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FLEA COMMUNITIES ON SMALL MAMMALS IN LOWLAND ENVIRONMENT

IVAN BALÁŽ, MARTINA ZIGOVÁ

Department of Ecology and Environmental Sciences, Faculty of Natural Sciences, Constantine the Philosopher University, Trieda A. Hlinku 1, 949 74 Nitra, Slovak Republic; e-mail: ibalaz@msnet.ukf.sk

Abstract

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The landscape of south-western Slovakia is characterised by anthropogenous reshaping, while fragments of undisturbed, waterlogged habitats have been preserved in what remains of the meandering ancient Žitava River. These refuges are inhabited by various small mammal species and their blood-sucking ectoparasites. Between 2014 and 2018, research on them was carried out in Slovakia's Danubian Lowland (*Podunajská nížina*) during three out of the four seasons (spring, summer and autumn). The small mammals were captured at 27 localities. The occurrence of nine flee species from the Hystrichopsyllidae, Ctenophthalmidae and Ceratophyllidae families was documented on 12 small burrowing mammals. During the course of all the seasons in which research was conducted, *Ctenophthalmus agyrtes, C. assimilis, Megabothris turbidus* a *Nosopsyllus fasciatus* were found, among the most dominant species to be seen on small burrowing mammals.

Key words: Siphonaptera, Rodentia, Eulipotyphla, wetlands.

Introduction

The southern part of Danubian Lowland is characterized by the presence of wetland habitats formed by the watercourses of rivers Hron, Žitava, Nitra, Dudváh and Danube. This area is characterized by the diversity of vegetation and animals that are bound up with water and wetland habitats. An important factor, which has shaped and altered the physiognomy of landscape and its natural components is a human. Over the last 100 years, the area has been significantly metamorphosed by anthropic activities into the agrocoenosis, while the last remnants of wetland habitats with propriate lot of biocoenosis have gradually subsided (Dúbravková, Hajnalová, 2012; www.staremapy.sk – Topographic maps of Czechoslovakia). Unwatering activities and intensive farming have caused water and wetland ecosystems to be among the most vulnerable ecosystems in Slovakia. In this context, it is important to conduct the research on selected groups of biota in these last biodiversity refuges in the predominantly agricultural land of the Podunajská nížina-lowland. We primarily focused on wetland habitats of the Podunajská nížina-lowland (the rural zones of municipalities Iža, Marcelová and Chotín) with the intention of small mammal communities (Poláčiková, 2010; Kalivodová et al., 2018) and their ectoparasites (flea Siphonaptera).

The data focusing on the presence of fleas in this lowland can be found in the works of Rosický (1950, 1952, 1957a,b, 1958), Cyprich, Kiefer (1981, 1982, 1983, 1984), Cyprich et al. (1976, 1984, 1987), Ambros, Dudich (1996). The Ectoparasitofauna of the small mammals in the Podunajská nížina-lowland was studied by Dudich (1986, 1994); this very same author also engaged himself in extension and introgressive hybridization of *Ctenophthalmus agyrtes* in the mentioned lowland Dudich (1987, 1993a). Ectoparasites (Acarina, Anoplura, Siphonaptera) of the Čenkov Forest Steppe in the Podunajská nížina-lowland were evaluated by Dudich (1993b). This paper seeks to evaluate flea communities found on small mammals in the Danubian Lowland.

Material and methods

Research was conducted on small mammals and their blood-sucking ectoparasites trapped in the Danubian Lowland between 2014 and 2018. The mammals were trapped during the spring (April), summer (July) and autumn (October) of each year. They were trapped at 27 localities in cadastre territories of Iža, Chotín and Marcelová (Fig. 1). Michalko in Mazúr, Lukniš (1980) classifies the region's associations of potential natural vegetation as follows: alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Salicion albae*) (Tüxen, 1955) Müller et Görs 1958; riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *U. minor* (*Ulmion* Oberdorfer 1953); xerophilous oak forests, Pontic-Pannonian oak forests and *Quercion pubescenti-petraeae* Braun-Blanquet 1931 pp., *Aceri tatarici-Quercetum pubescentis-roboris* Zólyomi and Jakucs 1957.

Live traps were used for CMR (Capture – Mark – Recapture) ecological surveying of the small animals. The traps were set in lines (25 traps for each line) ten metres apart over two to four trapping days in lines (25 traps in each line). The traps were checked twice during the day. The bait was a mixture of cereals, apples and bacon.

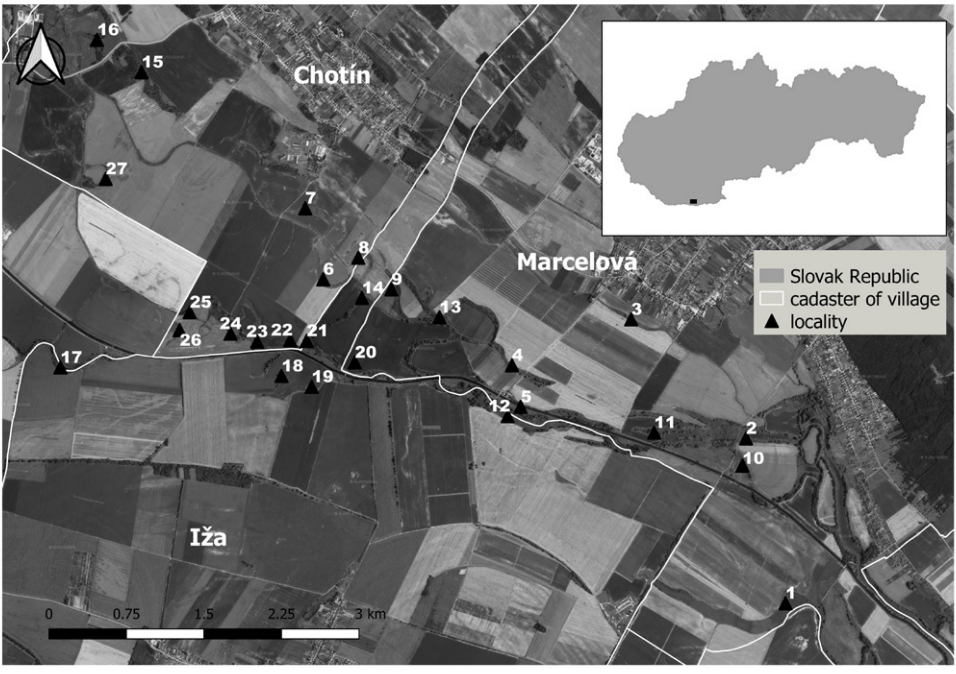


Fig. 1. Localities of catching small mammals in cadastre territories of Iža, Chotín and Marcelová.

The fleas collected from the small mammals were recorded and preserved in 70% ethyl alcohol and some of the specimens were mounted on slides. O'Mahony's method was used to process and mount fleas on microscope slides using Canada balm (Rosický, 1957b). The fleas were identified to the respective species using the keys developed by Rosický (1957b), Skuratowicz (1967), Brinck-Lindroth, Smit (2007).

The structural and quantitative characteristics of the small mammal flea communities were assessed and the data was analysed using the dominance and prevalence on all small mammal individuals and the prevalence on small mammal species according to Schwerdtfeger (1975) and Margolis et al. (1982). Ecological indices of dominance (D%), prevalence (P%), mean intensity of infestation (MII), ratio of host individual infested (Bush et al., 1997) and the preference index (Ip) (Dudich, 1995) were calculated, where P% is the number of individual host species infested with a particular parasite species out of the number of hosts examined, Nhspi is the number of host species infested with particular flea species, MII is the total number of parasites of a particular species found in a sample divided by the number of hosts infested with that parasite and (Ip) is the preference index – the rate of a parasite bond to particular host species.

Results and discussion

Between 2014 and 2018, 4,164 individuals from 19 small mammal species in the Eulipotyphla, Rodentia and Carnivora orders were caught at selected locations in the Danubian Lowland villages of Chotín, Marcelová and Iža. Fleas were then collected from the insectivores and rodents, with the most abundant species turning out to be *Ctenophthalmus agyrtes, C. assimilis, Megabothris turbidus* a *Nosopsyllus fasciatus* (Table 1).

The most flea material from small mammals was collected in autumn and the least in spring. Similarly, the highest species richness was recorded in autumn (682 individuals of nine species: *Ctenophthalmus agyrtes, C. assimilis, Doratopsylla dasycnema, Hystrichopsylla orientalis, Leptopsylla segnis, Megabothris turbidus, M. walkeri, Nosopsyllus fasciatus, Palaeopsylla soricis* from 10 host´ species – 275 individuals: *Apodemus agrarius, A. flavicollis, A. sylvaticus, A. uralensis, Micromys minutus, Microtus arvalis, M. oeconomus, Clethrionomys glareolus, Neomys anomalus, Sorex araneus*), with seven species (245 individuals of fleas) detected by us in the summer (*Ctenophthalmus agyrtes, C. assimilis, Doratopsylla dasycnema, Megabothris turbidus, M. walkeri, Nosopsyllus fasciatus, Palaeopsylla soricis* from 11 host´ species – 127 individuals: *Apodemus agrarius,*

T a b l e 1. Quantitative structure of fleas from small mammals captured in the Danubian Lowland.

Fleas	**n**	**D%**	**P%**	**Nhspi**	**MII**
Hystrichopsylla orientalis	71	6.7	1.39	5	1.48
Ctenophthalmus agyrtes	499	46.9	6.81	10	2.12
Ctenophthalmus assimilis	197	18.5	2.98	12	1.91
Doratopsylla dasycnema	8	0.7	0.09	2	2.67
Palaeopsylla soricis	29	2.7	0.29	4	2.90
Megabothris turbidus	121	11.4	2.40	7	1.46
Megabothris walkeri	16	1.6	0.26	2	1.78
Nosopsyllus fasciatus	121	11.4	2.72	8	1.29
Leptopsylla segnis	1	0.1	0.03	1	1.00
Total	1063	100			

Notes: n – abundance of fleas; D% – dominance; P% – prevalence; Nhspi – number of host species infested by particular flea species; MII – mean intensity of infestation.

A. sylvaticus, A. uralensis, Micromys minutus, Microtus arvalis, M. oeconomus, M. subterraneus, Clethrionomys glareolus, Neomys anomalus, Sorex araneus, Crocidura suaveolens) and four (136 individuals of fleas) in the spring (*Ctenophthalmus agyrtes, C. assimilis, Megabothris turbidus, Nosopsyllus fasciatus* from 5 host´ species – 45 individuals: *Apodemus agrarius, A. sylvaticus, Micromys minutus, Microtus arvalis, M. oeconomus*, Table 2). In all seasons, *Ctenophthalmus agyrtes, C. assimilis, Megabothris turbidus* and *Nosopsyllus fasciatus* were found to be the most dominant flea species infesting small mammals. *Doratopsylla dasycnema, Palaeopsylla soricis* and *Megabothris walkeri* were the species present in summer and autumn. *Hystrichopsylla orientalis* and *Leptopsylla segnis* were collected from the fur of various mammals in autumn, with *Hystrichopsylla orientalis* typically occurring in the second half of the year and *Leptopsylla segnis* the chief parasite hosted by synanthropic rodent species and yet rare in the wild.

Summary of flea species by hosts

1,063 individuals covering nine flea species were gathered from the 12 small mammal species that we caught (Table 3).

- *Sorex araneus* Linnaeus, 1758 – 5 species detected: *Ctenophthalmus agyrtes, C. assimilis, Palaeopsylla soricis, Doratopsylla dasycnema* and *Megabothris turbidus.* The common shrew was the most numerous insectivore caught in our traps.
- *Neomys anomalus* Cabrera, 1907 – 2 species detected: *Palaeopsylla soricis* and *Ctenophthalmus assimilis*. The Mediterranean water shrew was the second most numerous insectivore species caught in our traps.
- *Crocidura suaveolens* (Pallas, 1811) – only one *Ctenophthalmus assimilis* specimen was captured. Because this species tends to be synanthropic, there was only a single case when a lesser white-toothed shrew was caught in our traps.
- *Apodemus flavicollis* (Melchior, 1834) – four species determined: *Ctenophthalmus agyrtes, C. assimilis, Megabothris turbidus* and *Nosopsyllus fasciatus*. The yellow-necked field mouse is a very plastic species that occurs in the most diverse environments.
- *Apodemus sylvaticus* (Linnaeus, 1758) – 3 species detected: *Ctenophthalmus agyrtes, C. as-*

T a b l e 2. Small mammal fleas captured in the Danubian Lowland by season.

Fleas	**spring**	**summer**	**autumn**	**Total**
Hystrichopsylla orientalis	-	-	71	71
Ctenophthalmus agyrtes	42	98	359	499
Ctenophthalmus assimilis	10	123	64	197
Doratopsylla dasycnema	-	1	7	8
Palaeopsylla soricis	-	21	8	29
Megabothris turbidus	3	60	58	121
Megabothris walkeri	-	7	9	16
Nosopsyllus fasciatus	5	11	105	121
Leptopsylla segnis	-	-	1	1
Total	60	321	682	1063

T a b l e 3. Small mammal fleas collected in the Danubian Lowland.

Fleas / **Small mammals**	*Hystrichopsylla orientalis*	*Ctenophthalmus agyrtes*	*Ctenophthalmus assimilis*	*Doratopsylla dasycnema*	*Palaeopsylla soricis*	*Megabothris turbidus*	*Megabothris walkeri*	*Nosopsyllus fasciatus*	*Leptopsylla segnis*	**Total**
Apodemus agrarius	63	336	73	1	1	77	3	85	1	640
Apodemus flavicollis	-	8	1	-	-	3	-	4	-	16
Apodemus uralensis	-	8	3	-	-	-	-	4	-	15
Apodemus sylvaticus	-	26	5	-	-	7	-	15	-	53
Clethrionomys glareolus	3	42	2	-	-	22	-	1	-	70
Crocidura suaveolens	-	-	1	-	-	-	-	-	-	1
Micromys minutus	1	10	3	-	1	4	-	4	-	23
Microtus arvalis	3	45	63	-	-	5	-	2	-	118
Microtus oeconomus	1	15	5	-	-	-	13	6	-	40
Microtus subterraneus	-	4	39	-	-	-	-	-	-	43
Neomys anomalus	-	-	1	-	13	-	-	-	-	14
Sorex araneus	-	5	1	7	14	3	-	-	-	30
Total	71	499	197	8	29	121	16	121	1	1063

similis and *Nosopsyllus fasciatus*.

- *Apodemus uralensis* (Pallas, 1811) – 3 species detected: *Ctenophthalmus agyrtes, C. assimilis* and *Nosopsyllus fasciatus.* Wood mice and Ural field mice are species characteristic of the small mammal communities they create in agricultural biocenoses and for their structural elements – territorial boundaries and shrubs.
- *Apodemus agrarius* (Pallas, 1771) – 9 species detected: *Hystrichopsylla orientalis, Ctenophthalmus agyrtes, C. assimilis, Doratopsylla dasycnema, Palaeopsylla soricis, Megabothris turbidus, M. walkeri, Nosopsyllus fasciatus* and *Leptopsylla segnis*.
- *Micromys minutus* (Pallas, 1771) – 6 species detected: *Hystrichopsylla orientalis, Ctenophthalmus agyrtes, C. assimilis, Palaeopsylla soricis, Megabothris turbidus* and *Nosopsyllus fasciatus*. Striped field mice and Eurasian harvest mice are species that search for wetter habitats inhabited by common reeds of the genus *Phragmites* and in large sedge swamps (*Magnocaricion*).
- *Clethrionomys glareolus* (Schreber, 1780) – 5 species detected: *Hystrichopsylla orientalis, Ctenophthalmus agyrtes, C. assimilis, Megabothris turbidus* and *Nosopsyllus fasciatus.* Bank voles are a forest species that use reed stands and wetland biotopes in the Danubian Lowlands as replacement habitats.
- *Microtus arvalis* (Pallas, 1779) – 5 species detected: *Hystrichopsylla orientalis, Ctenophthalmus agyrtes, C. assimilis, Megabothris turbidus* and *Nosopsyllus fasciatus.*
- *Microtus oeconomus* (Pallas, 1776) – 5 species detected: *Hystrichopsylla orientalis, Ctenoph-*

thalmus agyrtes, C. assimilis, Megabothris walkeri and *Nosopsyllus fasciatus*.

- *Microtus subterraneus* (de Selys-Longchamps, 1836) – 2 species detected: *Ctenophthalmus agyrtes* and *C. assimilis*.

Systematic flea species review

- Hystrichopsyllidae
  - *Hystrichopsylla orientalis* Smit, 1956
    A euryzonal, euryxenous species widespread in eastern and south-eastern Europe, whose distribution covers the lowland plains of Poland to Germany and through the Pannonian Basin to the Alps, it is of eastern provenance and considered a boreal element in Slovakia's fauna (Dudich, 1993c). Hystrichopsyllidae live throughout Slovakia and are mesochronous, able to reach into the fur of an otherwise wide range of hosts only during a short period of the year between July and October.
- Ctenophthalmidae
  - *Ctenophthalmus agyrtes* (Heller, 1896)
    The species is a polyzonal, pleioxenous and eurychronous parasite found on small mammals that live primarily in the geobiocenoses of forests. It is a polytypical species with several subspecies and was the most numerous collected by us. In the Danubian Lowland between the Nitra and Hron rivers, the subspecies *Ctenophthalmus agyrtes agyrtes* (Heller, 1896) and *C. a. peusianus* (Rosický, 1955) are present as clearly defined taxa both morphologically and geographically. *C. a. slovacicus* (Rosický, 1950) is a phenon distributed over a narrow, primarily introgressive zone of the *agyrtes* and *peusianus* subspecies (Dudich, 1987). Introgression of the two *C. agyrtes* species emerged during the early Holocene and a hybrid zone of 30–40 kilometres formed between the Hron and Nitra Rivers. The species has a wide range of hosts and is present throughout the year.
  - *Ctenophthalmus assimilis* (Taschenberg, 1880)
    The species is widespread in the most diverse habitats ranging from riparian forests to agrocenoses and, mainly *Microtus arvalis*, is the predominant component in the Siphonaptera parasites of rodents. It can be found among animals living in forest steppes and steppes. It is the second most numerous species in our material. The populations of *Ctenophthalmus assimilis* distributed in the Danubian lowlands were assigned to the subspecies *C. a. assimilis*, a relatively uniform Pannonian form whose origin has been traced by Dudich (1986) to a hybrid population originating in one of the warmer phases of the Pleistocene Epoch.
  - *Doratopsylla dasycnema* (Rothschild, 1897)
    It is a pleioxenous species that infests insectivores of the Soricidae family living in forest habitats. Despite claims in studies from a number of authors (e.g., Dudich, 1986) that the species does not live in riparian forests and the open country is probably an insurmountable barrier for this species, eight specimens of *Apodemus agrarius* a *Sorex araneus* were collected by us.
  - *Palaeopsylla soricis* (Dale, 1878)
    This polyzonal, pleioxenous parasite infesting shrews (Soricidae) has wide ecological

potential. Although a true arboreal element of the Siphonaptera order in Slovakia, it has successfully survived in deforested agricultural landscapes. A subspecies, *Palaeopsylla soricis rosickyi*, occurs in the area under observation (Smit, 1960).

- Ceratophyllidae
  - *Megabothris turbidus* (Rothschild, 1909)
    Another polyzonal, pleioxenous species with a wide range of hosts, it is one of the more numerous species in our material. It occurs in wetland habitats together with *M. walkeri*.
  - *Megabothris walkeri* (Rothschild, 1902)
    The occurrence of this relict species is linked to relict populations of *M. oeconomus* and they have been living together since the early Holocene. Voles are the host animals, mainly *Microtus oeconomus*. Our material includes three specimens obtained from *Apodemus agrarius*.
  - *Nosopsyllus fasciatus* (Bosc d'Antic, 1800)
    This cosmopolitan parasite found in synanthropic rodents occurs predominantly in and around human dwellings and infrastructure. It has also survived in Slovakia's lowland regions not developed by humans, as demonstrated by its relatively high presence among our material. As both a synanthrope and azonal flea species, it is important from an epidemiological perspective as a causative agent of plague.
  - *Leptopsylla segnis* (Schonherr, 1811)
    A cosmopolitan species whose main hosts are synanthropic populations of *Mus musculus* and *Rattus norvegicus*, it is rare in the wild, as evidenced by only one specimen obtained from *Apodemus agrarius*.

Based on the preference index under the conditions in the Danubian Lowlands, a positive preference can be claimed for these parasite-host relationships: *Leptopsylla segnis* and *Hystrichopsylla orientalis* to *Apodemus agrarius; Nosopsyllus fasciatus* to *Apodemus flavicollis; Nosopsyllus fasciatus, Megabothris turbidus* and *Ctenophthalmus agyrtes* to *Apodemus sylvaticus*; *Ctenophthalmus assimilis* to *Crocidura suaveolens; Ctenophthalmus assimilis* and *C. agyrtes* to *Microtus arvalis*; *Megabothris walkeri* to *Microtus oeconomus*; *Ctenophthalmus assimilis* to *Microtus subterraneus; Megabothris turbidus* and *Ctenophthalmus agyrtes* to *Clethrionomys glareolus*; *Ctenophthalmus assimilis assimilis* to *Neomys anomalus*; *Doratopsylla dasycnema* to *Sorex araneus* (Table 4).

The nature of Siphonaptera biocenoses found in the typical wetland habitats of the Danubian Lowland is determined by four species detected to be the most numerous. The predominant flea species were *Ctenophthalmus agyrtes* (46.9% of all specimens), *C. assimilis* (18.5%), *Megabothris turbidus* (11.4%) and *Nosopsyllus fasciatus* (11.4%). There was also a relatively high incidence (6.7%) of *Hystrichopsylla orientalis*, whose major prevalence on its main host *Apodemus agrarius* (89%) only recently appeared in the Danubian Lowland (in 2010, Ambros et al., 2010).

A characteristic species located exclusively in marsh habitats is *Megabothris walkeri*, detected on its chief host *Microtus oeconomus*, while *Apodemus agrarius* was likewise documented. In the Pannonian Plain, *Megabothris walkeri* is existentially bound to *Microtus oeconomus*, a relict rodent, and has successfully survived here with its main host, resisting adverse changes from successive secular changes and anthropic transformation of their environment. *Palaeopsylla soricis* and *Doratopsylla dasycnem* colonise and are linked to insectivores of the Soricidae family. *D. dasycnema* is another flea species of the Siphonaptera order that infests Soricidae in forest habi-

T a b l e 4. Index of flea preference for hosts in the conditions found at the Danubian Lowland.

	Aag	*Afl*	*Asy*	*Aur*	*Csu*	*Mmi*	*Mar*	*Moe*	*Msu*	*Cgl*	*Nan*	*Sar*
Hystrichopsylla orientalis	1.39	-	-	-	-	0.43	0.83	0.21	-	0.69	-	-
Ctenophthalmus agyrtes	1.06	0.68	1.45	0.48	-	0.62	1.78	0.45	0.95	1.38	-	0.41
Ctenophthalmus assimilis	0.58	0.22	0.71	0.46	8.76	0.47	6.31	0.38	23.57	0.17	1.95	0.21
Doratopsylla dasycnema	0.20	-	-	-	-	-	-	-	-	-	-	35.55
Palaeopsylla soricis	0.05	-	-	-	-	1.06	-	-	-	-	171.99	19.61
Megabothris turbidus	1.00	1.06	1.61	-	-	1.02	0.82	-	-	2.98	-	1.01
Megabothris walkeri	0.29	-	-	-	-	-	-	12.04	-	-	-	-
Nosopsyllus fasciatus	1.10	1.41	3.45	0.99	-	1.02	0.33	0.73	-	0.14	-	-
Leptopsylla segnis	1.57	-	-	-	-	-	-	-	-	-	-	-

Notes: 1 – neutral relationship; < 1 – negative preference; > 1 – positive preference; Aag – *Apodemus agrarius*, Afl – *Apodemus flavicollis*, Asy – *Apodemus sylvaticus*, Aur – *Apodemus uralensis*, Csu – *Crocidura suaveolens*, Mmi – *Micromys minutus*, Mar – *Microtus arvalis*, Moe – *Microtus oeconomus*, Msu – *Microtus subterraneus*, Mgl – *Clethrionomys glareolus*, Nan – *Neomys anomalus*, Sar – *Sorex araneus*.

tats. The area of observation is not a typical environment for this species, and so, it has only been detected in small numbers on *Sorex araneus* and *Apodemus agrarius*. A total of nine flea species have been spotted on 12 host species, detected in Siphonaptera zones composed of small burrowing mammals and of synanthropic rodents.

There is the potential to confirm the occurrence of *Peromyscopsylla bidentata* in the area of interest. The presence of this species in south-western Slovakia was determined by Dudich (1997) and detected in both the Danubian Lowland (Podunajská nížina) and the Hron Hills (Hronská pahorkatina). It has an almost continuous distribution in forested geobiocenoses ranging from colline to supra-montane vegetation levels and in the riparian forests of lowland rivers. Its absence in the Danubian Lowland is a secondary phenomenon related to anthropic activity – almost complete deforestation of the region.

Based on the research conducted by Dudich (1986) in 1981–1984 at 22 locations in the Danubian Plain and Hron Hills, 15 species of rodents and insectivores were trapped with 14 flea species detected. Proof was provided to determine the occurrence of five different species (compared to our results). These were *Palaeopsylla similis, Rhadinopsylla pentacantha, R. isacantha, Peromyscopsylla bidentata* and *Ctenophthalmus solutus*.

According to Dudich (1986), the common feature of flea parasites (*Hystrichopsylla talpae, Ctenophthalmus congener* and *Palaeopsylla kohauti*) in the Danubian Lowland is the absence of montane and some European elements of the arboreal fauna complex, influenced by the region's continental climate and expressed in the pseudo-montane nature of its expansion. Nonetheless, they can be found together with true mountain species (*Atyphloceras nuperus* and *Peromyscopsylla fallax*) in the Little Carpathians and some of them are present even in the lowlands of the Záhorie region. Changes in the Danubian Lowlands are also evident in the presence of cosmopolitan species (*Nosopsyllus fasciatus* and *Leptopsylla segnis*) linked to the synanthropic occurrence of commensal rodent populations and their transition to alternative hosts.

In the area of observation within the Danubian Lowland, they live in an intensively humid environment and among arboreal elements, such as *Megabothris turbidus* and *M. walkeri* is boreal element, linked to the presence of the original biocenoses. They were completely missing in the neighbouring highlands, while *M. turbidus* was detected in the Little Carpathians (Dudich, 1986). Dudich (1986) considers waterlogged and periodically flooded riparian ecosystems to be an insurmountable ecological barrier for these species. The xerothermic Čenkov forest steppes in the Danubian Lowland are composed of host and ectoparasite species synusiae quite similar to riparian forest and wetland communities. Our traps even documented *Doratopsylla dasycnema,* a differential species characteristic of the forest community in the Danubian Hills, which Dudich (1986) indicated to be missing in wetland habitats.

Based on the structure of the flea communities, which were detected on small terrestrial mammals living in the southern Danubian Lowland between the Hron and Nitra Rivers, pauperised fauna can be claimed to exist in the 'soft', historically flooded *Saliceto-Alnetum* riparian forests and 'hard' plains flooded only at more than 20-year intervals (such as the 1965 flood when half of Great Schütt Island – Žitný ostrov was under water). Potentially, there are also xerothermophilic oak forests of Pontic-Pannonian *Aceri Quercion* located in the observed area. The occurrence of nine flea species from the Hystrichopsyllidae, Ctenophthalmidae and Ceratophyllidae families was documented on 12 small burrowing mammals.

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