa pokúša zdôrazniť nedostatočné vedomosti o vplyve *F. japonica* na biodiverzitu a ekologické procesy v pôde. Hoci sú pomerne dobre známe účinky na pôdne mikroorganizmy najmä huby, baktérie a niektoré článkonožce, vplyv na iné skupiny pôdnych organizmov sú takmer neznáme. Zaujímavým výsledkom tohto prehľadu je takmer úplná absencia ekohydrologických prác napriek tomu že *F. japonica* sa vyskytuje najmä na brehoch riek, kde okrem iného často spôsobuje aj pôdnu eróziu.

Všetky spomínané štúdie sa uskutočnili v európskych a amerických regiónoch, pričom väčšina štúdií mala lokálny charakter, preto je potrebné overiť pozorované účinky na živé organizmy aj v širšom rozsahu vo väčších nadnárodných štúdiách a zistiť do akej miery má *F. japonica* vplyv na pôdne organizmy a zároveň na životné prostredie. Nedostatok výskumu vplyvu inváznych rastlín vrátane *F. japonica* na biodiverzitu môže živiť skepticizmus o škodách spôsobených inváziou rastlín pokiaľ nie sú dostatočne podložené vedeckou literatúrou.

Poďakovanie

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Original paper

Sex determination of eurasian woodcock (*Scolopax rusticola* L.) by genetic and imaging diagnostic methods

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Abstract
In the study of the behavioural ecology, migration, and habitat use of the Eurasian woodcock (*Scolopax rusticola* L.), the knowledge of sexes would be of great importance. In our work, we tested the sex determination possibilities - in terms of practicality, reliability, and cost-effectiveness - and developed a protocol for professionals dealing with woodcock that is easy to implement in the field and offers reliable sex determination without damaging the captured birds. While evaluating the applicability of each method, we compared the genetic sex determination procedure using blood and feather samples with the X-ray, ultrasound, and endoscopic sex determination possibilities of birds. For our study, blood and feather samples were collected from birds with known sex (dissected birds) in the vicinity of Sopron (Hungary) during autumn ringings and spring hunts. In terms of sampling and taking into consideration the stress affecting the birds and the cost-effectiveness as well, the analysis of DNA samples from feathers and blood proved to be the most favourable. Sex determination was 100% successful for both type of samples. The field sampling methodology required for the genetic analysis and proposed by us is simple, fast and gentle, easy to master, and at the same time, based on itsresults, DNA of suitable quality and quantity can be obtained for geneticsex determination. DNA can be isolated from freshly taken feather samples with high reliability, so we recommend that this easy-to-collect, well-stored sample type should be used in large sample population genetic analysis instead of difficult-to-store muscle tissue samples.

Keywords: molecular sexing sex determination, sampling procedure, blood sampling, feathers DNA, blood DNA, wading bird

Introduction

In the case of woodcock, there are just slight differences between sexes, so it is hard to separate them based on their appearance traits, plumage colouration and markings as well as leg colour are useless as sexual characteristics (Clausager 1973; Cramp & Simmons 1983; Ferrand & Gossman 2009). However, knowledge of sex would be of great importance in migration research and behavioural ecology studies because the behavioural patterns of males and females are different (Clausager 1973; Cramp & Simmons 1983). Clausager (1973) was the first to point out the usability of the quotient of central feathes of tail and beak length. Subsequently, a number of studies (McCabe & Brackbill 1973; Glutz von Blotzheim 1977; Artmann & Schroeder 1976; Rochford & Wilson 1982; Hoodless 1994; Sorace et al. 1999; Ferrand & Gossmann 2009; Aradis et al. 2015) have been carried out to determine sex based on individual body sizes (e.g., bill, tail, wing measurement, body weight), but based on these, genders cannot be distinguished with sufficient reliability. According to Glutz von Blotzheim (1977) a woodcock with a beak longer than 77 mm and a tarsus longer than 38 mm is most likely to be a female, but no information is given on the reliability of this method.

Stronach et al. (1974) used a binary regression formula to separate the sexes according to the length of the beak and tail. Their results show that the model can be used with 72% reliability for males and 75% for females. The probability of error was 28% if young birds were included in the analysis. Birds less than 12 months of age may have been excluded by examining the tips and proximal edges of outer primaries (ragged outline on first years; smooth on older birds, at least until April) and the terminal lighter bar on primary coverts (broader and browner on young birds). When all birds that had not yet undergone full molting were excluded, an accuracy of around 95–98% was achieved (Shorten 1975). In a similar study, Ferrand & Gossmann (2009) obtained worse results. Their results showed that males on average had shorter bills and longer tails than females. The authors pointed to the fact that there was so much overlap between the data that it was impossible to reliably determine the sex of the majority. They propose several criterions for sexing using bill, tail length and their ratio for both adult and juveniles. However, they also pointed out that method does not allow sexing to be more accurate than 45% for adult birds and 25% for juveniles.

Detailed statistical studies based on differences in morphometric data — linear models, discriminant and principal component analysis — did not provide definite results for other Charadriiformes species either (Remisiewicz & Wennerberg 2006; Schroeder et al. 2008).

According to Hoodless (1994), the difference in body weight between the sexes in the laying phase of the nesting period may be suitable for sexing some individual woodcocks, but Aradis et al. (2015) reported that the method is not sufficiently reliable even in this narrow time interval.

Furthermore, Aradis et al. (2015) reported that discriminant function analysis applied to a set of selected morphometric traits did not achieve 80% confidence in

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the case of juvenile and even adult woodcocks (79.6% for females and 77.1% for males).

In the course of our study, we looked for an easy-to-apply, low-cost, yet highly reliable method of sex determination in the field, comparing it with other alternative sex determination options, the applicability of which could also be considered in the case of woodcock. The procedures tested were ultrasound, X-ray, and invasive endoscopic analyses, as well as genetic sex determination from feather and blood samples. In the case of birds equipped with a high-value radiotelemetry transmitter, knowledge of the sexes during migration or in the evaluation of the data concerning habitat use would be particularly important in order to understand how males and females differ in their behaviour patterns.

Unfortunately, either in the case of birds equipped with transmitter or in the case of ringed birds, the sex is generally unknown, despite the fact that turning ups often involve the death of birds, and destructive procedures could be used. Due to the problems detailed above, it would be useful to determine the sex of the birds at the time of marking, so that we can get to know this species better by having sex-differentiated data sets.

Material and method

Sampling

The cover net method used to catch living woodcock has long been known in the ornithological literature (Bub 1996). But it was first used for woodcock only in 1976 (Mansoori 1977), despite the fact that this method proved successful as early as 1939 in the case of American woodcock (*Scolopax minor* L.) (Merovka 1939). The method became widely general in France first (Gossmann et al. 1988; Ferrand & Gossmann 1989, 1990; Gossmann & Ibanez 1991), and has been used in Hungary since the 2000s. At night, birds feeding in the open, typically on short-grass land, are searched for and captured with the help of a reflector and cover net/drop net (Glasgow 1958) (Figure 1).

Figure 1. Woodcock catch with cover net method in the field of Sopron Mountain (Photo: A. Bende).

During the live capture, we searched for feeding woodcocks around Sopron (Hungary, Coordinates: 47.644599, 16.579262) with the help of a 1300 lumen reflector and a thermal imaging camera (Pulsar Axion Xm38), and then approached the continuously illuminated bird, covering it with a 1-meter diameter net attached loosely to its frame at the end of an 8-meter-long telescopic rod.

For the success, it was crucial that the catchers worked well together, standing behind the light source from beginning to end, and that the cover net was above the light beam until the last minute, otherwise, the bird would easily notice the device and fly away.

After capture, blood was drawn from the wing vein *(vena cutanea ulnaris)* according to the blood sampling protocol for small birds (Owen 2011), for which the feathers on the upper arm were not removed, only smoothed with wet cotton wool to make the vein clearly visible. Blood samples were taken with a 2 ml syringe and a 25G needle. Due to the high venous pressure and thin skin, a smaller hematoma may develop around the blood collection area, so after the blood collection, the bleeding was tamponed with dry sterile cotton wool while keeping the bird in a stable position, so the bleeding stopped quickly and the bird was able to be released after a few minutes. The amount of blood drawn was approximately 0.5–1 ml, which contains enough DNA for a successful genetic analysis (Harcourt & Brown 2000) (Figure 2).

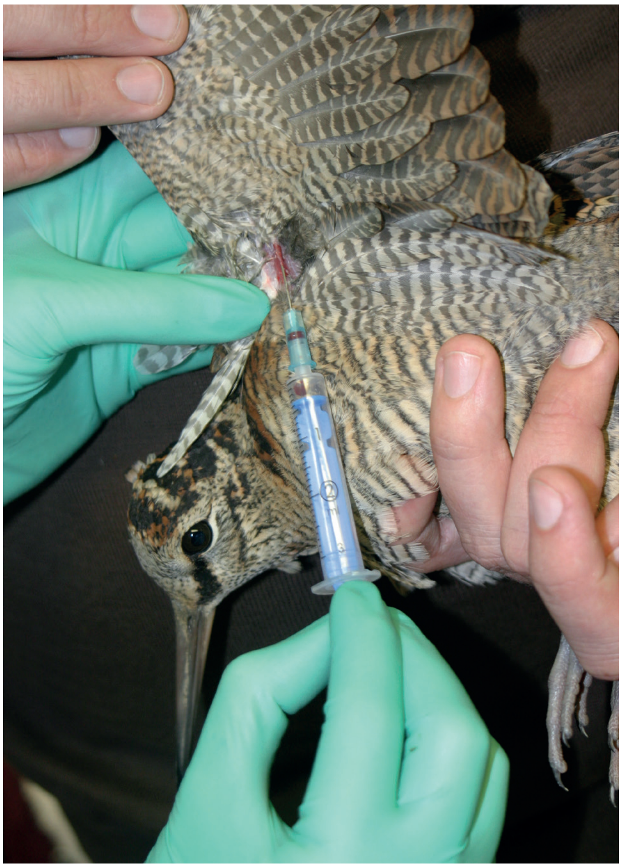

Figure 2. Blood sampling from the wing vein of the Woodcock (vena cutanea ulnaris) (Photo: A. Bende).

The blood sample was collected in a syringe and in blood collection tubes filled with anticoagulant (Na-EDTA) solution used in haematology test. Autumn samples were stored refrigerated (5 °C) for 5 days, while spring samples were stored frozen (-20 °C) for several months as an effect of delayed processing due to the pandemic situation. In our experience, the efficiency of the method was not affected by any of the applied sample storage methods, as the sex determination could be performed with 100% success in the case of blood samples stored for a short time without anticoagulant solution and even in the case of Na-EDTA blood samples frozen for months. To prevent DNA degradation, if analyses cannot be performed within a few days, it is recommended that the samples should be frozen. The feather samples required for genetic analysis were also collected from the primaries of birds bagged in March during the spring sampling in the Sopron area, which contained enough blood for the study.

Vili et al. (2009) found that fresh feathers were best suited for sex determination because in the case of shed feathers the quality of extractable DNA deteriorates sharply in a few months. Feather samples (3 scapulars from each bird) were stored in the same manner and for the same time as blood samples until genetic analysis. For genetic analysis, the superior umbilicus was removed with a scalpel to make the blood on which DNA extraction is based available (Horváth et al. 2005). The wing feathers and blood samples were not collected from the same birds, but the sex was known in all cases because the samples were collected from birds taken during the hunt.

For the dissection, we used woodcocks captured during the hunt for monitoring purposes. The woodcock can be hunted for research purposes in Hungary during the spring migration of the species in accordance with the law 79/2004. (V. 4.) FVM, appendix 1. Blood and feather samples collected from these birds provided an opportunity to verify the genetic identification method. They have also been used as a reference in imaging laboratory diagnostic tests to verify the reliability of each method tested.

By virtue of the fact that the research is conducted on wild species, we acted in accordance with Section 1§ 4 (f) of Government Decree 40/2013 (14.II.) on the regulation of animal experiments, which states that the research does not qualify as animal experimentation, and therefore does not require a permit.

Sex determination by genetic methods

The performed genetic analysis is based on different sex chromosomes, because in the case of birds, the females have heterogametic (WZ) and the males have homogametic (ZZ) sex chromosomes. With the help of the applied method, individual sexes can be separated by detecting sequences specific for the W chromosome, because in the female sex - in the case of most species - the so-called CHD-W gene binding to W encodes a chromo-helicase DNA binding protein (Griffiths & Tiwari 1995). In males Z-chromosome-binding version (CHD-Z) is also known. These sex-linked genes are located outside the recombinant pseudoautosomal region of the sex chromosomes, so they are least variable and, due to this property, suitable for defining sexes (Fridolfsson & Ellegren 1999). In our analysis, DNA samples from a total of 20 birds were extracted from blood samples (n=5 captured alive bird [November 2019.] n=15 hunted bird [March 2020.]) by the conventional salting out method modified for birds (Bodzsar et al. 2009; Miller et al. 1988). The DNA isolation protocol of the collected feather samples (20 individuals, 3 feathers from each bird) differed in that the bloody feather ends had been added directly to the seed lysis-SDS mixture (Bodzsar et al. 2009) by adding proteinase-K enzyme, followed by a so-called digestion process (56 °C, overnight). Concentrations of DNA samples were measured using a Nanodrop 2000 spectrophotometer (Thermo Fisher Scientific). Then, they were equalized to 20 ng/µl density and stored frozen at -20 °C until further use. DNA-based sex determination was performed using the P2/P8 primer pair designed by Griffiths et al. (1998), which amplifies DNA fragments of different sizes on the aforementioned CHD-Z and CHD-W (Chromobox-Helicase-DNA-binding) genes; this results in a fragment of one size in the male sex and two in the female. The final volume of 15 uL master mix contained 10x Dream Taq Buffer with 20mM $MgCl_2$ (Thermo Fisher Scientific), 5 µM primer, 25mM dNTP mix (Thermo Fisher Scientific), 20 mg/ml BSA (Bovine Serum Albumin, Thermo Fisher Scientific), 5U/µL Taq DNA polymerase (DreamTaq DNA polymerase, Thermo Fisher Scientific) and 100 ng genomic DNA. PCR profile was determined according to the protocol reported by Griffiths et al. (1998) with some modifications: 95°C for 4 min denaturation followed by 30 cycles of amplification: 94°C for 30 sec, 48°C for 45 sec and 72°C for 45 sec and final extension at 72°C for 5 min (Kyratec Trinity Supercycler). The PCR products were detected on 1.5% agarose gel (Bio-Rad) using 10000x GelGreen® nucleic acid stain (Biotum) with gel electrophoresis.

Imaging diagnostic procedures

The imaging laboratory diagnostic procedures were tested on individuals from which blood and feather samples were obtained (n=15 hunted bird, n=5 captured bird). Endoscopy was performed on non-living birds (n=4) that were also hunted during spring sampling.

The possibility of physical analysis of the reproductive organs of birds is greatly limited due to their physiological and anatomical features. As an alternative, the applicability of widespread imaging diagnostic procedures (ultrasound, X-ray, and invasive endoscopy) to determine the sex of the woodcock is brought up. The analysis necessary for the evaluation and comparison of the methods were performed by veterinarians dr. László Boa and dr. Fanni Molnár.

For the **X-ray analysis** at the Sopron Veterinary Center, we used a Gierth RHF 200 ML portable X-ray machine with Jungwon Precision Ind. Co. LTD X-ray cartridges and green-sensitive intensifying screens (speed: 400) with Retina XOE green-sensitive films. In the ventrodorsal position, the bird was placed with its back on the cassette, with wings fixed to the side, legs pulled slightly back and to the side, and head turned to the side and fixed at the jaw joint. In the latero-lateral position, pictures were taken, with the wings of the birds placed consistently to the right, folded out, and fixed above the body in the direction of the back. Taking latero-lateral radial images in the case of live wild birds may even lead to spontaneous respiratory arrest due to the increased stress situation, so the study should be performed with caution (Molnár et al. 2007).

For **ultrasound diagnostic analysis**, a Mindray Digiprince DP-6900 Vet mobile ultrasound device with a micro-convex transducer at 8.5 MHz was used at the Sopron Veterinary Centre. The analysis method was tested on freshly captured woodcocks during spring sampling. There are only two areas on the body that provide a suitable echo-window for the analysis. These are the ventromedial part of the abdominal wall between the processus xiphoideus of the sternum and the pelvic bone, and in the parasternal direction on the dorsolateral side of the abdomen between the femoral joint and the last rib arch (Beregi 2007). In our own analysis, we examined the body cavity of the woodcock using a probe behind the caudal end of the sternum in the dorsally laid birds, slightly to the right of the midline, thus bypassing the gizzard, which degrades the quality of imaging due to the food residues it contains.

Invasive endoscopy is an expensive procedure that can also be used in wild bird research, one of the indications of which is typically the separation of the sexes in bird species without sexual dimorphism. In most bird species, only the left ovary, including fallopian tube, develops, so the standard endoscopic entry site is situated on the right side. The body cavity of the bird placed in the lateral position was penetrated behind the last rib, below the musculus flexor cruris medialis muscle and the os pubis, in front of the cranial edge of the vastus muscle (Taylor 1994). For the analysis of live birds weighing around 300 g, isoflurane anaesthesia without premedication is recommended; it is used successfully in the vast majority of bird species (Sós et al. 2007). The woodcock endoscopic analyses used in the comparison were performed on four specimens by dr. László Boa at the Veterinary Clinic of the Budapest Zoo & Botanical Garden with a Karl Storz type rigid endoscope, with a viewing angle of 0–30 degrees and a diameter of 2.7 mm.

Results and Discussion

Sex determination from feather and blood samples

Genetic analyses are gaining ground in ornithological research, but they are still not considered commonplace. One common type of genetic analysis targets sex determination (Fridolfsson & Ellegren 1999; Hipkiss et al. 2002), as many bird species have no visible sex dimorphisms. In the case of woodcock, the possibilities of the separation of sexes by genetic methods have also been studied (Väli & Elts 2002; Vučićević et al. 2012). However, these studies do not approach the issue from a field applicability perspective. Non-invasive sampling can be carried out without significant disturbance of the analysed specimens, but at the same time in the case of the woodcock - since it is a rare nesting species in Hungary, appearing in larger numbers only during its autumn-spring migration (Hadarics & Zalai 2008) - finding moulted feathers is uncertain, and the DNA obtained from them is of poorer quality than the sample obtained by blood sampling after capturing the animals during the semi-invasive procedure (Taberlet & Luikart 1999). In all cases, usable amounts and qualities of DNA could be extracted from the blood samples we collected, stored, and processed, so sex determination was successful in all cases. Of the 20 samples, 8 proved to be females and 12 specimens to be males (Figure 3).

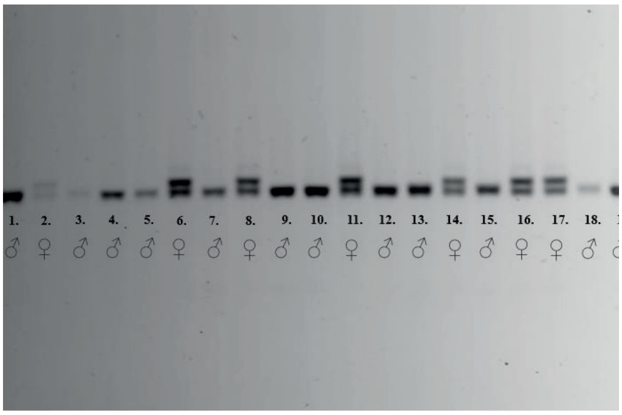

Figure 3. Sexes detected as a result of gel electrophoresis from blood samples during the PCR reaction used (Photo: N. Pálinkás-Bodzsár).

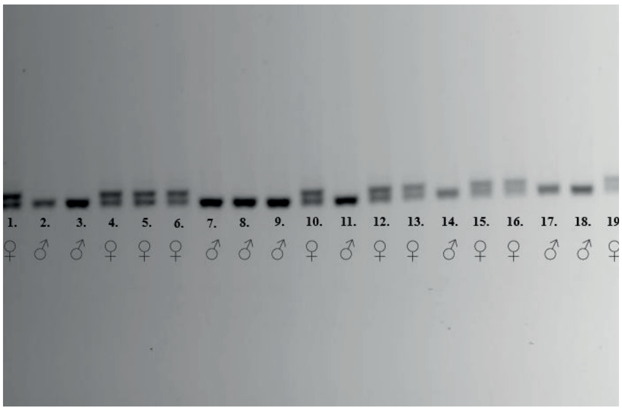

Figure 4. Sexes detected as a result of gel electrophoresis from feather samples during the PCR reaction used (Photo: N. Pálinkás-Bodzsár).

The method is recommended for ringing, and for determining the sex of birds marked with a telemetry transmitter. The sampling method can be mastered with a little practice, and the collection of samples does not require significant equipment, so the procedure can be carried out easily and safely in the field during the marking. In the case of feather samples, all PCR reactions were

evaluable during sex determination. Of the 20 samples analysed, 11 were females and 9 were males (Figure 4).
Efficiency is greatly enhanced by DNA extraction from fresh feather samples (Väli & Elts 2002), but at the same time removal of primaries from live birds is not recommended due to the significant stress effect.
Based on our results, fresh feather samples after hunting utilization may be optimal for genetics studies, since sufficient quality and amount of DNA can be extracted from the samples for analysis and sampling does not require special training and sampling equipment, so a wide range of data providers can be included in the sampling. The easily collected, deep-frozen, easy-to-store feather samples could be used to replace muscle tissue samples collected in a 2 ml "Micro test tube" with 70% concentration of ethyl alcohol, in Hungary in 2015 during the National Eurasian Woodcock Monitoring Program.

Figure 5. Ventrodorsal radiological recording of the Eurasian woodcock (Scolopax rusticola L.) (Photo: A. Bende).

Imaging diagnostic procedures
The applicability of these methods is significantly influenced by the age of the birds to be analysed and the time of the analysis, since the possibility to detect juvenile or inactive adult gonads by imaging diagnostic procedures is severely limited. The juvenile ovary is flat, elongated, finely granular in structure, and during maturing the similarity to a bunch of grapes due to the differently developed follicles will become more and more dominant. Fully or almost fully developed eggs also increase the chances of sex detection. Juvenile testicles are better visualized as they stand out more, so even both gonads can be identified on the images. Based on the above, these abdominal organs can be analysed with radiological methods with greater success in the sexually active phase and in adults due to their hyperplasia.
During the **X-ray analysis**, the dense plumage covering the body and the internal organs having prominently indistinguishable contrasts made the evaluation of radiological recordings more difficult (Figure 5). In the recordings, even the gizzard is not always a reliable orientation point, since in the case of woodcock it rarely contains solid mineral parts of lime structure. Molnár et al. (2007) found that gonads between the lungs and kidneys had been observable only occasionally. In our X-ray analysis, we were able to successfully determine the sex of the specimen in only a few cases. While analysing a live bird, proper fixation is a basic criterion for successful recording, which must be done very carefully, taking into consideration the stress sensitivity generally characteristic of wild birds. Based on the above, due to its low reliability, this method is not recommended for determining the sex of the woodcock.

Ultrasound diagnosis is of less importance in birds than in mammals for anatomical reasons. This is explained in part by the dense plumage and in part by the abdominal and anterior/posterior thoracic air sacs systems with high air content in the bodies of birds, and the intestinal tract with the gizzard, which also significantly reduces the quality of ultrasound imaging. According to Faragó et al. (2000) results, in the case of woodcocks weighing about 350–400 g, the gonads (paired testicles of several centimetres and ovaries with a few millimetres of well-developed follicles and oocyte) are quite small and difficult to image even in the state of sexually active hyperplasia. It is likely that eggs formed in the fallopian tube, especially in the advanced state of egg development, are clearly visible during ultrasound imaging. The performed analyses have shown that the applicability of the non-invasive ultrasound procedure is limited. In the case of the analysed woodcocks (n=20), in no case was the genital organ recognized with complete certainty.

Invasive endoscopy analyses were previously performed by dr. László Boa, during which the genitals could be well visualized in all cases (n=4), which proves that endoscopy would be an applicable procedure for the clear determination of the sexes in the research of the woodcock. It is an invasive procedure that can be used with relatively little risk; it is safe, and provides immediate results, with the disadvantages of anaesthesia and high infrastructure requirements, which cannot be provided in all cases and not necessarily immediately and is a significant cost. Bleeding may be mentioned as a risk factor, which in part impairs visibility and in part may endanger the analysed individual. In case

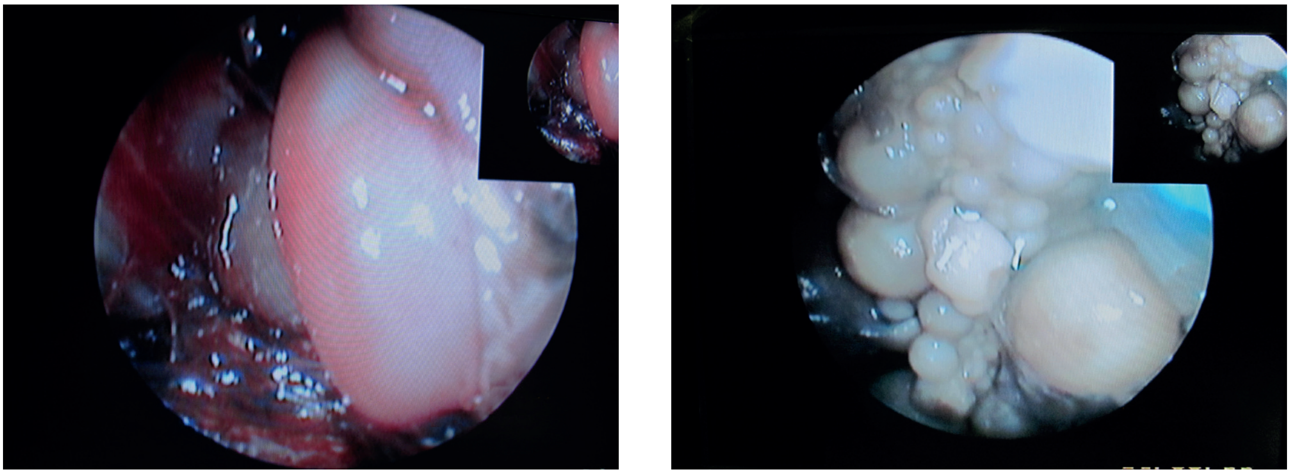

Figure 6. Invasive endoscopic analysis of the Eurasian woodcock (*Scolopax rusticola* L.). a) shows the female´s reproductive organs, b) the male's reproductive organs (Photo: L. Boa).

of bleeding, the analysis should be interrupted to clean the optics and to detect the location of the bleeding. The advantage of the method is mentioned by Sós et al. (2007) that the coelomic cavity of birds is relatively resistant to bacterial infections, so the likelihood of septic complications is minimal. However, in our view, the practical applicability of the method is limited given its high infrastructural and anaesthetic needs, the stress affecting the captured birds, and also the costs (Figure 6a, b).

Proposed sampling and sex determination procedure

We recommend an easy-to-perform, easy-to-learn protocol for sex determination in the following terrain during ringing and telemetry transmitter marking of the woodcock:

Take blood after capturing the woodcock with a cover net in addition to the data recorded during the usual ringing; this requires two people. One keeps the bird stable, while the other draws a few drops of blood (0.5 to 1 ml) from its wing vein *(vena cutanea ulnaris)* with a 2 ml syringe and a 25G needle, according to the sampling protocol for small birds.

Do not remove feathers from the blood collection area; smoothing aside with 70% alcohol cotton wool will make the vein clearly visible.

Keep the bird stable, as the bird trying to escape can be easily injured, and high venous pressure around the blood collection area can cause hematomas. After blood collection, the bleeding is tamponed with 70% alcohol cotton wool so that the bleeding stops quickly and the bird can be released after a few minutes.

The blood sample can be stored in blood collection tubes filled with anticoagulant (Na-EDTA) solution or even in a sampling syringe. Chilled (5 °C) samples should not be stored for more than a week. Frozen (-20 °C) samples can be stored for up to months without DNA damage. The genetic laboratory will perform sex determination from blood samples within a few days to make the sex of the marked live birds known, allowing gender-differentiated processing of research results.

Removal of feathers from live birds is not recommended. Fresh samples of feathers, which are suitable for population genetics studies with a large number of elements, should be collected after the hunt. These feather samples could be used to replace muscle tissue samples that are difficult to collect and store.

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Abstrakty 3. ročníka Študentskej vedeckej a odbornej činnosť (ŠVOČ) Katedry ekológie

Katedra ekológie, Fakulta humanitných a prírodných vied Prešovská univerzita v Prešove

27. apríla 2023

Zoznam príspevkov

Silvia Karin Tkáčová* & *Stanislav Kowalski
Kvantitatívne parazitologické vyšetrenie pôvodcu nozematózy (*Nosema* spp.) a vhodnosť aplikácie tymolu pri profylaxii včely medonosnej (*Apis mellifera*)

Dominika Hadbavná* & *Peter Manko
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Obrázok 1. Spoločná fotografia súťažiacich na ŠVOČ 2023 Katedry ekológie (Foto: L. Demková).

Prezentované príspevky hodnotila Rada KE FHPV ŠVOČ v zložení: A. Eliašová, J. Fedorčák, J. Koščo, J. Oboňa, L. Bobuľská, R. Mariychuk. Abstrakty prezentovaných vedeckých prác boli následne recenzované dvomi nezávislými recenzentami.

Kvantitatívne parazitologické vyšetrenie pôvodcu nozematózy (*Nosema* spp.) a vhodnosť aplikácie tymolu pri profylaxii včely medonosnej (*Apis mellifera*)

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Abstrakt
V práci sme sa venovali kvantitatívnemu parazitologickému vyšetreniu pôvodcu nozematózy (*Nosema* spp.) za pomoci mikroskopovania rozterov abdomenov 10 náhodne vybraných včiel. Naším cieľom bolo vyhodnotiť adekvátnosť aplikácie tymolu pri liečbe včely medonosnej (*Apis mellifera* Linnaeus, 1758) v závislosti od ročného obdobia. Počas prvého kvantitatívneho vyšetrenia (február 2023) sme zistili, že až 14 z 20tich úľov (70 % prevalencia) bolo nakazených nozematózou. Iba v dvoch včelstvách boli evidentné klinické príznaky tohto ochorenia (pokalené plásty a letáče) bez zaznamenaného úhynu včelstiev. Druhé kvantitatívne vyšetrenie (apríl 2023) na prítomnosť pôvodcu nozematózy preukázalo, že včelstvá, ktoré napriek výskytu nozematózy dokázali prežiť náročné zimné obdobie, sa počas teplých jarných dní samozbavili infekčnej záťaže (0 % prevalencia) očisťovacími preletmi a posilnili svoju imunitu výdatnou peľovou znáškou – nezaznamenali sme žiadnu výraznú záťaž včelstiev týmto ochorením. Došlo teda k podstatnému zlepšeniu zdravotného stavu bez preventívneho použitia tymolu. V súvislosti s liečbou nozematózy je nutné zohľadniť aj nežiadúce účinky tymolu, keďže jeho aplikácia môže negatívne ovplyvňovať imunitné procesy vo včelstve. Preto konštatujeme, že tymol je vhodné aplikovať ako preventívnu liečbu až v závere včelárskej sezóny (v mesiacoch júl/august), teda v období, kedy sa vyvíja dlhoveká generácia včiel. Toto ošetrenie by malo byť vždy spojené aj s kvantitatívnym parazitologickým vyšetrením (realizované pred a po aplikácii tymolu), pomocou ktorého by sme dokázali stanoviť mieru účinnosti tohto ošetrenia.

Kľúčové slova: včela medonosná, nozematóza, kvantitatívne parazitologické vyšetrenie

Poďakovanie: Naše poďakovanie patrí všetkým, ktorí akokoľvek prispeli k vzniku tejto práce.

Ochrana subteránnych habitatov z pohľadu nálezov vzácnych a ohrozených druhov

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Abstrakt
V práci sa venujeme štúdiu špecifického subteránneho biotopu opustených baní, v ktorom sa nachádza množstvo zaujímavých organizmov. Je známe, že veľké podzemné habitaty sú dôležitými rezervoármi biodiverzity. V práci prezentujeme výsledky získané v modelovom území Gelnica – Turzov, kde sme v troch opustených štôlňach zaznamenávali environmentálne premenné a zbierali vzorky fauny v období 09/20-09/21. V našich zberoch sme okrem množstva iných druhov zaznamenali 5 druhov nových pre Slovensko (*Bolitophila spinigera*, *Mycomya brunea*, *Mycomya trivitata*, *Rymosia cottii*, *Mycetophila lubomirskii,* všetko Diptera: Sciaroidea), vzácny druhu *Culiseta glaphyroptera* (Diptera: Culicidae), vzácneho karpatského endemita *Paranemastoma kochi* (Arachnida: Opiliones), veľkú populáciu chránených obojživelníkov (*Salamandra samňlamandra*) a štyri druhy netopierov (*Myotis myotis*, *Myotis daubentonii*, *Rhinolopus hipposideros*, *Plecotus auritus*). Naše zistenia potvrdzujú, že aj umelé (antropogénne) subteránne habitaty sú z pohľadu biodiverzity a ochrany veľmi dôležité. Na základe získaných výsledkov by nami študované biotopy mali mať vyššiu prioritu v programoch ochrany, keďže v súčasnosti dochádza ku negatívnym zásahom ovplyvňujúcim populácie chránených a vzácnych druhov. Neoprávnené vstupy (štôlne Boží dar, Mokré pole) a rozvoj turizmu (rekonštrukcia vnútorných priestorov, organizované hromadné návštevy v štôlni Jozef) spôsobujú ničenie habitatov a rušenie stavovcov aj bezstavovcov, čo môže vplývať na zloženie spoločenstiev a najmä v období hibernácie zvyšovať mortalitu živočíchov. Okrem týchto faktorov sa objavili snahy o ďalšie komerčné využívanie opustených baní na študovanej lokalite, čo by v ešte väčšej miere ovplyvnilo faunu týchto biotopov. Je zrejmé, že rozhodnutia o tom, ktoré areály chrániť, často zahŕňajú protichodné záujmy viacerých záujmových skupín a ochranárske záujmy sú najmä v umelých (antropických) habitatoch prioritou iba výnimočne. Snaha o ochranu by sa preto mala zameriavať na podzemné biotopy ako celok a navrhnúť alternatívnu schému hodnotenia relevantnosti, ktorá by mohla pomôcť zjednodušiť hodnotenie a nasmerovať viac zdrojov na účinnú ochranu podzemnej biodiverzity.

Kľúčové slova: podzemné habitaty, opustené bane, faunistika, biodiverzita

Poďakovanie: Práca vznikla s podporou projektu APVV-20-0140.

Vybrané ekologické a biologické aspekty rýb rodu karas v povodiach Slovenska

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Abstrakt

Cieľovým druhom tejto práce je invázny a nepôvodný druh – karas striebristý (*Carassius gibelio* Bloch 1782) patriaci do komplexu *C. auratus*. Pre tento druh je charakteristická sexuálna reprodukcia (gynogenéza, hybridogenéza). Cieľom našej práce bolo stanovenie kondície, vekovej štruktúry a ploidnej úrovne jedincov druhu *C. gibelio* pochádzajúcich z chovných rybníkov (Hrhov, Iňačovce). Ploidná úroveň jedincov bola odhadnutá z dĺžky jadier erytrocytov jedincov voči krvnému štandardu (*C. auratus*). Vo vzorke 50-tich jedincov boli zastúpené vekové kategórie 1+ až 4+. Dominovala veková kategória 3+ (48%) a najmenej zastúpená bola kategória 4+ (2%). Veková štruktúra jedincov *C. gibelio* z chovných rybníkov zodpovedá spôsobu hospodárenia a pohlaviu jedincov. Pozitívny alometrický rast naznačuje priaznivú kondíciu študovaných jedincov z lokality Iňačovce vo veku 1+ až 2+ pre všetky ploidné úrovne (2n, 3n, 4n). Naopak negatívny alometrický rast sme zaznamenali v lokalite Hrhov u starších jedincov vo veku 3+ až 4+. Mladšie vekové skupiny (1+, 2+) vykazujú lepšiu kondíciu ako staršie jedince, a na kondíciu jedincov nemá vplyv ich ploidná úroveň. Percentuálne zastúpenie samíc s priemernou dĺžkou tela (SL) 225,8 mm v analyzovanej vzorke dosahovalo až 84% Naopak iba 16% zo vzorky tvorili samce s menšou priemernou dĺžkou tela (SL 187,4 mm). Z 50-tich jedincov sme identifikovali 50% diploidov (SL = 204,8 mm), 36% triploidov (SL = 236,2 mm) a 14% tetraploidov (SL = 230,1 mm). V rámci analyzovaných morfologických znakov sme tiež zistili, že počet žiabrových tyčiniek je v priemere vyšší u polyploidných jedincov.

Kľúčové slová: karas striebristý, polyploidia, ekológia, biológia, kondícia, vek, annulus

Poďakovanie: Práca bola podporená z projektov APVV SKAT-20-0009 a VEGA1/0364/20. Poďakovanie patrí zamestnancom aj majiteľom chovných rybníkov Iňačovce a Hrhov za poskytnutie vzoriek rýb z výlovov. A našim kolegom za technickú pomoc v teréne.