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SIPHONAPTERA OF SMALL TERRESTRIAL MAMMALS AND THEIR NESTS IN THE WESTERN CARPATHIANS

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Abstract. The authors studied 1095 specimens of fleas (19 species and subspecies), collected from small mammals and their nests in the Western Carpathians. The results are presented with regard to the occurrence of fleas on hosts and in their nests; the fleas found on the hosts are discussed according to their numbers, seasons of the year and hosts species, the fleas found in nests according to their numbers, seasons, hosts, biotopes, nest localization, nesting material and co-existence of flea species. These findings are compared with the results obtained from similar collections from Trans-Carpathia and Leningrad region.

The present paper is an extension of the publication by Mrciak, Daniel and Rosický (1966) and represents another contribution to the implementation of an extensive research program on the parasitocenoses of small terrestrial mammals and their nests, undertaken in collaboration with the Institute of Zoology of the U.S.S.R. Academy of Sciences. Apart from fleas collected from the hosts themselves, fleas found in nests of small mammals from the Czechoslovak territory had not been studied before on the basis of large material. Hitherto papers concerning mammalian nests dealt with the analysis of winter nests of *Talpa europaea* (Rosický 1957a, Jurík 1968). The fleas collected from *Microtus arvalis* nests from the High Tatras were studied by Cyprich and Kiefer (1972).

MATERIAL AND METHODS

In the years 1959—1960 investigations on the parasites and nidicoles of small mammals were carried out in the Western Carpathians in the region of the upper reaches of the river Vsetínská Bečva and its tributaries (environs of the village Velké Karlovice, northern Moravia).

During five expeditions of a fortnight each, organized in different seasons, 253 small terrestrial mammals were trapped and 251 of their nests were obtained. *Clethrionomys glareolus* was the most abundant species present in all localities studied; it represented 56 % of the total number of animals captured. The next most numerous species was *Apodemus flavicollis* which occurred primarily in the vicinity of forest streams. *Sorex araneus*, almost as numerous, was found in all forest biotopes throughout the year. *Talpa europaea* was abundant in meadows and fields adjoining Bečva (judging from its burrowing activities); as no special mole-traps were used it is represented by only two specimens in our material. Moreover, the following small mammals were trapped: *Sorex minutus*, *Sorex alpinus*, *Neomys fodiens*, *Apodemus sylvaticus*, *Apodemus agrarius*, *Microtus arvalis* and *Pitymys subterraneus*. Number of each species and their nests are given in Table 1.

The fleas from small mammals and their nests were found in 18 localities (see Fig. 1). Some localities are situated in the southeastern area of the Vsetínské hills, other are in the northwestern part of the Javorníky Mts. Localities in the area studied were mostly originally covered

Table 1. A survey of fleas of small mammals and their nests.

		Number of animals or nests examined	Number of animals or nests infested with fleas	% of animals or nests infested with fleas	Total number of fleas obtained	Mean number of fleas per host or nest	Mean number of fleas per positive host or nest	Number of flea species	*H. talpae*	*A. nuperum*	*Rh. integellus*	*Rh. mesoides*	*D. dasycnema*	*P. kohauti*	*P. similis*	*P. soricis*	*Ct. agyrtes*	*Ct. bisortodentatus*	*Ct. congener*	*P. bidentata*	*L. segnis*	*N. fasciatus*	*M. arvicolae*	*M. turbidus*	*C. gallinae*
Hosts	*T. europaea*	2	1	—	5	—	—	2	—	—	—	—	—	4	—	—	—	1	—	—	—	—	—	—	—
	S. araneus	32	9	28.1	19	0.6	2.1	8	1	—	1	—	7	3	—	3	2	—	—	1	—	—	—	1	—
	S. minutus	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	S. alpinus	5	3	—	19	—	—	3	—	—	—	—	1	—	—	8	10	—	—	—	—	—	—	—	—
	N. fodiens	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	A. flavicollis	34	12	35.3	32	0.9	2.7	6	—	—	—	—	2	—	—	4	22	—	—	—	1	1	—	2	—
	A. sylvaticus	3	1	—	7	—	—	1	—	—	—	—	—	—	—	—	7	—	—	—	—	—	—	—	—
	A. agrarius	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. glareolus	142	76	53.5	231	1.6	3.0	12	3	13	25	1	1	1	—	—	131	2	7	21	—	—	—	25	1
	M. arvalis	8	6	75.0	31	3.9	5.2	5	1	—	1	—	4	—	—	6	19	—	—	—	—	—	—	—	—
	P. subterraneus	17	10	58.8	45	2.6	4.5	4	—	—	—	—	—	—	—	—	31	—	5	1	—	—	8	—	—
	Total	253	118	46.6	389	1.5	3.3	16	5	13	27	1	15	8		21	222	3	12	23	1	1	8	28	1
Nests	*T. europaea*	6	4	—	33	—	—	5	—	—	—	—	—	—	2	—	24	5	1	—	—	—	—	1	—
	S. araneus	23	9	39.1	69	3.0	7.7	4	—	—	—	—	—	—	—	—	46	—	5	—	—	—	15	3	—
	S. minutus	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	A. flavicollis	22	11	50.0	77	3.5	7.0	7	6	1	3	—	—	—	—	—	49	—	13	—	—	—	1	4	—
	C. glareolus	154	51	33.1	427	2.8	8.4	11	23	6	22	5	1	2	—	12	291	—	31	—	—	—	26	8	—
	M. arvalis	39	21	53.8	100	2.6	4.8	4	5	—	—	—	—	—	—	—	82	—	6	—	—	—	—	7	—
	P. subterraneus	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Total	251	96	38.2	706	2.8	7.3	13	34	7	25	5	1	2	2	12	492	5	56	—	—	—	42	23	—

with a beach forest which has in some cases been replaced by spruce monoculture. Besides forest biotopes in which the major part of material was obtained (e.g. Babská, Razula, Makytka, Krivý Grúň, Kyčerka, Dynčák, Vlčí údolí, Vranča), collections (esp. of *M. arvalis*) were also regularly made in densely overgrown ridges north of N. Hrozenkov. For comparative purpose nests of *M. arvalis* were collected in meadows near Halenkov. The collections were made at the altitude of 450 to 740 m. A detailed description of localities and their biotopes, geomorphological, climatic and vegetational conditions, is given in the paper by Mrciak, Daniel and Rosický (1966).

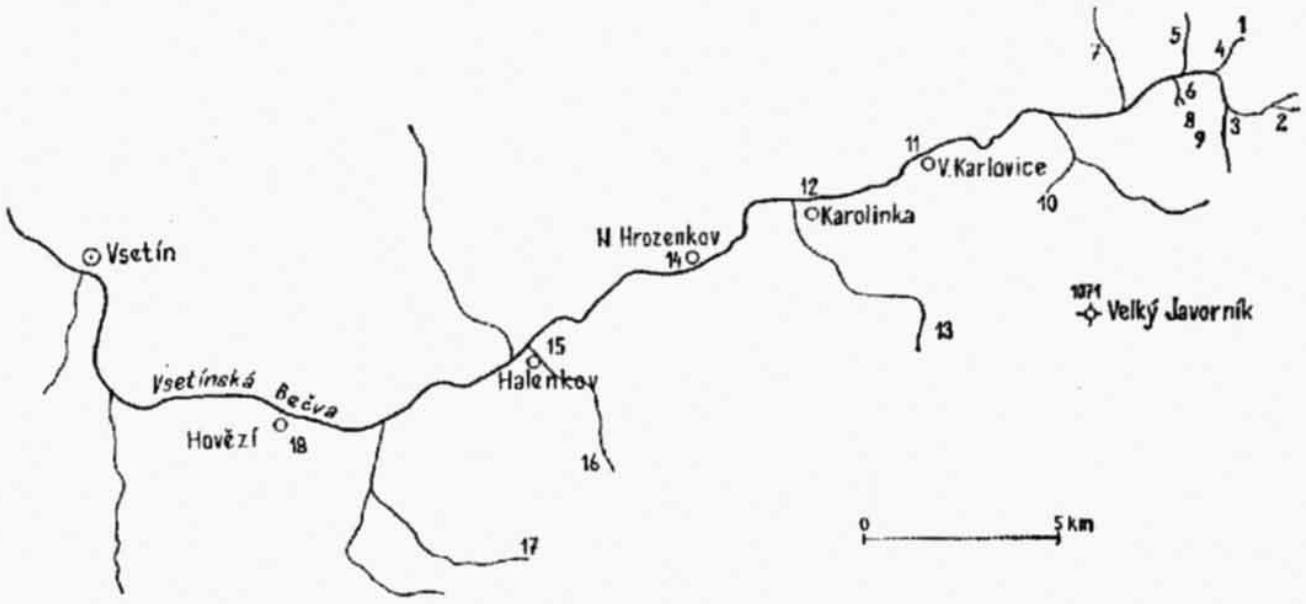

Fig. 1. A map of the collecting localities in the region studied: 1 — Dynčák, 2 — Krivý Grúň, 3 — Kyčerka, 4 — Makytka, 5 — Babská, 6 — Vlčí údolí, 7 — Rybjanka, 8 — Razula, 9 — Ostrižná, 10 — Malé Karlovice, 11 — Velké Karlovice, 12 — Karolinka, 13 — Stanovica, 14 — Nový Hrozenkov, 15 — Halenkov, 16 — Čerňanská Kyčera, 17 — Vranča, 18 — Hovězí.

RESULTS

A total of 1095 flea specimens belonging to 19 species and subspecies were found:

1. *Hystrichopsylla talpae* (Curtis, 1826)
2. *Hystrichopsylla orientalis* Smit, 1956
3. *Atyphloceras nuperum* (Jordan, 1931)
4. *Rhadinopsylla integella* Jordan et Rothschild, 1921
5. *Rhadinopsylla mesoides* Smit, 1957
6. *Doratopsylla dasycnema dasycnema* (Rothschild, 1897)
7. *Palaeopsylla kohauti* Dampf, 1911
8. *Palaeopsylla similis similis* Dampf, 1910
9. *Palaeopsylla soricis rosickyi* Smit, 1960
10. *Ctenophthalmus agyrtes agyrtes* (Heller, 1896)
11. *Ctenophthalmus bisoctodentatus bisoctodentatus* Kolenati, 1863
12. *Ctenophthalmus bisoctodentatus heselhausi* (Oudemans, 1914)
13. *Ctenophthalmus congener congener* Rothschild, 1907
14. *Peromyscopsylla bidentata* (Kolenati, 1863)
15. *Leptopsylla segnis* (Schönherr, 1811)
16. *Nosopsyllus fasciatus* (Bosc, 1800)
17. *Malaraeus arvicolae* (Ioff, 1948)
18. *Megabothris turbidus* (Rothschild, 1909)
19. *Ceratophyllus gallinae* (Schrank, 1803)

From the animals 389 fleas were taken, their average number per host trapped was 1.5 and per positive host 3.3. Out of 253 hosts captured 118 were positive (46.6 %). From the small mammal nests 706 fleas were collected; the average flea number per nest found was 2.8, per positive nest 7.3. Out of 251 nests found 96 were positive (38.2 %). Similar results were obtained by Vysotskaya (1964) from the material of 1202 small mammals and 500 nests found in the Trans-Carpathian region where the mean flea infestation per host trapped (positive was 1/3 and the mean flea infestation per nest found) positive was 7/13. The flea infestation of hosts and their nests is given in Table 1.

A. FLEAS FOUND ON SMALL TERRESTRIAL MAMMALS

1. Numbers and seasonal dynamics of fleas

The most abundant species on all hosts (except *T. europaea*) was *Ctenophthalmus agyrtes* which made up 57.1 % of the fleas found. This species is the most characteristic representative of the zone of siphonapteria*) of small terrestrial mammals and by far the most abundant species in forests ; this agrees with the findings of Rosický and Černý (1956). *Ct. agyrtes* occurs on small mammals throughout the year; the increase in its numbers in winter and summer is partially influenced by the number of animals captured, but we found females with eggs in these seasons. The summer maximum is higher than the winter one, while in the nests it is vice versa. In collections from hosts females of *Ct. agyrtes* were more numerous than males, the approximate ratio being 1.7 : 1.

Table 2. A survey of fleas collected from small mammals per season

Flea species \ Number of hosts captured	Spring (18)	Summer (70)	Autumn (35)	Winter (130)
H. talpae + *H. orientalis*	1	1	—	3
A. nuperum	—	—	—	13
Rh. integella	1	—	1	25
Rh. mesoides	—	—	—	1
D. dasycnema	3	8	1	3
P. kohauti	—	5	—	3
P. similis	—	—	—	—
P. soricis	10	9	—	2
C. [illegible]*s*	37	100	15	70
Ct. bisoctodentatus	—	1	—	2
Ct. congener	2	7	—	3
P. bidentata	—	—	2	21
L. segnis	1	—	—	—
N. fasciatus	—	—	—	1
M. arvicolae	1	2	5	—
M. turbidus	—	23	—	5
C. gallinae	—	1	—	—
Total number of flea species	8	10	5	13

*) Due to the fact that the name Siphonaptera has been generally accepted for fleas, we designate a group of flea species on one host and in one nest as "siphonapterium" instead of the term "aphanipterium" previously used by Rosický (1950), and accordingly, we introduce the term "zone of siphonapteria" for a group of related flea communities.

Of the other species the next most frequent were *Megabothris turbidus* (7.2 %), with the maximum in summer (at which time females with eggs were found), *Rhadinopsylla integella* and *Peromyscopsylla bidentata* (6.9 and 5.9 % respectively), which have a marked winter maximum of occurrence despite their small numbers. In December specimens of *P. bidentata* with eggs were found. The occurrence in winter is also characteristic of *Atyphloceras nuperum*. This species was originally considered in this country to be an inhabitant of the montane zone of Czech-German mountain system where it was collected by Rosický (1957b) at the altidute of 800—1350 m. The first record of the occurrence of *A. nuperum* in the Carpathian mountain system at 700 m altitude was published by Jurík (1960). Subsequently *A. nuperum* was also found in the Carpathian by Haitlinger (1971), namely in the foothills of the Beskid Zywiecki Mts. and by Bartkowska (1972, 1973) in the Polish part of the High Tatras. Our specimens of *A. nuperum* (3 males and 10 females, 2 of the latter with eggs) came from *C. glareolus* collected at Ostrižná, Makytka, Krivý Grúň, Dynčák and Vranča (altitude 540—750 m) in December 1960. The fleas of Soricidae, *Palaeopsylla soricis* (5.4 %) and *Doratopsylla dasycnema* (3.9 %), occurred primarily in summer and spring. Other species made up 0.3—3.1 % of the total number of fleas found on hosts and their occurrence in particular seasons of the year could not be assessed due to their small numbers (see Table 2).

2. Species composition of fleas on the most abundant hosts

Of the small terrestrial mammals the most numerous captured was *C. glareolus*; *A. flavicollis*, *S. araneus* and *P. subterraneus* were also frequent. Only a small number of other species was trapped (see Table 1.).

A total of 142 individuals of *C. glareolus* was captured, 53.5 % of which were infested with fleas. The average number of fleas per animal captured was 1.6, per positive animal 3.0. The most frequent flea species was *Ct. agyrtes* (56.7 %). *Rh. integella* (10.8 %), *M. turbidus* (10.8 %), *P. bidentata* (9.1 %) and *A. nuperum* (5.6 %) were less frequently found. Other flea species occurred sporadically: *Ct. congener*, *H. talpae*, *Ct. bisoctodentatus*, *D. dasycnema*, *P. kohauti*, *C. gallinae* and *Rh. mesoides*. Among the last mentioned species there are some zoogeographically interesting facts, especially the find of *Rhadinopsylla mesoides* (1 female, *C. glareolus*, 9. 12. 1960, Makytka). This species, reported from France, Greece and Romania, was recorded in this country from the High Tatras by Rosický (1957 b) and from the Kremnické Mts. by Jurík (1960) as *Rh. messa*. A mole-flea rare in our fauna was also found as an accidental parasite on *C. glareolus* — *Ctenophthalmus bisoctodentatus heselhausi* (1 female, *C. glareolus*, 13. 12. 1960, Vranča). The nominate subspecies *Ct. b. bisoctodentatus* (1 female, *Talpa europaea*, 15. 7. 1960, Vlčí údolí) was likewise found in the study area. Of the three specimens of *Hystrichopsylla* found on *C. glareolus* two belong to *H. orientalis* (1 male, *C. glareolus*, 11. 12. 1960, Kyčerka and 1 male, *C. glareolus*. 18. 7. 1960, Halenkov) and one to *H. talpae* (1 male, *M. arvalis*, 23. 4. 1960, also at Halenkov).

Out of 34 individuals of *A. flavicollis* trapped 35.3 % were infested with fleas. The average number of fleas per host was 0.9, per positive host 2.7. *A. flavicollis* was infested with half the number of flea species listed for preceding species. *Ct. agyrtes* was again predominant, while *M. turbidus* and the shrew-fleas *P. soricis* and *D. dasycnema* were found sporadically. Single specimens of the housemouse flea *L. segnis* (1 female, 23. 4. 1960, Makytka) and of the rat flea *N. fasciatus* (1 male, 10. 12. 1960, Kyčerka) were found. In warmer regions *N. fasciatus* is a regular flea of *A. flavicollis* in free nature; e.g. in a grove of the south-Moravian lowland 19.9 % of fleas found on *A. flavicollis* were *N. fasciatus* (Rosický and Černý 1956).

Out of 32 individuals of *S. araneus* 28. 1 % were flea-positive. The average number

of fleas per host was 0.6, per positive host 2.1. Single specimens of 8 flea species were found on *S. araneus*. On this shrew *Ct. agyrtes* was not predominant over other flea species.

Out of 17 specimens of *Pitymys subterraneus* captured 58.8 % were flea-positive. The average number of fleas was 2.6 per host, 4.5 per positive host. *Ct. agyrtes* was found to be predominant, while *M. arvicolae*, *Ct. congener* and *P. bidentata* were less frequent.

B. FLEAS FOUND IN NESTS OF SMALL TERRESTRIAL MAMMALS

1. Numbers and seasonal dynamics of fleas

As on hosts, *Ct. agyrtes* constituted the majority (69.7 %) of all fleas found in nests of small terrestrial mammals. This species was most numerous in winter nests; in spring and summer its numbers decreased by more than a half. The winter maximum of *Ct. agyrtes* in the nests of small mammals (on an average 11 specimens per nest) in the Leningrad region was established by Vysotskaya and Sazonova (1953). As on hosts, the number of females in nests exceeded that of males at a ratio of 1.45 : 1. Of the other species, *Ct. congener* (7.9 % collected from nests) and *M. turbidus* (3.3 %) occurred in nests of all host species all year round. *M. arvicolae*, which was present in the nests of 3 hosts (*C. glareolus*, *S. araneus*, *A. flavicollis*) primarily in winter, represented 5.9 % of the fleas collected. The maximum occurrence in winter was also recorded for *H. talpae* (4.8 % of fleas collected from nests) and *Rh. integella* (3.5 %). *P. soricis* was found in the nests only in summer. The seasonal dynamics of flea species found in nests are shown in Table 3.

Winter nests of *C. glareolus* were the most heavily flea-infested ones. In winter 8 nests of *C. glareolus* were found with 15—47 fleas per nest (average number 24.3). In spring there were 16—22 fleas per nest (average number 18.3) in 4 nests of *C. glareolus*. In summer we found only 3 nests with a relatively rich flea population: 2 nests of *C. glareolus* with 13 and 35 fleas respectively, and one nest of *A. flavicollis* with 19 fleas. In autumn the flea number varied between 2 and 11 per nest.

Table 3. A survey of fleas found in nests of small mammals per season

Flea species	Spring	Summer	Autumn	Winter
H. talpae + *H. orientalis*	11	4	—	19
A. nuperum	2	—	1	4
Rh. integella	6	—	3	16
Rh. mesoides	—	5	—	—
D. dasycnema	—	1	—	—
P. kohauti	—	1	—	1
P. similis	—	—	—	2
P. soricis	—	12	—	—
Ct. agyrtes	101	116	28	247
Ct. hisoctodentatus	—	—	—	5
Ct. congener	19	15	3	19
M. arvicolae	11	—	—	31
M. *turbidus*	8	1	3	11
Number of flea species	7	8	5	10

2. Division according to hosts

The majority of nests found belonged to *C. glareolus* (154), 33.1 % were flea-positive. The nests of *C. glareolus* contained 60.1 % of all fleas found in nests of small mammals. The average number of fleas per nest investigated was 2.8, per positive nest 8.4 .Of 11 flea species present in the *C. glareolus* nests *Ct. agyrtes* constituted 68.2 %.

Less frequent species were *Ct. congener* (7.2 %), *M. arvicolae* (6.1 %), *Rh. integella* and *H. talpae*. In the nests of *C. glareolus* were found *H. talpae* (1 male, 24. 4. 1960, Halenkov; 1 male, 12. 12. 1960, Ostřižná) and *H. orientalis* (1 male, 27. 4. 1960, Vranča; 1 male, 12. 12. 1960, Ostrižná). In one nest of *C. glareolus* 12 specimens of *P. soricis* were found. Five nests contained 6 specimens of *A. nuperum*. More details on the occurrence of this species in the Carpathians are presented in Chapter A. 1. In two nests of *C. glareolus* 5 speciemens of *Rh. mesoides* (1 female and 4 males) were found for the first time in Moravia. Apart from above mentioned species, the nests of *C. glareolus* contained single specimens of *M. turbidus*, *P. kohauti* and *D. dasycnema*.

Of the 35 nests of *M. arvalis* 53.8 % contained fleas. The average number per nest was 2.6, per positive nest 4.8. Of the 4 species found the most frequent was again *Ct. agyrtes;* the predominance of *Ct. agyrtes* in *M. arvalis* nests in the High Tatras was reported by Cyprich and Kiefer (1972). Another 3 species (*M. turbidus*. *Ct. congener* and *H. talpae*) occurred sporadically.

23 nests of *S. araneus* were found 39.1 % of which contained fleas. The average number of fleas per nest investigated was 3, per positive nest 7.7 Of the four flea species found in the *S. araneus* nests (*Ct. agyrtes*, *M. arvicolae*, *Ct. congener*, *M. turbidus*) not one is specific to Soricidae. Similar results were obtained by Vysotskaya and Sazonova (1953) who analyzed a similar number of nests of *S. araneus* in the Leningrad region. Nevertheless, Vysotskaya (1964) found *D. dasycnema* in the nests of *S. araneus* and *Microtus arvalis* and *P. soricis* in the nests of S. *araneus*, *M. arvalis* and *Apodemus flavicollis* in the Trans-Carpathian region.

22 nests of *A. flavicollis* were found, 50.0 % of which were flea-positive. Siphonapteria of *A. flavicollis* nests seem to be similar to those of *C. glareolus* nests in our material. All 7 flea species infesting the nests of *A. flavicollis* were also found in the nests of *C. glareolus*. The average number of fleas per nest was 3.5, per positive nest 7.0.

Of the 6 nests of *T. europaea* 4 were found to contain fleas. Siphonapteria of mole nests consisted of 5 species known from earlier papers of Rosický (1957 a) and Jurík (1968) who analyzed in detail a large material of winter nests of mole. Noteworthy is the discovery of three females of *Ctenophthalmus bisoctodentatus heselhausi* at Halenkov on 11. 12. 1960.

In most cases the mammal inhabiting the nest could not be established according to the species composition of fleas. Thus, for some flea species the nests become a favourable place of contact of different host species and consequently the place of parasite interchange. Our results also show that places of contact (nests) contain—as is to be expected—some flea species found on the various host species concerned. Similar observations were made by Rosický (1953) in places of contact between mammalian species of different biotopes.

3. Division according to biotopes

The region studied was divided into four main biotopes: forest, glade, field and meadow (see Table 4). In all biotopes the most abundant flea was *Ct. agyrtes*. Ct. *bisoctodentatus* and *P. similis* were found only in mole nests in the meadow. The biotope poorest in fleas was the field where a total of 17 nests were found. Of these, 6 nests of

M. arvalis contained 30 specimens of *Ct. agyrtes* and single specimens of *H. talpae*, *Ct. congener* and *M. turbidus*.

The highest number of fleas occurred in the forest (11) where 83.3 % of all nest fleas were found. Although the result obtained is somewhat distorted by the number of nests investigated, the following 8 flea species may be mentioned as characteristic of the forest biotope (or the glade): *Ct. agyrtes*, *Ct. congener*, *M. arvicolae*, *H. talpae*, *Rh. integella*, *M. turbidus*, *A. nuperum* and *Rh. mesoides*. Of these species the most adaptable ecologically are *Ct. agyrtes*, *H. talpae*, *Ct. congener* and *M. turbidus* which occur in all kinds of biotopes, although they are most numerous in the forest.

Table 4. A survey of fleas collected from nests of small mammals in different types of biotopes.

Biotope (number of nests found) / Flea species	forest (178)	glade (23)	field (17)	meadow (33)
H. talpae + *H. orientalis*	28	4	1	1
A. nuperum	5	2	—	—
Rh. integella	22	3	—	—
Rh. mesoides	5	—	—	—
D. dasycnema	1	—	—	—
P. kohauti	2	—	—	—
P. similis	—	—	—	2
P. soricis	12	—	—	—
Ct. agyrtes	376	25	30	61
Ct. bisoctodentatus	—	—	—	5
Ct. congener	49	3	1	3
M. arvicolae	41	1	—	—
M. turbidus	17	3	1	2
Number of flea species	11	7	4	6

4. Division according to nest location

The nests of small terrestrial mammals found were divided according to their location into three main types: underground nests, nests built on the ground and nests above the ground. According to the concept of Daniel, Mrciak and Rosický (1971) underground nests are those situated under the ground surface and closed primarily from above. Underground nests are mostly covered with a soil layer; sometimes they are situated deep in the ground below a tree stump or rock. The nests built on the ground are situated either directly on the surface or in a shallow soil hollow which is usually covered with the wood of a tree-stump or rotten timber. The nests built above the ground are mostly covered from all sides and are situated above the ground surface (mostly only a few centimeters).

The richest flea fauna was found in the nests built on the ground and in underground nests (see Table 5). The nests above the ground had a poorer flea fauna; the result, however, is perhaps distorted by the number of nests found. The average number of fleas per nest found was about the same in all three nest types. Among the surface nests those situated in the tree-stumps or beneath rotting logs were the richest in the number and species composition of fleas. In a detailed experiment (see Daniel 1969) the three-stump

nests were shown to be most favourable for the development of most nidicolous ectoparasites.

Table 5. Survey of fleas found in nests of small mammals in different locations

Flea species	Underground nest (113)	On the ground (122)	Above the ground (16)
H. talpae + *H. orientalis*	18	16	—
A. nuperum	2	4	1
Rh. integella	11	12	2
Rh. mesoides	5	—	—
D. dasycnema	—	1	—
P. kohauti	1	1	—
P. similis	—	2	—
P. soricis	12	—	—
Ct. agyrtes	228	236	28
Ct. bisoctodentatus	—	5	—
Ct. congener	16	26	14
M. arvicolae	13	29	—
M. turbidus	8	10	5
Number of flea species	10	11	5

5. Division according to nest building material

Out of the total number of 251 nests 118 were built with leaves, 81 with grass, 31 with grass and moss and 21 with moss. 11 flea species were found in nests built with leaves. These nests were also the richest in the number of fleas (50.2 % of nest fleas). Out of 6 nests containing 5 to 6 flea species per nest and 15—47 fleas per nest 5 were built with leaves. 36.2 % of nest fleas were found in nests built with grass (7 flea species). The nests built with moss and grass contained 6 flea species. In the nests built with moss single specimens of species with a wide ecological valency only could be found: *Ct. agyrtes*, *Ct. congener*, and *M. turbidus*, and in one case *Rh. integella* and *A. nuperum*.

While grass nests are most favourable for parasitic mites (Mrciak, Daniel and Rosický, 1966) the leaves seem to be most favourable nest building material for the occurrence of fleas.

6. Coexistence of flea species

Almost all flea species found occurred together with one or several (up to five) other species, as also reported by Szabó (1969). The richest in species were the winter nests of *C. glareolus* built in the forest biotope on the ground in tree-stumps or below rotting timber (leaves as nest building material). This nest type was represented by 1 nest with 6 flea species and 4 nests with 5 flea species. In the spring only 1 nest with 5 flea species (underground grassy nest of *C. glareolus* in the forest biotope) and 1 nest with 4 flea species (surface grassy nest of *C. glareolus* in the glade) contained numerous species. None of the summer nests contained more than three flea species. In the autumn only 1 nest of *A. flavicollis* contained 5 flea species (a forest nest built with moss and grass above the ground); other nests found in the autumn contained 1—2 flea species. Largest communities (5 to 6 flea species in joint occurrence) were composed of only the

species characteristic of the forest biotope: *Ct. agyrtes, Ct. congener, M. arvicolae, H. talpae, Rh. integella, M. turbidus* and *A. nuperum*. The most frequent joint occurrence (24) in nests could be observed with *Ct. agyrtes—Ct. congener*.

We attempted to asses mathematically particular communities of flea species found in the *C. glareolus* nests according to the index of affinity derived by Fager (1957) and used by Daniel and Holubičková (1972) for assessing the relationships of gamasoid mites in the nests of *C. glareolus* found in the environs of V. Karlovice. The deviations from the value anticipated, however, did not reach the critical quantity for establishing a positive community even in the most frequent groupings and we therefore consider the presence of communities of several flea species in one nest to be accidental in our material studied.

C. COMPARISON OF OUR FINDINGS WITH THE FLEA FAUNA OF THE TRANS-CARPATHIA AND THE LENINGRAD REGION

Vysotskaya (1964) found 4,898 fleas on 1,202 animals and in 500 nests of small mammals in Trans-Carpathia. Of the 25 flea species parasitic on small mammals in Trans-Carpathia the following 14 were present in our collections: *H. talpae, Rh. integella, D. dasycnema, P. kohauti, P. similis, P. soricis, Ct. agyrtes, Ct. bisoctodentatus, Ct. congener, P. bidentata, L. segnis, N. fasciatus, M. arvicolae* and *M. turbidus*. Another 8 species in Trans-Carpathia are known from other parts of the Western Carpathians in this country (absent in our collections): *Amphipsylla rossica, Rh. pentacantha, P. steini, Ct. assimilis, Ct. solutus, Ct. obtusus, Ct. uncinatus, M. penicilliger*. In our collections as well as in other regions of the Western Carpathians the following species found in Trans-Carpathia are missing: *Ct. capriciosus, N. consimilis, N. mokrzeckyi* and *Stenoponia tripectinata*. The flea fauna of Trans-Carpathia differs from our collections in the absence of *A. nuperum* (in the U.S.S.R. it is known only from the Caucasus) and *Rh. mesoides* (absent in the U.S.S.R.). The species different for both regions occurred sporadically. The comparison of the mean infestation of hosts and their nests with fleas appears in the text.

The flea fauna of the Leningrad region was analyzed by Vysotskaya and Sazonova (1953). Most flea species of the Leningrad region are also known from the Western Carpathians, although they are not present in our material. In both regions (as in the whole of Europe) *Ct. agyrtes* is the most abundant flea of small mammals and their nests. The next frequent species in the fur of animals was *M. turbidus;* in our material in the nests more numerous were *Ct. congener, M. arvicolae, H. talpae* and *Rh. integella*. Of the frequent species found in the Leningrad region our material lacks *Ct. uncinatus* and *P. soricis starki* (this subspecies is present in our territory starting from the High Tatras eastwards). In the High Tatras intergrades between *P. s. rosickyi* and *P. s. starki* have been found. In the Leningrad region *Ct. congener* and *A. nuperum* are absent. In the material of both studies compared *Ct. assimilis* is missing. Both regions differ in the number of flea species in different seasons of the year. While in the Leningrad region the highest number of flea species occurs on hosts in summer, our materials show that the number of flea species on hosts is highest in winter. Vysotskaya and Sazonová (1953) found an equal number of flea species in nests of small mammals from summer to winter. In our material the highest number of flea species and a marked maximum of their numbers was revealed in the winter nests. Our findings, however, agree in many respects with the results from the Leningrad region—see comparison in the text.

CONCLUSIONS

1. During 1959—1960 studies were carried out on the parasites of small terrestrial mammals and their nest inhabitants in the Western Carpathians along the upper reaches of the river Vsetínská Bečva and its tributaries (environs of Velké Karlovice, North Moravia). In different seasons of the year a total of 253 hosts (46.6 % with fleas) were trapped and 251 mammals nests (38.2 % with fleas) were collected. A total of 1095 fleas (389 in the fur and 706 in nests), belonging to 19 species and subspecies were found.
2. The most abundant small mammal in our material collected was *Clethrionomys glareolus*. *Apodemus flavicollis* and *Sorex araneus* ranked as the next most numerous species.

The predominant flea species on hosts was *Ctenophthalmus agyrtes; Megabothris turbidus* and *Rhadinopsylla integella* were also relatively frequent. The numbers of fleas were highest in summer, the species composition was richest in winter. In summer the most numerous species were *Ct. agyrtes*, *M. turbidus*, *Palaeopsylla soricis* and *Doratopsylla dasycnema*. *Rh. integella*, *Peromyscopsylla bidentata* and *Atyphloceras nuperum* were most numerous in winter.

12 flea species were found on *C. glareolus*, the most abundant being *Ct. agyrtes*, also *Rh. integella*, *M. turbidus*, *P. bidentata* and *A. nuperum*. 6 flea species were found on *A. flavicollis*, of which *Ct. agyrtes* was predominant (and other species sporadic). In the fur of *S. araneus* 8 flea species were found, with no marked predominance of any of them.

Ct. agyrtes had the widest range of hosts (7 species). *P. soricis* and *D. dasycnema* occurred on 4 to 5 host species, other fleas were found on 1 to 3 host species.

The average number of fleas per one host examined was 1.5, per positive host 3.3.

3. The highest number of nests found belonged to *C. glareolus*. Other nests frequently discovered were those of *Microtus arvalis*, *S. araneus* and *A. flavicollis*.

The most numerous nest flea was *Ct. agyrtes* which was present in the nests of all host species throughout the year. *Ct. congener*, *Malaraeus arvicolae*, *Hystrichopsylla talpae*, *Rh. integella* and *M. turbidus* ranked as the next most numerous species. *Ct. congener* and *M. turbidus* occurred, like *Ct. agyrtes*, in the nests of all host species all year round. The maximum of occurrence of *M. arvicolae* and *H. talpae* was in winter, while *P. soricis* was found in summer only.

The nests of *C. glareolus* contained 11 flea species, mainly *Ct. agyrtes*, but *Ct. congener*, *M. arvicolae*, *H. talpae*, *Rh. integella*, *P. soricis* were also quite common in them; other species occurred sporadically. The nests of *M. arvalis* contained 4 flea species: *Ct. agyrtes*, *M. turbidus*, *Ct. congener* and *H. talpae*. The nests of *S. araneus* also contained 4 flea species: *Ct. agyrtes*, *M. arvicolae*, *Ct. congener* and *M. turbidus*. None of these fleas is specific to Soricidae. The nests of *A. flavicollis* contained 7 flea species, mainly *Ct. agyrtes* and *Ct. congener*, other species occurred in them sporadically.

In most cases the mammal inhabiting the nest cannot be determined according to the flea species composition. The highest number of fleas and their species was found in the forest biotope in the nests built with leaves on the ground surface (mostly in a tree-stump or beneath a rotting tree-trunk).

Most flea species occurred in company of one or several (up to 5) other species. The richest in species were the nests of *C. glareolus* during the winter. However, it was not successful to demonstrate mathematically a positive community even in the most frequent concentrations of joint occurrence of several flea species.

The fleas are more numerous in the nests of small mammals than on hosts themselves. The average number of fleas per nest investigated was 2.8 and per positive nest 7.3.

From the zoogeographic aspect the findings of *Rhadinopsylla mesoides*, *Ctenophthalmus bisoctodentatus heselhausi* and *Hystrichopsylla orientalis* (western boundary of distribution of the latter species in our territory) are of interest.

4. The flea fauna of small mammals, common throughout Europe, of the western Carpathians, Trans-Carpathia and the Leningrad region is very similar; the regions compared differ in flea species occurring mostly as single specimens.

БЛОХИ (SIPHONAPTERA) МЕЛКИХ НАЗЕМНЫХ МЛЕКОПИТАЮЩИХ И ИХ ГНЕЗД В ЗАПАДНЫХ КАРПАТАХ

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Резюме. Авторами обработан материал, насчитывающий 1095 экземпляров блох, относящихся к 19 видам и подвидам и обнаруженных в шерсти и в гнездах мелких млекопитающих западных Карпат. Полученные результаты рассмотрены с точки зрения нахождения блох на хозяевах и в их гнездах; блохи, обнаруженные в шерсти дифференцированы смотря по их численности, временам года и хозяинным видам, а блохи в гнездах — по их численности и сезонам года, по их хозяевам, биотопам, локализации гнезд, строительному материалу для гнезд и по сосуществованию отдельных видов блох. Полученные результаты сопоставлены с результатами, полученными путем одинаковой методики в Закарпатии и в Ленинградской области.

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