Parasitological investigation of small mammals of Gory Sowie. VI. Siphonaptera, Anoplura, Acarina

1 author:

Haitlinger Ryszard
Wrocław University of Environmental and Life Sciences

POLSKIE PISMO ENTOMOLOGICZNE
BULLETIN ENTOMOLOGIQUE DE POLOGNE

Tom 47: 429–492 Wrocław 30 VIII 1977

Parasitological investigation of small mammals of Góry Sowie (Middle Sudetes). VI. *Siphonaptera*, *Anoplura*, *Acarina*

Badania parazytologiczne drobnych ssaków Gór Sowich (Sudety Środkowe). VI. *Siphonaptera*, *Anoplura*, *Acarina*

BY

RYSZARD HAITLINGER

ABSTRACT. Faunistic and ecological investigations of *Siphonaptera*, *Anoplura* and *Acarina* of small mammals were carried out in Góry Sowie (Middle Sudetes) in 1971 and 1972. There were 11, 532 specimens, belonging to 106 species, collected on 1388 specimens of *Rodentia* and *Insectivora*, belonging to 17 species. The changes in arthropod numbers on small mammals have been discussed in respect to season of the year, elevation, sex and body size of hosts. Pure, mixed and accidental infestations have also been discussed, and the zoogeographical characteristics of the arthropods concerned have been presented.

In 1971 and 1972 the faunistic and ecological studies on the arthropods occurring on *Rodentia* and *Insectivora* were carried out in the submontane (300–500 m a.s.l.) and montane (600–900 m a.s.l.) zones of Góry Sowie. The materials were collected from March till December inclusive, each year. The studies included *Siphonaptera*, *Anoplura*, *Mesostigmata*, *Trombidiformes*, *Sarcoptiformes* and *Ixodides*. Thus, almost all arthropods occurring on small mammals were taken into consideration. For technical reasons, very small parasites of the families *Demodecidae* and *Psorergatidae* (*Acarina*), were excluded from the studies. The results of these studies have been reported in 5 parts. Each of the arthropod groups, mentioned above, has been discussed separately. The phenological observations and the fluctuation of numbers of the common species, as well as the changes in respect to sex and dimensions (age) of hosts and the problem of mixed and accidental invasions, have been discussed. Some of the problems have been given separately for the montane and submontane zone (HAITLINGER, 1973, 1975, 1976 a, b, 1977).

Such studies are frequent, but in relation to a particular order or family of the external parasites. The complex studies are rare. Frequently, the arthropod fauna on a single host is very diversified. The qualitative and quantitative composition of parasite population on various hosts depends, not only on the environmental factors and the host characteristics, but also on the relationships among species included in the parasitocoenosis. The observations concerning these relationships are of great importance in explanation of the processes regulating the structure of the parasitocoenosis. Such studies were done by SOSNINA (1967a), VYSOCKAJA (1967), ARZAMASOV, MERKUŠEVA, MIHOLAP, ČIKLEVSKAJA (1969) and EDLER, NILSSON (1973). The mutual influence of fleas, lice and mites were commented by many authors (HOPKINS, 1949; WEGNER, 1970; BARTKOWSKA, 1973).

Up to the recent times, the parasitic arthropods on small mammals were almost unknown in Poland, in spite of their common occurrence. Serious faunistic studies on *Siphonaptera*, *Anoplura* and *Ixodides* were carried out in the fifties and sixties, and they resulted in catalogues of *Siphonaptera* and *Anoplura* (SKURATOWICZ, 1964; WEGNER, 1966), and the list of *Ixodides* (LACHMAJER, 1967). The knowledge of *Sarcoptiformes*, *Trombidiformes* and *Mesostigmata* may be considered as introductory. The neglect of these groups is serious, more so, because of the considerable progress in acarological studies in some European countries.

The mountain regions in Poland were almost completely omitted in the studies on the groups mentioned above. There are some recent publications on *Siphonaptera* of Sudetes and Carpathians (SKURATOWICZ, 1966; HAITLINGER, 1970a, b, 1971, 1973a, 1974b; BARTKOWSKA, 1973), and faunistic reports on *Anoplura* (GERWEL,1954; EICHLER, 1960; SZCZĘŚNIAK, 1963; HAITLINGER, 1974a), but they do not exhaust the problem.

The comprehensive studies, carried out year round, and including all parasitic arthropods of small mammals, have not yet been completed in Poland.

In the present paper, the problems analysed before, in respect to each of the arthropod groups, as mentioned above, are discussed in relation to the entire collection. Also the zoogeographical characteristics, not discussed before, are presented now.

The biological characteristics and the information on the collecting

places have already been given in the earlier publications. The small mammals were mainly collected at the edge of a forest. In the submontane zone, the collections were made at the edge of spruce and mixed (spruce, birch, sycamore maple, oak) forests, and in the montane zone at the edge of spruce, spruce-beech, and spruce-sycamore maple forests. The areas adjacent to forests were more or less wet meadows.

MATERIAL

The arthropods were collected from small mammals using a widely utilised method of combing. It permits the evaluation of relative numbers of animals, and makes possible the observations of the processes taking place in the population under consideration, but without the exact evaluation of their quantitative strength (WASYLIK, 1965). It provides repeatability and comparability of experiments.

There were 11532 arthropods (11283 specimens belonging to 106 species, and 249 unidentified specimens) collected during 20 months on 1388 small mammals, belonging to 17 species (6 species of *Insectivora* and 11 *Rodentia*). The most numerous are *Mesostigmata*, of which 47 species make up 38.6% of the collection; 22 species of *Siphonaptera* 15.9%; 18 species of *Trombidiformes* 15.7%; 11 species of *Sarcoptiformes* 14.7%; 6 species of *Anoplura* 11.6%; and 2 species of *Ixodides* 3.5%.

The *Mesostigmata* were the most diverse group, but out of 47 species only 7 may be considered as numerous (Table 1). Quite diverse were *Siphonaptera*, but beside *Ctenophthalmus agyrtes* (HELL.), only 5 species were collected frequently on small mammals. The relatively low numbers of the common flea species are influenced by the narrow seasonality of some of them: *Peromyscopsylla silvatica* (MEIN.), *P. bidentata* (KOL.), *Rhadinopsylla integella* (JORD., ROTHS.), usually expressed more strongly than in *Acarina* and *Anoplura*.

A relatively high faunistic diversity is shown by Trombidiformes, but only 2 species occured in high numbers. The poor faunistic composition of *Sarcoptiformes* results probably from failure to identify some of them. Only 4 species were identified from among over 100 specimens.

Poorly diversified are *Anoplura* and *Ixodides*, which is understandible, because the number of species connected with small mammals under our climatic conditions is small. Both species of *Ixodides* and 3 species of *Anoplura* belong to the most common parasites of small mammals of Góry Sowie.

The arthropod fauna, collected in the small territory of Góry Sowie,

Table 1. Dominant species of arthropods collected on small mammals of Góry Sowie

	Species	Number of specimens	% of collection
1	*Laelaps agilis* Koch	1684	14,6
2	*Neotrombicula zachvatkini* Schlug.	1241	10,8
3	*Dermacarus hypuadei* (Koch)	746	6,5
4	*Hoplopleura edentula* Fahr.	716	6,2
5	*L. clethrionomydis* Lange	608	5,2
6	*Ctenophthalmus agyrtes* (Hell.)	554	4,8
7	*Haemogamasus nidi* Mich.	473	4,1
8	*N. inopinata* (Oud.)	395	3,4
9	*L. hilaris* Koch	367	3,2
10	*H. acanthopus* (Burm.)	270	2,3
11	*Hyperlaelaps microti* (Ewing)	265	2,3
12	*Polyplax serrata* (Burm.)	259	2,2
13	*Afrolistrophorus apodemi* Fain	244	2,1
14	*Orycteroxenus soricis* (Oud.)	242	2,1
15	*Ixodes trianguliceps* Bir.	210	1,8
16	*Palaeopsylla soricis* (Dale)	204	1,8
17	*Peromyscopsylla bidentata* (Kol.)	199	1,7
18	*Ixodes ricinus* (L.)	197	1,7
19	*P. silvatica* (Mein.)	176	1,5
20	*Doratopsylla dasycnema* (Roths.)	176	1,5
21	*Listrophorus brevipes* Dubin.	153	1,3
22	*Eulaelaps stabularis* (Koch)	148	1,3
23	*Megabothris turbidus* (Roths.)	138	1,2
24	*Hirstionyssus isabellinus* (Oud.)	126	1,1

is very rich. This fact certainly is responsible for low numbers of individual species, of which only 2 make over 10% of the collection. The most numerous 24 species are listed in Table 1 (only those were listed that made at least 1% of the collection).

Laelaps agilis Koch (14.6%) and *Neotrombicula zachvatkini* Schlug. (10.8%) dominate in the collection. Those species that made 3–7% of the collection vere considered as numerous, and there were 7 of them. The remaining 15 species were considered as common, but not numerous (1–3% of the collection).

Among the more common species hast specificity is expressed in various degree, and same of them, closely connected with one mammal species, do not contact the others at all, or connections are loose. The contacts are also limited by seasonality of occurence, and the presence of active forms at different times. The dominance of individual arthropod

species is different in *Microtidae*, *Muridae* and *Soricidae*, and in particular species of these families. The same is observed during particular seasons of a year.

STRUCTURE OF ARTHROPOD GROUPS ON SMALL MAMMALS OF GÓRY SOWIE

TAXONOMIC AND NUMERICAL GROUPS

Clethrionomys glareolus (Schreber, 1780)

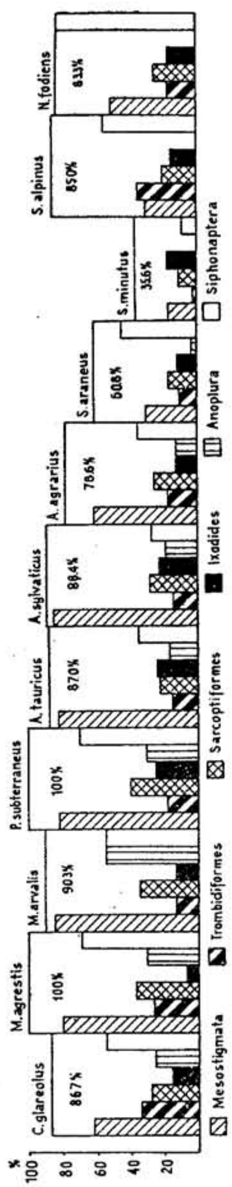
There were 5397 arthropods, belonging to 80 species, collected. Among them 37 species of *Mesostigmata*, 15 of *Siphonaptera*, 13 of *Trombidiformes*, 8 of *Sarcoptiformes*, 5 of *Anoplura*, and 2 species of *Ixodides*. The highest extensity of invasion was shown by *Mesostigmata* (61.5%) and *Siphonaptera* (54.3%), the lowest by *Anoplura* (26.3%) and *Ixodides* (15.7%; Fig. 1). The highest intensity of infection was recorded for *Trombidiformes* (2.80) and *Mesostigmata* (2.57), the lowest for *Ixodides* (0.30; Fig. 2).

The extensity of invasion of 10 species was over 10%. *Neotrombicula zachvatkini* Schlug. reached the highest extensity. It was followed by *C. agyrtes* (25.9%), *Hoplopleura edentula* Fahr., *L. clethrionomydis* (Lange) (22.2%), *Haemogamasus nidi* (Mich.) (21.2%) and *Dermacarus hypuadei* (Koch) (21.1%). Only *H. edentula* and *L. clethrionomydis* are closely connected with *C. glareolus*. The others are also common on other small mammals.

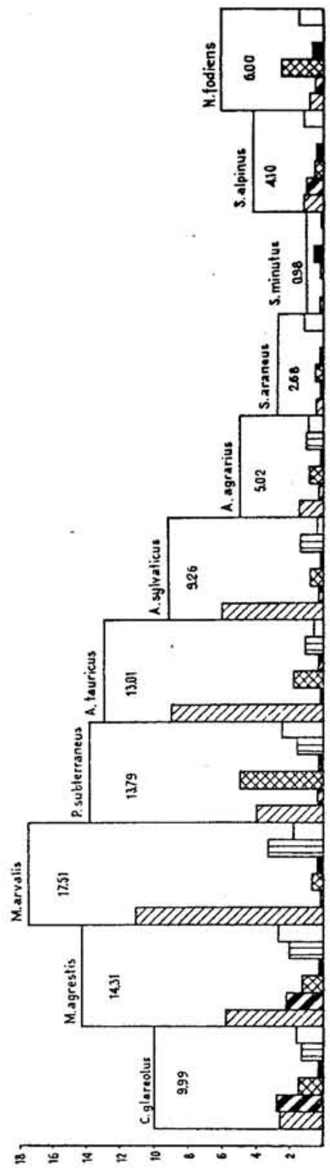
The second group is made up of the species with extensity of invasion 10–20%: *P. bidentata* (15.9%), *P. silvatica* (12.2%), *N. inopinata* (Oud.) (11.8%) and *Megabothris turbidus* (Roths.) (10.7%). With the exception of the last one, all are seasonal species, with a limited period of occurrence (Fig. 3).

There are other species, commonly occurring on *C. glareolus*, of which the extensity of invasion was not much lower than 10%, such as *Ixodes trianguliceps* Bir., *Eulaelaps stabularis* (Koch), *R. integella*, *I. ricinus* (L.), *C. congener* Roths., *Hirstionyssus isabellinus* (Oud.) and *L. agilis*.

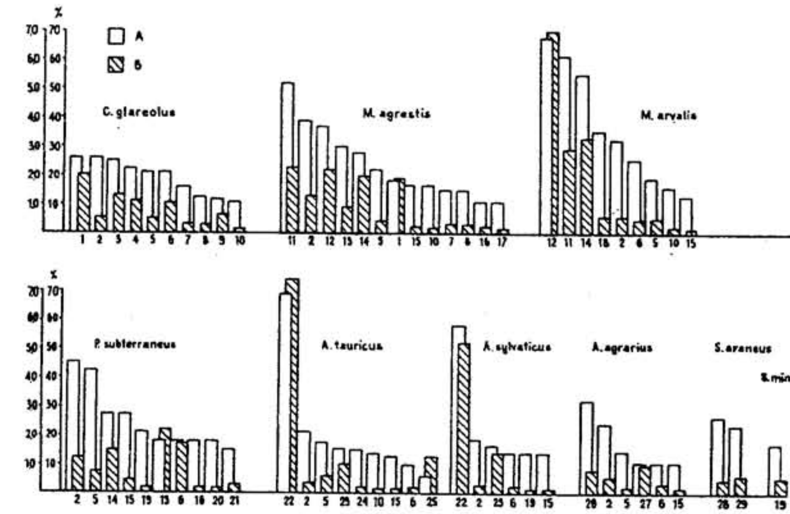
The species of which the mean intensity of infection was over 1.0 were considered as dominant. *N. zachvatkini* (2.0), *H. edentula* (1.29), *L. clethrionomydis* (1.12) and *D. hypuadei* (1.07) were dominant on *C. glareolus*. The species with a mean intensity of infection between 0.50 and 1.00 were subdominant: *N. inopinata* (0.66), *C. agyrtes* (0.52), and *H. nidi* (0.51; Fig. 3).



1. Total extensity of invasion of arthropods and of *Mesostigmata*, *Trombidiformes*, *Sarcoptiformes*, *Ixodides*, *Anoplura* and *Siphonaptera* on common species of small mammals of Góry Sowie



2. Total mean intensity of infection with arthropods and mean intensity of infection with *Mesostigmata*, *Trombidiformes*, *Sarcoptiformes*, *Ixodides*, *Anoplura* and *Siphonaptera* of common species of small mammals of Góry Sowie (labels as in Fig. 1)



3. Species with the greatest stability of occurrence and dominant on most common species of small mammals of Góry Sowie: 1 — *N. zachvatkini*, 2 — *C. agyrtes*, 3 — *H. edentula*, 4 — *L. clethrionomydis*, 5 — *H. nidi*, 6 — *D. hypuadei*, 7 — *P. bidentata*, 8 — *P. silvatica*, 9 — *N. inopinata*, 10 — *M. turbidus*, 11 — *H. microti*, 12 — *L. hilaris*, 13 — *L. brevipes*, 14 — *H. acanthopus*, 15 — *E. stabularis*, 16 — *H. isabellinus*, 17 — *H. talpae*, 18 — *C. assimilis*, 19 — *I. trianguliceps*, 20 — *C. congener*, 21 — *M. arvicolae*, 22 — *L. agilis*, 23 — *P. serrata*, 24 — *I. ricinus*, 25 — *A. apodemi*, 26 — *L. jettmari*, 27 — *H. affinis*, 28 — *D. dasycnema*, 29 — *P. soricis*. A — extensity of invasion, B — mean intensity of infection

In case of fleas, the intensity was much lower than in common representatives of other groups of arthropods, at the same extensity of invasion. Among species with a high stability of occurrence, the greatest number belonged to *Siphonaptera* (4), two species to *Mesostigmata*, two to *Trombidiformes*, one to *Anoplura* and one to *Sarcoptiformes*.

Microtus agrestis (Linnaeus, 1761)

There were 772 arthropods collected. They belonged to 40 species, of which 13 were *Mesostigmata*, 13 *Siphonaptera*, 6 *Sarcoptiformes*, 3 *Trombidiformes*, 3 *Anoplura* and 2 *Ixodides*.

The highest extensity of invasion was recorded for *Mesostigmata* (80%) and *Siphonaptera* (68.5%), the lowest for *Anoplura* (29.6%) and *Ixodides* (7.4%; Fig. 1). The highest mean intensity of infection was recorded for *Mesostigmata* (5.78), the lowest for *Ixodides* (0.26; Fig. 2). Exceptionally high mean intensity of infection, in relation to extensity of invasion, was recorded for *Trombidiformes* and *Anoplura*, and exceptionally low for *Siphonaptera*.

In this group, three species are characterized by a high degree of stability; *Hyperlaelaps microti* (EVING) (51.8%), *C. agyrtes* (38.9%) and *L. hilaris* KOCH (37%), and ten by the medium stability: *Listrophorus brevipes* DUBIN. (29.6%), *H. acanthopus* (BURM.) (27.8%), *H. nidi* (22.2%), *N. zachvatkini* (18.5%), *M. turbidus* (16.7%), *E. stabularis* (16.7%), *P. bidentata* (14.8%), *P. silvatica* (14.8%), *H. isabellinus* (11.1%), and *Hystrichopsylla talpae* (CURT.) (11.1%; Fig. 3).

None of the species, listed above, is closely connected with *M. agrestis*. *L. hilaris*, *H. microti*, *L. brevipes* and *H. acanthopus* are connected with representatives of the genus *Microtus*, and to a lesser degree, the genus *Pitymys*.

The dominant species are as follows: *H. microti* (2.30), *L. hilaris* (2.19), *H. acanthopus* (1.98), *N. zachvatkini* (1.91), *C. agyrtes* (1.28), and *L. brevipes* (0.93).

Among species of high stability of occurrence, 5 belong to *Siphonaptera* and *Mesostigmata*, 1 to *Anoplura*, 1 to *Trombidiformes* and 1 to *Sarcoptiformes*.

Microtus arvalis (Pallas, 1779)

There were 543 arthropods collected. They belonged to 27 species, of which 11 were *Mesostigmata*, 9 *Siphonaptera*, 3 *Sarcoptiformes*, 2 *Ixodides*, 1 *Anoplura*, and 1 *Trombidiformes*.

The highest extensity was recorded for *Mesostigmata* (83.9%), and the lowest for *Ixodides* and *Trombidiformes* (12.9% each; Fig. 1). The highest mean intensity of infection was recorded for *Mesostigmata* (11.10), and the lowest for *Trombidiformes* (0.19; Fig. 2).

The above, very high, indices are probably connected with the low numbers of M. *arvalis* in Góry Sowie. In Pieniny, on 250 *M. arvalis*, the extensity of invasion of *Siphonaptera* was only 44%, and that of the most common, *C. agyrtes* and *C. assimilis*, did not go over 20%. Therefore, it was almost two times lower than in Góry Sowie (HAITLINGER, 1974b). The difference resulted from the different population density of *M. arvalis* in Pieniny and Góry Sowie.

On *M. arvalis*, there were 5 species with high and 4 with medium degree of stability. The following belong to the first group: *L. hilaris* (67.7%), *H. microti* (67.3), *H. acanthopus* (54.8%), *Ctenophthalmus assimilis* (TASCH.) (35.5%), and *C. agyrtes* (32.3%).

To the second group belong the following species: *D. hypuadei* (25.8%), *M. turbidus* (16.1%), and *E. stabularis* (12.9%). None of them is exclusively connected with *M. arvalis*, and only 4 are at all closely connected with the genera *Microtus* and *Pitymys*.

The following are the dominant species: *L. hilaris* (7.03), *H. acanthopus* (3.35), and *H. microti* (2.94). The subdominants are as follows: *C. agyrtes* (0.65), *C. assimilis* (0.61), and *H. nidi* (0.52; Fig. 3).

The high extensity of invasion of *H. acanthopus* on *M. arvalis* is characteristic, as well as a relatively high extensity of invasion of *D. hypuadei* at the low mean intensity of infection.

Among the species of high stability of occurrence there are 4 belonging to *Mesostigmata*, 3 to *Siphonaptera*, 1 to *Anoplura*, and 1 to *Sarcoptiformes*.

Pitymys subterraneus (de Selys Longchamps, 1835)

There were 455 arthropods collected, of which 18 species belong to *Mesostigmata*, 12 to *Siphonaptera*, 7 to *Sarcoptiformes*, 4 to *Trombidiformes* and 2 to *Anoplura* and *Ixodides*. The highest extensity of invasion was recorded for *Mesostigmata* (81.8%) and *Siphonaptera* (69.9%), and the lowest for *Trombidiformes* (18.2%).

The highest mean intensity of infection was recorded for *Sarcoptiformes* (5.0) and *Mesostigmata* (4.06), the lowest for *Trombidiformes* (0.36) and *Ixodides* (0.27).

In the collection from *P. subterraneus*, there are 2 species of high stability of occurrence: *C. agyrtes* (45.5%), *H. nidi* (42.2%), and 8 of medium stability: *H. acanthopus* (27.3%), *E. stabularis* (27.3%), *I. trianguliceps* (21.2%), *C. congener*, *L. brevipes*, *D. hypuadei*, *H. isabellinus* (18.2% each), and *Malareus arvicolae* IOFF (15.2%). Only the last species is closely connected with *P. subterraneus*.

The following are the dominant species: *L. brevipes* (2.21), *D. hypuadei* (1.76), *H. acanthopus* (1.48) *H. microti* (1.27), and *C. agyrtes* (1.24). *H. nidi* is a subdominant species (0.76).

Among the species of high stability of occurrence, there are 3 species belonging to *Mesostigmata* and *Siphonaptera*, 2 to *Sarcoptiformes*, 1 to *Anoplura*, and 1 to *Ixodides*.

Apodemus tauricus (Pallas, 1811)

There were 2406 arthropods collected, belonging to 63 species. 32 species of *Mesostigmata*, 13 *Siphonaptera*, 8 *Sarcoptiformes*, 5 *Trombidiformes*, 3 *Anoplura* and 2 *Ixodides*.

The highest extensity of invasion was recorded for *Mesostigmata* (83.2%), the lowest for *Trombidiformes* (15.6%; Fig. 1). The highest intensity of infection was recorded for *Mesostigmata* (8.98), the lowest for *Trombidiformes* (0.21; Fig. 2).

A particularly high stability of occurrence was reached by *L. agilis* (69.2%). The medium stability of occurrence was reached by the following species: *C. agyrtes* (21.6%), *H. nidi* (17.3%), *Polyplax serrata* (Burm.) (15.7%), *I. ricinus* (15.7%), *M. turbidus* (14.1%), *E. stabularis* (13.0%), and *D. hypuadei* (10.2%). Of the species with the extensity of invasion lower than 10%, *Afrolistrophorus apodemi* Fain (6.0%) should be mentioned, since it occurred in large numbers on several specimens of *A. tauricus*.

L. agilis is a dominant species (7.42). The following are subdominants: *A. apodemi* (1.30), *P. serrata* (1.02) and *H. nidi* (0.51). *C. agyrtes*, frequently occurring on *A. tauricus*, reached the mean intensity of infection of only 0.35.

Among 8 species of high stability of occurrence, 3 belonged to *Mesostigmata*, 2 to *Siphonaptera*, 1 to *Anoplura*, 1 to *Ixodides* and 1 to *Sarcoptiformes*. None of them is exclusively connected with *A. tauricus*, and only *P. serrata*, *L. agilis* and *A. apodemi* are connected with mice of the subgenus *Sylvaemus* or also *Apodemus*.

Apodemus sylvaticus (Linnaeus, 1758)

There were 398 arthropods collected. They belong to 29 species, out of which 12 were *Mesostigmata*, 6 *Siphonaptera*, 4 *Sarcoptiformes*, 4 *Trombidiformes*, 2 *Ixodides* and 1 *Anoplura*. The highest extensity of invasion was recorded for *Mesostigmata* (88.4%), and the lowest for *Trombidiformes* (14.0%). The highest mean intensity of infection was recorded for *Mesostigmata* (6.07), and the lowest for *Ixodides* (0.23). Only *L. agilis* reached a high stability of *occurrence* (58.1%). The medium stability was reached by *C. agyrtes* (18.6%), *P. serrata* (16.3%), *D. hypuadei* (14.0%), *E. stabularis* (13.9%), and *I. trianguliceps* (13.9%).

L. agilis is a dominant species (5.33), and *P. serrata* a subdominant species (1.40). The mean intensity of infection of the remaining species does not go over 0.50 (*C. agyrtes* 0.28).

Out of 6 species of high stability of occurrence, 2 belong to *Mesostigmata*, and the others to *Siphonaptera*, *Anoplura*, *Sarcoptiformes* and *Ixodides* — one each. None of them is exclusively connected with *A. sylvaticus*.

Apodemus agrarius (Pallas, 1771)

Out of 422 arthropods collected, belonging to 43 species 20 species, were *Mesostigmata*, 8 *Siphonaptera*, 6 *Sarcoptiformes*, 5 *Trombidiformes*, 2 *Anoplura*, and 2 *Ixodides*. The highest extensity was recorded for *Mesostigmata* (60.7%), and the lowest for *Anoplura* and *Ixodides* (11.9% each). The highest mean intensity of invasion was recorded for *Mesostigmata* (1.66) and *Anoplura* (1.04), and the lowest for *Ixodides* (0.18).

L. jettmari (Vitzth.) (32.1%) and *C. agyrtes* (23.8%) reached a high stability of occurrence. *H. nidi* (14.3%), *H. affinis* (Burm.), *E. stabularis* and *D. hypuadei* (10.7% each) reached a medium stability.

H. affinis (1.02), *L. jettmari* (0.79) and *C. agyrtes* (0.54) were the dominant species.

Among the species of high stability of occurrence, 3 belong to *Mesostigmata*, 1 to *Anoplura*, 1 to *Siphonaptera*, and 1 to *Sarcoptiformes*.

L. jettmari and *H. affinis* are closely connected with *A. agrarius*, but their intensity of invasion and the mean intensity of infection are much lower than those of the most common species occurring on mice of the subgenus *Sylvaemus*.

Mus musculus Linnaeus, 1758

There were 22 arthropods, belonging to 11 species, collected, of which 4 species were *Mesostigmata*, 5 *Trombidiformes*, 2 *Siphonaptera*, 1 *Ixodides*, and 1 *Sarcoptiformes*. *Proctolaelaps pygmaeus* (Müll.) was the most numerous species.

Sorex araneus Linnaeus, 1758

There were 824 arthropods collected, belonging to 66 species, including 28 *Mesostigmata*, 14 *Siphonaptera*, 12 *Trombidiformes*, 7 *Sarcoptiformes*, 3 *Anoplura*, and 2 *Ixodides*. The highest extensity of invasion was recorded for *Siphonaptera* (43.9%), the lowest for *Anoplura* (2.9%) and *Trombidiformes* (10.1%). The highest mean intensity of infection was also recorded for *Siphonaptera* (1.21), and the lowest for *Anoplura* (0.04) and *Trombidiformes* (0.21).

High stability of occurrence was reached by *Doratopsylla dasycnema* (Roths) (26.4%) and *Palaeopsylla soricis* (Dale) (23.4%). At the same time they are the dominant species (mean intensity of infection was 0.47 and 0.60).

Sorex minutus Linnaeus, 1766

There were 58 arthropods collected, belonging to 14 species, including 6 *Mesostigmata*, 3 *Siphonaptera*, 3 *Sarcoptiformes*, 1 *Ixodides*, and 1 *Trombidiformes*. The highest extensity was recorded for *Mesostigmata* (17%) and *Ixodides* (16.9%), the lowest for *Trombidiformes* (1.7%). No *Anoplura* were collected.

The highest intensity of infection was reached by *Ixodides* (0.56), and the lowest by *Trombidiformes* (0.02). The highest stability of occurrence and the strongest dominance was shown by *I. trianguliceps* (16.9%, 0.56).

Sorex alpinus Schinz 1837

There were 82 arthropods collected, belonging to 29 species, including 12 *Mesostigmata*, 9 *Trombidiformes*, 3 *Siphonaptera*, 3 *Sarcoptiformes*, and 2 *Ixodides*. The highest extensity of invasion was recorded for *Siphonaptera* (55%), the lowest for *Ixodides* (15%). No *Anoplura* were collected.

The highest intensity of infection was reached by *Mesostigmata* (1.15), the lowest by *Ixodides* (0.40). *D. dasycnema*, *P. soricis* and *I. ricinus* were the species most frequently collected.

Neomys fodiens (Pennant, 1771)

There were 72 arthropods collected, belonging to 20 species, including 6 *Mesostigmata*, 5 *Siphonaptera*, 4 *Sarcoptiformes*, 3 *Trombidiformes*, and 2 *Ixodides*. The highest extensity was shown by *Siphonaptera* (83.3%), and the lowest by *Trombidiformes* and *Ixodides* (16.7% each). No *Anoplura* were collected.

The highest mean intensity of infection was recorded for *Sarcoptiformes* (2.50), the lowest for *Trombidiformes* (0.50). *Orycteroxenus soricis* (Oud.) was a dominant species (2.00), and *D. dasycnema* was also frequently collected (0.75).

*

The individual species of small mammals have different faunistic, biological and quantitative associations with the arthropods. The numbers of species collected depend on the numbers of a host, the area occupied, and its ecological valency. The numerous and active species have a greater opportunity to become infected by the accidental fauna. This is why the arthropod fauna of the three most numerous small mammals of Góry Sowie was the richest.

There were 80 arthropod species collected on *C. glareolus*, 66 species on *S. araneus*, and 63 species on *A. tauricus*. These numbers are high. Arzamasov (1969), on 645 *S. araneus*, collected over the period of 13 years, in different parts of Bielorussia, found only 54 species of external parasites; on 66 *S. minutus* 15 species, and on 31 *N. fodiens* 20 species. Vysockaja (1967), the highest number of arthropod species (80) reported on *M. arvalis*.

Table 2. Arthropods collected on *Microtidae* of Góry Sowie

Species	*Clethrionomys glareolus* (Schreb.)	*Microtus agrestis* (L.)	*Microtus arvalis* (Pall.)	*Pitymys subterraneus* (de Sel. Long.)
Siphonaptera				
Ctenophthalmus agyrtes (Hell.)	281	69	20	41
C. congener Roths.	59	2	3	7
C. assimilis (Tasch.)	7	10	19	1
C. solutus Jord., Roths.		1	1	1
C. obtusus Jord., Roths.		1		
Peromyscopsylla bidentata (Kol.)	169	19	2	5
P. silvatica (Mein.)	149	18	1	4
Megabothris turbidus (Roths.)	77	11	7	3
Malareus penicilliger (Grube)	4	3	2	5
M. arvicolae Ioff	1			10
Rhadinopsylla integella (Jord., Roths.)	86	1		
R. pentacantha (Roths.)	2			4
Nosopsyllus fasciatus (Bosc.)	1			
Atyphloceras nuperum (Jord.)	1			
Hystrichopsylla talpae (Curt.)	8	9	1	1
H. orientalis Smit		2		
Doratopsylla dasycnema (Roths.)	5	1		
Palaeopsylla soricis (Dale)	1			2
Total	854	147	56	84
Anoplura				
Hoplopleura edentula Fahr.	696	3		2
H. acanthopus (Burm.)	8	107	104	49
H. affinis (Burm.)	2	1		
Polyplax serrata (Burm.)	9			
P. hannswrangeli Eich.	2			
Total	717	111	104	51
Mesostigmata				
Laelaps clethrionomydis Lange	603		2	
L. hilaris Koch	14	118	218	10
L. agilis Koch	45	3	2	4
Hyperlaelaps microti (Ewing)	3	124	91	42
Androlaelaps fahrenholzi (Berl.)	9	1	2	5
A. casalis (Berl.)	1			
Hypoaspis sardoa (Berl.)	2			1
H. oblonga (Halb.)	1		1	
H. heselhausi Oud.	1			

Table 2

Species	*Clethrionomys glareolus* (SCHREB.)	*Microtus agrestis* (L.)	*Microtus arvalis* (PALL.)	*Pitymys subterraneus* (DE SEL. LONG.)
Hypoaspis sp.	2			
Eulaelaps stabularis (KOCH)	52	13	6	15
Haemogamasus nidi MICH.	278	25	16	25
H. hirsutus BERL.	20	4		1
H. horridus MICH.	19	1	1	1
H. hirsutosimilis WILLM.	3			
Hirstionyssus isabellinus (OUD.)	97	13	2	7
H. apodemi ZUEV.	4			
Cyrtolaelaps mucronatus (G.R. CAN.)	15			1
C. minor WILLM.	13			1
Euryparasitus emarginatus (KOCH)	20			4
Veigaia nemorensis (KOCH)	2			
Proctolaelaps pygmaeus (MÜLL.)	13			
Macrocheles tardus (KOCH)	5	2		
M. muscadomesticae (SCOP.)	1			
M. montanus WILLM.	1			
Macrocheles sp.	2			
Geholaspis longispinosus (KRAM.)	1			
Parasitus kraepelini (BERL.)	26	3		6
P. lunulatus (MÜLL.)	20	1	1	1
P. remberti (OUD.)	20	1		3
P. distinctus (BERL.)	1			
Parasitus sp.	57	2	1	3
Holoparasitus intermedius (HOLZ.)	1			
H. pseudoperforatus (BERL.)	2			
Pergamasus alpestris (BERL.)	1			
P. runciger (BERL.)	4			
P. longicornis BERL.	2			1
P. crassipes (L.)	4			
P. quisquiliarum (G.R. CAN.)	1			
Pergamasus sp.	2	1		1
Leptogamasus sp.			1	
Poecilochirus necrophori VITZT.	13			1
Total	1390	312	344	134
Ixodides				
Ixodes ricinus (L.)	78	2	9	2
I. trianguliceps BIR.	84	12	2	7
Total	162	14	11	9

Table 2

Species	*Clethrionomys glareolus* (SCHREB.)	*Microtus agrestis* (L.)	*Microtus arvalis* (PALL.)	*Pitymys subterraneus* (DE SEL. LONG.)
Trombidiformes				
Neotrombicula zachvatkini SCHLUG.	1078	103	4	2
N. inopinata (OUD.)	358	14		1
N. autumnalis (SHAW)	2			3
Cheladonta costulata (WILLM.)	1			3
Pygmephorus forcipatus WILLM.	7	1		
P. soricis KRCZAL	1			
P. erlangensis KRCZAL	4			
P. krczali MAHUN.	32			
Pygmephorus sp.	2			
Bakerdania cultrata (BERL.)	1			
B. bavarica (KRACZAL)	12			
Bakerdania sp.	3			
Amorphacarus elongatus (POPPE)	3			
Radfordia lemnina (KOCH)	6			
Radfordia sp.			2	1
Myobia musculi (SCHRANK)	1			
Cheyletidae sp.		1		2
Total	1511	119	6	12
Sarcoptiformes				
Myocoptes japonensis RADF.	13	4		3
Trichoecius tenax (MICH.)				1
Listrophorus brevipes DUB.	17	50		73
Dermacarus hypuadei (KOCH)	578	8	15	58
Xenoryctes krameri (MICH.)	41	1	2	11
X. punctatus FAIN	2			
Orycteroxenus soricis (OUD.)	28		1	15
Acarus farris (OUD.)	6	3		
Acotyledon pedispinifer (NESB.)	34	1		3
Sarcoptiformes sp.	19	1	2	
Oribatidae sp.	25	1	2	1
Total	763	69	22	165
Number of mites	5397	772	543	455
Number of mammals	540	54	31	33
Mean intensity of infection	9.99	14.31	17.51	13.79
Intensity of invasion	11.53	14.31	19.40	13.79
Extensity of invasion %	86.7	100	93.6	100
Range of invasion	1–164	1–50	1–64	1–58

Table 3. Arthropods collected on *Muridae* of Góry Sowie in 1971–1972

Species	*Apodemus tauricus* (PALL.)	*Apodemus sylvaticus* (L.)	*Apodemus agrarius* (PALL.)	*Mus musculus* L.
Siphonaptera				
Ctenophthalmus agyrtes (HELL.)	64	12	45	
C. congener ROTHS.	1	1		1
C. assimilis (TASCH.)	1		3	
C. solutus JORD., ROTHS.	7	2	8	
Peromyscopsylla bidentata (KOL.)	1			
P. silvatica (MEIN.)	2			
Megabothris turbidus (ROTHS.)	28	1	7	
Rhadinopsylla integella (JORD., ROTHS.)	3	1	2	
R. pentacantha (ROTHS.)	1			
Leptopsylla segnis (SCHÖNH.)	2		4	2
Nosopsyllus fasciatus (BOSC.)	2	1	4	
Hystrichopsylla talpae (CURT.)	2		5	
Monopsyllus sciurorum (SCHR.)	1			
Total	115	18	78	3
Anoplura				
Hoplopleura acanthopus (BURM.)	1			
H. edentula FAHR.	6			
H. affinis (BURM.)			86	
Polyplax serrata (BURM.)	189	60	1	
Total	196	60	87	
Mesostigmata				
Laelaps agilis KOCH	1372	229	14	
L. clethrionomydis LANGE	1		1	
L. hilaris KOCH			1	
L. jettmari VITZT.			67	
Hyperlaelaps microti (EWING)	1		1	
Androlaelaps fahrenholzi (BERL.)	2		1	
A. casalis (BERL.)			1	
Hypoaspis sardoa (BERL.)	2			
H. oblonga (HALB.)	1			
H. heselhausi OUD.	1			
Eulaelaps stabularis (KOCH)	31	7	16	2
Haemogamasus nidi (MICH.)	94	10	16	
H. hirsutus BERL.	24		3	
H. horridus MICH.	3		1	
H. hirsutosimilis WILLM.	13	1	1	

Table 3

Species	*Apodemus tauricus* (PALL.)	*Apodemus sylvaticus* (L.)	*Apodemus agrarius* (PALL.)	*Mus musculus* L.
Hirstionyssus isabellinus (OUD.)	3	2	1	
H. apodemi ZUEV.	34	2	2	
Myonyssus rossicus BREG.	1			
M. ingricus BREG.	3			
Cyrtolaelaps mucronatus (G.R. CAN.)	3	1		
C. minor WILLM.	13			
Euryparasitus emarginatus (KOCH)	3			
Veigaia kochi TRÄG.			1	
Pachylaelaps furcifer OUD.	2			
Proctolaelaps pygmaeus (MÜLL.)	3	2		7
Uropodidae	1			
Macrocheles tardus (KOCH)	2			
M. muscadomesticae (SCOP.)				1
Macrocheles sp.	1			
Geholaspis alpinus (BERL.)	1			
Parasitus kraepelini (BERL.)	6	2	2	
P. lunulatus (MÜLL.)	7	1		
P. remberti (OUD.)	5		4	
P. magnus (KRAM.)	1			
P. distinctus (BERL.)				1
Parasitus sp.	16	2	3	
Pergamasus alpestris (BERL.)	1		1	
P. runciger (BERL.)	1		1	
P. longicornis BERL.	1	1		
P. crassipes (L.)	4			
Pergamasus sp.	1			
Poecilochirus necrophori VITZT.	4	1	1	
Total	1662	261	139	11
Ixodides				
Ixodes trianguliceps BIR.	17	6	13	1
I. ricinus (L.)	46	4	2	
Total	63	10	15	1
Trombidiformes				
Neotrombicula autumnalis (SHAW)	1	1	10	1
N. inopinata (OUD.)	5	2	1	
N. zachvatkini SCHLUG.	19	10	14	1
Chelodonta costulata WILLM.	6			

Table 3

Species	*Apodemus tauricus* (PALL.)	*Apodemus sylvaticus* (L.)	*Apodemus agraricus* (PALL.)	*Mus musculus* L.
Pygmephorus stammeri KRCZAL			2	
Pygmephorus sp.	2			
Bakerdania cultrata (BERL.)		1		
B. bavarica (KRCZAL)			1	
Amorphacarus elongatus (POPPE)	1			
Radfordia sp.	3			
Myobia musculi (SCHRANK)				1
Cheyletus sp.	1			
Total	38	14	28	3
Sarcoptiformes				
Myocoptes japonensis RADF.	1			
M. musculinus (KOCH)	1			4
Myocoptes sp.	1			
Listrophorus brevipes DUB.			8	
Afrolistrophorus apodemi FAIN	241	3		
Dermacarus hypuadei (KOCH)	35	10	31	
Xenoryctes krameri (MICH.)	7	16	2	
X. punctatus FAIN	1			
Orycteroxenus soricis (OUD.)	29	1	5	
Acarus farris (OUD.)			3	
Acotyledon pedispinifer (NESB.)	5		4	
Sarcoptiformes sp.	1	3	20	
Oribatidae	10	2	2	
Total	332	35	75	4
Number of mites	2406	398	422	22
Number of mammals	185	43	84	11
Mean intensity of infection	13.1	9.26	5.02	
Intensity of invasion	14.94	10.47	6.30	
Extensity of invasion %	87.0	88.4	79.8	
Range of invasion	1–199	1–117	1–68	1–98

The forest species, or those living at the edge of a forest, but in moist habitats, have more diversified fauna than the species of open areas and the edge of a forest, but in dry habitats. Therefore, there were 45 arthropod species found on *P. subterraneus*, 40 species on *M. agrestis*, 43 on *A. agrarius*, 29 on *S. alpinus*, and 20 species on *N. fodiens*. *M. arvalis* (27 species) and *A. sylvaticus* (29 species), living in very dry habitats, have a little diversified fauna, as compared with the related species. Only *S. minutus*, connected with a moist habitat, had a very poor fauna (14 species).

The poor fauna (11 species) characterizes also synanthropic *M. musculus*. The faunistic data are presented in Tables 2 and 3.

The extensity of even the most common arthropods was very low. Fig. 3 shows the species with the extensity of invasion over 10%. The largest number of them was found on *M. agrestis* (13), *C. glareolus* and *P. subterraneus* (19 each). In the most numerous rodents of Góry Sowie, the dominance and the greatest stability of occurrence are shown in two ways: in *C. glareolus*, there is no distinct dominant, and the value of indices is low; in *A. tauricus*, there is a distinctly dominant species, and low numbers of other species. The more numerous the host, the indices are lower (with the exception of *L. agilis*).

A relatively large number of dominants and the species with high stability of occurrence were recorded on *M. agrestis* (4) and *M. arvalis* (3). It is assumed, that this is connected with the way the area is occupied by the host. The species localized in centres, in large numbers in a small area, have higher extensity of infection than those which are scattered.

At the edge of a forest, an immigratory element was mainly *M. arvalis*. Nevertheless, the greatest number of mutual characteristcs, using the species with greatest stability of occurrence as an indicator, was shown in *Microtidae* by *M. agrestis* and *M. arvalis*; and in *Muridae* by *A. tauricus* and *A. sylvaticus*. It turned out that only few arthropod species circulate in great numbers throughout the entire complex of small mammals (*C. agyrtes*, *H. nidi*, *D. hypuadei*, *E. stabularis*). Others are connected with smaller set of hosts.

The greatest diffusion, usually unproportional to the numbers, is exibited by *Siphonaptera*. Their low mean intensity of infection, as compared with arthropods of distinctly lower extensity of invasion, is partially connected with seasonal occurrence. ARZAMASOV (1969) observed, that in a strongly diversified parasitocoenosis, the numbers of dominants and subdominants are similar, and as a result, the competition between species increases, and the intensity of infection decreases. Among the arthropods collected on *C. glareolus* in Góry Sowie, the greatest number of dominants and subdominants was found in the case of the *Siphonaptera*. This is probably the reason for the smaller total numbers.

The arthropod fauna of the individual species of *Microtidae* of Góry Sowie, at the habitat border, may be practically identical. The faunistic

Table 4. Arthropods collected on *Soricidae* of Góry Sowie in 1971–1972

Species	*Sorex araneus* L.	*Sorex minutus* L.	*Sorex alpinus* SCHINZ.	*Neomys fodiens* (PENN.)	*Crocidura suaveolens* (PALL.)
Siphonaptera					
Ctenophthalmus agyrtes (HELL.)	13			5	
C. congener ROTHS.	1				
C. assimilis (TASCH.)	2				
C. solutus JORD., ROTHS.	1				
Peromyscopsylla bidentata (KOL.)	3				
P. silvatica (MEIN.)	1	1			
Megabothris turbidus (ROTHS.)	2				
Rhadinopsylla integella (JORD.)	1				
R. pentacantha (ROTHS.)				1	
Hystrichopsylla talpae (CURT.)	6		3	1	
H. orientalis SMIT	4				
Doratopsylla dasycnema (ROTHS.)	145	3	8	9	5
Palaeopsylla soricis (DALE)	185	2	10	2	
P. kohauti DAMPF	6				
P. similis DAMPF	2				
Total	372	6	21	18	**5**
Anoplura					
Hoplopleura edentula FAHR.	9				
H. acanthopus (BURM.)	1				
H. affinis (BURM.)	1				
Polyplax reclinata (NITZCH)					6
Total	11				6
Mesostigmata					
Laelaps agilis KOCH	12	2		1	
L. clethrionomydis LANGE	1				
L. hilaris KOCH	5				1
L. jettmari VITZT.	2				
Hyperlaelaps microti (EWING)	3				
Androlaelaps fahrenholzi (BERL.)	1				
Eulaelaps stabularis (KOCH)	4	1			1
Haemogamasus nidi (MICH.)	3	1	1	3	
H. hirsutus BERL.	9				
H. horridus MICH.	13		2	2	
H. hirsutosimilis WILLM.	2		1		
Hirstionyssus isabellinus (OUD.)	1				
H. soricis TÜRK	13		1		
H. carnifex (KOCH)	1				
Myonyssus rossicus BREG.				1	
M. ingricus BREG.	3		1		

Table 4

Species	*Sorex araneus* L.	*Sorex minutus* L.	*Sorex alpinus* SCHINZ.	*Neomys fodiens* (PENN.)	*Crocidura suaveolens* (PALL.)
Cyrtolaelaps mucronatus (G.R. CAN.)	10				
C. minor WILLM.	1		1		
Euryparasitus emarginatus (KOCH)	10		3	1	
Eviphis ostrinus (KOCH)	1				
Veigaia nemorensis (KOCH)	1				
Proctolaelaps pygmaeus (MÜLL.)	5		1		
Macrocheles tardus (KOCH)	1				
Parasitus kraepelini (BERL.)	3	1	1		
P. lunulatus (MÜLL.)	8	2			
P. remberti (OUD.)	10		2	1	1
P. magnus (KRAM.)			1		
Parasitus sp.	8	2	6	1	
Pergamasus alpestris (BERL.)	2	1			
P. runciger (BERL.)	1				
Pergamasus sp.			1		
Poecilochirus necrophori (VITZT.)	2		1		
Total	136	10	23	10	3
Ixodides					
Ixodes trianguliceps BIR.	27	33	2	6	
I. ricinus (L.)	44		6	2	1
Total	71	33	8	8	1
Trombidiformes					
Neotrombicula autumnalis (SHAW)	3				
N. inopinata (OUD.)	5		1		
N. zachvatkini SCHLUG.	6		2	2	
Pygmephorus forcipatus WILLM.	2		2		
P. soricis KRCZAL	7				
P. microti KRCZAL	3		6	2	
P. spinosus KRAM.	1		1		
P. erlangensis KRCZAL	4	1	1	1	
Pygmephorus sp.	6				
Bakerdania sp.			2	1	
Protomyobia claparedei (POPPE)	8		1		
P. onoi JAM., DUSB.	2				
Amorphacarus elongatus (POPPE)	15		2		
Radfordia lemnina (KOCH)			1		
Myobia musculi (SCHRANK)	1				
Cheyletus sp.	1		1		
Total	64	1	20	67	

Table 4

Species	*Sorex araneus* L.	*Sorex minutus* L.	*Sorex alpinus* SCHINZ.	*Neomys fodiens* (PENN.)	*Crocidura suaveolens* (PALL.)
Sarcoptiformes					
Myocoptes sp.	1			1	
Listrophorus brevipes DUBIN.	5				
Dermacarus hypuadei (KOCH)	8	1		1	
Xenoryctes krameri (MICH.)	6	2	1	2	
X. punctatus FAIN.	3				
Orycteroxenus soricis (OUD.)	129	5	4	24	
Acarus farris (OUD.)	1				
Acotyledon pedispinifer (NESB.)	6		5	2	
Sarcoptiformes	2				
Oribatidae sp.	9				1
Total	170	8	10	30	1
Number of mites	824	58	82	72	16
Number of mammals	307	59	20	12	4
Mean intensity of infection	2.68	0.98	4.10	6.00	
Intensity of invasion	4.41	2.76	4.82	7.20	
Extensity of invasion %	60.8	35.6	85.0	83.3	

diversity of arthropods on *C. glareolus* is connected, in the first place, with large numbers, activity and large area of occurrence of this species, as compared with low numbers of such species as *M. arvalis*, and *P. subterraneus*, and with their small area, or low extensity of invasion. Also the mite fauna of nests of small mammals of the same region is similar, and regulated by ecological type of the nest (DANIEL, 1969, 1970). Thus, all the species occurring on *M. arvalis*, *P. subterraneus* and *M. agrestis* were also found on *C. glareolus*. Nevertheless, these four species differ in the stability of occurrence and the dominance of the particular parasites, as well as in the percentage of 6 groups of *Arthropods*, discussed above (Fig. 4).

C. glareolus is characterized by the low percentage of *Mesostigmata* (25.8%), the lowest among *Microtidae*, and high percentage of *Trombidiformes* (28%). In *M. agrestis*, a distinct dominance of *Mesostigmata* (40.3%) may be observed. *M. arvalis* differs from the previous two species by: 1) high dominance of *Mesostigmata* (63.4%); 2) small percentage of *Trombidiformes* (1.1%) and *Sarcoptiformes* (4.0%).

The dominance of *Sarcoptiformes* (36.4%) and small percentage of *Trombidiformes* (2.2%) are characteristic for *P. subterraneus*.

A high and similar extensity of invasion of *Mesostigmata* and *Siphonaptera* is characteristic for *Microtidae*. The species of the genus *Microtus* and *Pitymys* differ, in Góry Sowie, from *C. glareolus* because of their higher extensity of *Sarcoptiformes* and lower of *Trombidiformes*. On *C. glareolus*, the differences in extensity of invasion of fleas, lice and mites are smaller than in other *Microtidae*.

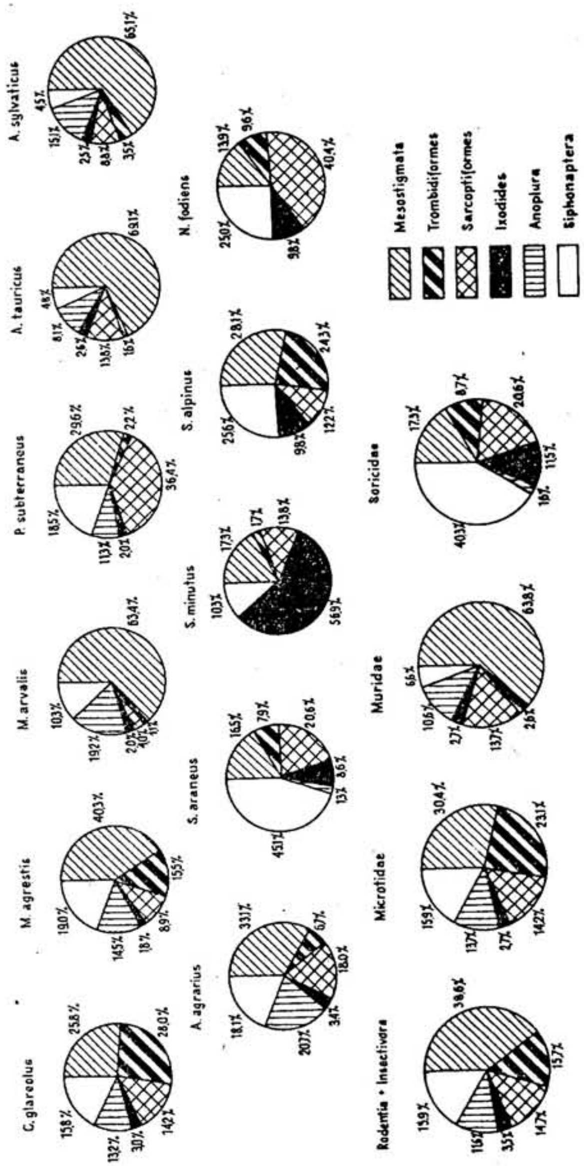
On all *Microtidae* of Góry Sowie only 4–6 species of arthropods are characterized by a high extensity of invasion. The higher extensity refers to the species occurring on hosts having smaller numbers (*C. glareolus* maximum 26.1%; the other from 45.5% to 67.7%). A rich percentage of fleas is characteristic, but their numbers are low, as compared with *Mesostigmata*. However, fleas are closely connected with small mammals. Among *Mesostigmata*, there are many species accidentally occurring on *Rodentia* and *Insectivora*.

Among *Muridae* of Góry Sowie, there is considerable similarity between *A. tauricus* and *A. sylvaticus*. The dominant species, of high stability of occurrence, are identical on both hosts (*L. agilis*, *C. agyrtes*, *P. serrata*), with the exception of *A. apodemi*, a subdominant of *A. sylvaticus* (Fig. 3). The percentage of 6 arthropod groups is alike on both species.

Both species are characterized by a high dominance of *Mesostigmata* (on *A. tauricus* the highest among small mammals of Góry Sowie; extensity of invasion on *A. tauricus* 83.2%, mean intensity of infection 8.98; *A. sylvaticus* 88.4%, 6.0), a relatively high percentage of *Anoplura* and *Sarcoptiformes*, and low of *Trombidiformes*.

A. agrarius is different, because of the presence of two specific species: *H. affinis* and *L. jettmari*, and the different percentages of various groups of *Arthropoda*. It is characterized by the low percentage of *Mesostigmata* (33.1%), and high percentage of *Anoplura*, *Siphonaptera* and *Sarcoptiformes* (Fig. 4). The extensity of invasion (60.7%) and mean intensity of infection (1.66) of the most frequent *Mesostigmata* were much lower than in *A. tauricus* and *A. sylvaticus* (Table 3).

Out of the *Soricidae*, the largest number of mutual characteristics was observed in the case of *S. araneus* and *S. alpinus*. *Siphonaptera* distinctly dominate on *S. araneus* (45.1%), before *Sarcoptiformes* (20.6%) and *Mesostigmata* (16.5%). The percentage of *Trombidiformes* is low. *Mesostigmata* dominate on *S. alpinus*, while the percentages of *Siphonaptera* and *Trombidiformes* are high. *S. alpinus* was much less numerous than *S. araneus*. The above proportions would have been different if the numbers of both species were equal. The same concerns *N. fodiens*, which is characterized by high dominance of *Sarcoptiformes* (40.4%) and *Siphonaptera* (25%) and low percentage of *Mesostigmata*.



4. Percentage of 6 arthropod groups in the collections on all small mammals, on *Microtidae*, *Muridae* and *Soricidae* and common species of *Rodentia* and *Insectivora*

S. minutus is characterized by high dominance of *Ixodides* (56.9%) and small percentage of *Siphonaptera* (10.3%; Fig. 4).

Microtidae, *Muridae* and *Soricidae* differ much from one another in respect to percentage of arthropod groups.

On *Microtidae*, the highest percentage was reached by *Mesostigmata* (30.4%) and *Trombidiformes* were not much behind (23.1%). The second group was made up by *Siphonaptera*, *Sarcoptiformes* and *Anoplura*. Only the percentage of *Ixodides* was small (2.7%; Fig. 1). The percentage of *Mesostigmata* on *Muridae* is twice as large as on *Microtidae* (63.8%), which is connected with particularly low percentages of *Trombidiformes*, *Siphonaptera* and *Ixodides*. The percentages of *Sarcoptiformes* and *Anoplura* on *Microtidae* are similar.

The greatest percentage on *Soricidae* was reached by *Siphonaptera* (40.3%). They are followed by *Sarcoptiformes* (20.6%). Poorly represented are *Mesostigmata* and *Trombidiformes*, while the percentage of Ixodides has increased. Higher numbers of fleas and ticks on *Soricidae* were reported in Sweden by EDLER, NILSSON (1973).

BIOLOGICAL GROUPS

Many arthropods, connected with small mammals, are characterized by seasonality of occurrence. It effects the infection indices of *Rodentia* and *Insectivora* in different seasons of a year.

Five phenological groups have been distinguished, taking the period of activity of arthropods on small mammals into consideration (however, this division does not equal the activity of all developmental stages of a given species). I. Spring species (III–VI) — rarely collected in other months. II. Late summer months (VII–VIII–IX) — occurring in great numbers in August, little less in September and sporadically in the autumn. III. Autumn species (IX–XII) — do not occur on small mammals between April and July, with maximum in autumn. IV. Autumn–spring species (X–IV) — with two peaks: in spring and autumn, sporadically found in the summer. V. Species numerous during the entire year — the fluctuations of their numbers during the year are distinct, but they are present year round. Only a small number of arthropods were included in this subdivision, their percentage in the collection was small, and the knowledge of their biology little. These facts made the classification difficult.

I group: *C. congener*; II group: *P. silvatica*, *N. inopinata*; III group: *P. bidentata*, *R. integella*, *A. nuperum*, *L. jettmari*, *N. autumnalis*, *O. soricis*;

IV group: *L. clethrionomydis*, *L. hilaris*, *H. microti*; V group: *N. zachvatkini*, *C. agyrtes*, *M. turbidus*, *P. soricis*, *D. dasycnema*, *H. edentula*, *H. acanthopus*, *P. serrata*, *H. affinis*, *L. agilis*, *E. stabularis*, *H. nidi*, *H. hirsutus*, *H. isabellinus*, *P. pygmaeus*, *P. kraepelini*, *P. lunulatus*, *P. remberti*, *D. hypuadei*, *X. krameri*, *A. pedispinifer*, *L. brevipes*, *I. trianguliceps*.

I. ricinus does not fit to this classification. Since it occurs at the end of spring and beginning of summer, and sometime in the autumn, it may be described as late spring and autumn species.

Different arthropod species dominate in different months. Their number in spring is smaller than in the autumn. In 1971, their number from March till August varied from 4 to 8, and from September till December from 10 to 14. In 1972, from March till July it varied from 7 to 13, and from August till November from 13 to 22.

The dominance of various arthropod species on *C. glareolus* during consecutive months is described below. The species with mean intensity of invasion above 0.50 were considered as dominants and subdominants.

In March–April (1971–1972) *L. clethrionomydis* and *N. zachvatkini* dominated on *C. glareolus*, while *C. agyrtes* and *H. nidi* were subdominant species (Table 7). From May till July, *H. edentula* was a stable dominant (especially in 1972), and *N. zachvatkini*, *C. agyrtes* and *I. ricinus* were subdominant species, but not in all months. Exceptionally *H. isabellinus* dominated in May of 1971. In August and September the following species were most frequently subdominants and dominants: *N. inopinata*, *H. edentula*, *P. silvatica* and *D. hypuadei*. From October till December, *N. zachvatkini* was a main dominant, and in some months *H. nidi*, *L. clethrionomydis* and *D. hypuadei*. *P. bidentata* was a constant subdominant, and in December also *R. integella* (Table 7).

The degree of dependence of arthropods on their hosts also varies. Sosnina (1967a) distinguished 4 groups of external parasites: 1) permanent parasites; 2) parasites remaining on a host for a long period of time; 3) obligatory, blood sucking, nest parasites; 4) facultative, blood sucking, nest parasites. On small mammals, however, there are species that have other relations with their hosts. Therefore, the following 7 groups of arthropods have been distinguished in the present study: 1) permanent parasites (19 species), including 6 *Anoplura* species, 4 species of the genus *Laelaps*, *H. microti*, *Protomyobia claparadei* (Poppe), *P. onoi* Jam., Dusb., *Amorphacarus elongatus* (Poppe), *Radfordia lemnina* (Koch), *Myobia musculi* (Schrank), *Myocoptes japonensis* Radf., *M. musculinus* (Koch), *Trichoeciux tenax* (Mich.); 2) periodic parasites (6 species): *I. ricinus*, *I. trianguliceps*, *N. zachvatkini*, *N. inopinata*, *N. autum-*

Table 5. Biological structure of arthropod groups on *Microtidae* of Góry Sowie

Arthropods	*Clethrionomys glareolus* (Schreb.)			*Microtus agrestis* (L.)			*Microtus arvalis* (Pall.)			*Pitymys subterraneus* (de Sel. Long.)		
	number of species	number of specimens	% of collection	number of species	number of specimens	% of collection	number of species	number of specimens	% of collection	number of species	number of specimens	% of collection
Permanent parasites	13	688	15.1	7	358	46.9	5	417	78.0	7	111	25.0
Periodic, parasites	6	1601	35.1	4	131	17.2	3	15	2.8	6	18	4.0
Obligatory nest parasites	17	955	20.9	14	160	20.9	10	58	10.8	13	91	20.5
Facultative nest parasites	7	382	8.4	5	44	5.8	5	26	4.8	5	47	10.5
Permanent comensals	1	17	0.4	1	50	6.5				1	73	16.4
Periodic comensals	6	689	15.1	4	13	1.7	3	18	3.4	4	87	19.6
Accidental arthropods	30	227	5.0	5	8	1.0	1	1	0.2	9	19	4.0
Total	80	4559	100	40	764	100	27	525	100	45	446	100

Table 6. Biological structure of arthropod groups on *Muridae* and *Soricidae* of Góry Sowie

Arthropods	*Apodemus tauricus* (PALL.) number			*A. sylvaticus* (L.) number			*A. agrarius* (PALL.) number			*Sorex araneus* L. number			*Sorex minutus* L. number			*Sorex alpinus* SCHINZ number			*Neomys fodiens* (PENN.) number		
	of species	of specimens	% of collection	of species	of specimens	% of collection	of species	of specimens	% of collection	of species	of specimens	% of collection	of species	of specimens	% of collection	of species	of specimens	% of collection	of species	of specimens	% of collection
Permanent parasites	9	1573	66.4	2	289	74.2	7	171	43.4	12	59	7.4	1	2	3.6	3	4	5.6	1	1	1.4
Periodic parasites	6	94	4.0	5	23	5.9	5	40	10.1	5	85	10.7	1	33	59.0	4	11	15.3	3	10	14.5
Obligatory nest parasites	17	156	6.6	8	22	5.8	10	81	20.6	18	390	49.0	3	6	10.7	4	22	30.4	6	19	27.5
Facultative nest parasites	6	166	7.0	3	18	4.6	7	39	10.0	6	32	4.0	2	2	3.6	3	4	5.6	2	5	7.3
Permanent comensals	1	241	10.2	1	3	0.8	1	8	2.0	1	5	0.6									
Periodic comensals	5	77	3.2	3	27	6.9	5	42	10.6	6	153	19.2	3	8	14.2	3	10	13.9	4	29	42.0
Accidental arthropods	19	61	2.6	7	7	1.8	8	13	3.3	18	72	9.1	4	5	8.9	12	21	29.2	4	5	7.3
Total	63	2368	100	29	389	100	43	397	100	66	796	100	14	56	100	29	72	100	20	69	100

Table 7. Dominant arthropods on *C. glareolus* during consecutive months of 1971 and 1972 (mean intensity of infection)

1971 dominants		1971 subdominants		1972 dominants		1972 subdominants	
March							
L. clethrionomydis	11.45	*C. agyrtes*	1.95	*N. zachvatkini*	4.79	*L. clethrionomydis*	1.95
		N. zachvatkini	1.65			*H. edentula*	1.79
		H. nidi	0.70			*C. agyrtes*	1.26
		R. integella	0.50			*H. nidi*	0.95
April							
small material				*L. clethrionymydis*	1.90	*H. nidi*	0.58
				C. agyrtes	1.21		
May							
H. isabellinus	4.31	*C. agyrtes*	0.62	*H. edentula*	6.00	*C. agyrtes*	1.31
H. edentula	2.69			*N. zachvatkini*	4.88	*L. clethrionomydis*	1.00
L. clethrionomydis	1.92					*D. hypuadei*	0.94
						I. ricinus	0.71
June							
H. edentula	2.11	*C. agyrtes*	0.56	*H. edentula*	4.97	*N. zachvatkini*	1.35
N. zachvatkini	1.22					*I. trianguliceps*	0.90
M. turbidus	1.00					*I. ricinus*	0.83
July							
no dominants				*H. edentula*	1.54	*N. zachvatkini*	0.51
August							
N. inopinata	1.02			*N. inopinata*	5.22	*D. hypuadei*	2.03
P. silvatica	0.60			*H. edentula*	3.75	*P. silvatica*	1.75
September							
P. silvatica	0.42			*N. inopinata*	1.38	*D. hypuadei*	0.85
H. edentula	0.35					*P. silvatica*	0.71
October							
N. zachvatkini	2.51	*P. bidentata*	0.87	*N. zachvatkini*	5.11	*H. edentula*	1.62
		L. clethrionomydis	0.49			*N. inopinata*	1.57
						P. bidentata	0.89

Table 7

1972				1971			
dominants		subdominants		dominants		subdominants	
November							
H. nidi	1.20	*P. bidentata*	0.65	*D. hypuadei*	8.80	*L. clethrionomydis*	1.44
L. clethrionomydis	0.90	*H. edentula*	0.60	*N. zachvatkini*	6.85	*P. bidentata*	1.06
		C. agyrtes	0.47				
December							
N. zachvatkini	3.75	*H. edentula*	1.12	*N. zachvatkini*	3.55	*H. nidi*	0.59
H. nidi	2.37	*C. agyrtes*	1.09	*D. hypuadei*	3.07	*R. integella*	0.59
		R. integella	0.81	*L. clethrionomydis*	2.14		
		L. clethrionomydis	0.56				
		P. bidentata	0.47				

nalis and *Cheladonta costulata*; 3) obligatory, nest parasites (28 species), including 22 flea species, 4 mite species of the genus *Hirstionyssus*, *Myonyssus ingricus* Breg. and *M. rossicus* Breg.; 4) facultative, nest parasites (7 species), including mites of the genera *Haemogamasus*, *Androlaelaps* and *Eulaelaps*; 5) permanent commensals (2 species): *L. brevipes*, *A. apodemi*; 6) periodic commensals (6 species): *D. hypuadei*, *O. soricis*, *Xenorytes krameri* (Mich.), *X. punctatus* Fain, *Acarus farris* (Oud.), *Acotyledon pedispinifer* (Nesb.); 7) accidental predators, necrophagous species, etc.: species of undetermined connections with small mammals (38 species): 9 mite species of the genera *Pygmephorus* and *Bakerdania*, and 29 mite species of the families *Parasitidae* and *Macrochelidae*.

Below, are the percentages of various arthropod groups on individual species of small mammals (only identified species were taken into consideration in the calculations). *Orbitidae* and unidentified *Parasitidae* and *Sarcoptiformes* were not considered.

Among *Microtidae*, on *M. arvalis*, *M. agrestis*, *P. subterraneus*, permanent parasites dominate (79.4%, 46.8, 24.9 respectively), then obligatory, nest parasites (11.0%, 20.9, 20.4; Table 5). Periodic parasites (35.1%) dominate on *C. glareolus*, before periodic commensals (15.1%) and permanent parasites (15.1%). The accidental parasites are best represented on *C. glareolus* and *P. subterraneus*.

Among *Muridae*, especially on *A. agrarius* and *A. sylvaticus*, the permanent parasites dominate (66.4%, 74.2%), and on *A. tauricus* as follows: permanent commensals (10.2%), facultative nest (7.0%) and obligatory nest (6.6%), and on *A. agrarius*: permanent (43.4%), obligatory nest (20.6%).

Among *Soricidae*, on *S. araneus* and *S. alpinus*, the obligatory, nest parasites dominate (49.0% and 30.4%), on *S. minutus* periodic parasites (59.0%), and on *N. fodiens*, periodic commensals (42.0%) (Table 6).

DYNAMICS OF NUMBERS

The annual extensity of invasion (1971+1972), for the entire collection was 79.7%. Edler, Nilsson (1973), for *Insectivora* and *Rodentia* of Sweden reported 82.6%, and the difference between *Insectivora* and *Rodentia* reached over 10%. The same was observed in Góry Sowie. The extensity of invasion on *Muridae* and *Microtidae* amounted to 88.6% and 86.3%, and on *Soricidae* only 59.5%, which was caused by the low degree of infection of *S. minutus* (35.6%) and *S. araneus* (60.8%). Only on *S. alpinus* (85%) and *N. fodiens* (83.3%), the extensity of invasion was high.

The differences between individual rodent species are not so great. Among *Muridae*, *M. agrestis* and *P. subterraneus* were 100% infected, *M. arvalis* in 90.3% and *C. glareolus* in 86.7%. In case of *Muridae*, the highest infection was recorded on *A. sylvaticus* (97.7%), and then on *A. tauricus* (87%) and *A. agrarius* (78.6%; Fig. 3).

In general, the extensity of invasion was inversely proportional to the mammal numbers (with the exception of *S. minutus*). Beside *Ixodides*, collected on *S. minutus* in large numbers, other arthropods occur sporadically, and only occasionally in large numbers (Arzamasov, 1969; Edler, Nilsson, 1973).

There were considerable differences in the mean intensity of infection of small mammals. The greatest value of this index was recorded on *M. arvalis* (17.51), and the smallest on *S. minutus* (0.98). It is high on all *Microtidae*, but the differences between species reach 7.52 (Fig. 4). A relatively high mean intensity of infection was recorded on *A. tauricus* (13.01) and *A. sylvaticus* (9.26), mainly because of large numbers of *L. agilis*.

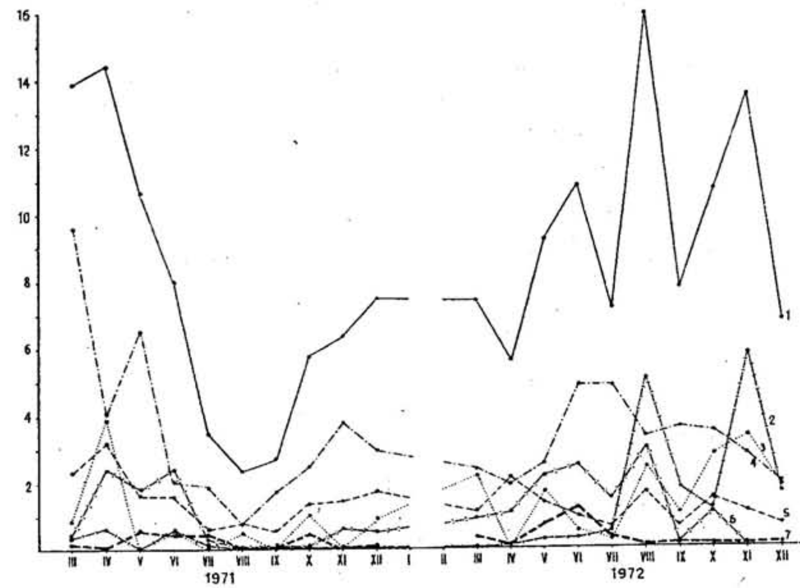
The mean intensity of infection on *A. agrarius* (5.02) was about 2, 3 times smaller than that on *A. tauricus* and *A. sylvaticus*, and even smaller than on some *Soricidae*.

Out of *Soricidae*, the highest mean intensity of infection was recorded on *N. fodiens* (6.0) and *S. alpinus* (4.10), and the lowest on *S. minutus*.

The numbers of the most common species of *Arthropoda* change from year to year. This is reflected in the curve of the arthropod numbers, in respect to all collected small mammals. The curve for 1971 is completely different from that for 1972. In 1971, the mean intensity of infection had two peaks, with maximum in April (14.45), and the second peak in December (7.56). The drop of arthropod numbers to minimum (August 2.36, September 2.75), and their increase towards winter, were gradual.

In 1972, the curve had 4 peaks (4th, low in March). The peaks were separated by distinct drops. They occurred in March (7.50), June (10.88), August (16.07) and November (13.67). Slight depression was recorded in April (5.72), and stronger in July (7.26), September (7.83) and December (6.94; Fig. 5).

To sum up: 1) the "uneven" character of the curve of arthropod numbers corresponds to the increase of arthropod numbers in 1972; 2) it is possible to detect distinct changes in numbers within one month;



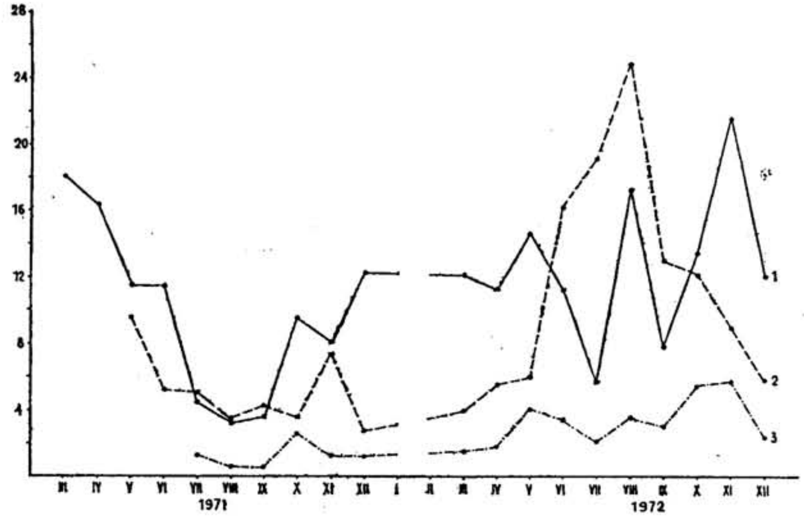
5. Mean intensity of infection of small mammals (*Rodentia* + *Insectivora*) in 1971 and 1972, with *Arthropoda* (1) and *Sarcoptiformes* (2), *Trombidiformes* (3), *Mesostigmata* (4), *Siphonaptera* (5), *Anoplura* (6) and *Ixodides* (7)

3) the maximum and minimum in arthropod numbers in consecutive years occurs at different times (maximum in 1972 corresponds to minimum in 1971).

The picture of changes in arthropod numbers is different when *Microtidae*, *Muridae* and *Soricidae* are considered separately. Only *C. glareolus* could be used for the seasonal analysis, because of its rich fauna.

On *Soricidae*, the curve of arthropod numbers (mean intensity of infection) had two peaks within a year. The data from the first half of 1971 are not quoted, because of the small number of *Soricidae* collected. The peaks occurred at the end of spring (V) and end of autumn (X–XI), and in 1971 a small peak in the summer (VIII). The maximum of 1972 (XII — 5.83) was very low as compared with rodents, but it was twice as high as in 1971 (X — 2.70). The minimum of 1972 (III — 1.60) was higher than the value for any month in 1971 (with the exception of maximum). The minimum in 1971 occurred in September — 0.57. In both years the peaks were caused by other arthropod groups. In the autumn (X) of 1971, the peak was caused by *Siphonaptera* and *Ixodides*, and in the autumn (X–XI) of 1972 by *Siphonaptera*, *Mesostigmata*, *Trombidiformes* and *Sarcoptiformes*. In October, 1972 the collection consisted in 48.5% of *Siphonaptera*, in 23.1% of *Sarcoptiformes* and in 18.3% of *Mesostigmata*, while in November of the same year, it consisted in 42.2% of *Sarcoptiformes*, in 21.4% of *Trombidiformes*, and only in 18.6% of *Siphonaptera*. It is interesting to compare the numerical peaks of the two main groups of *Arthropoda* on *Soricidae*: *Siphonaptera* and *Sarcoptiformes*. The mean intensity of infection with *Siphonaptera* was 0.47 in September, while that of *Sarcoptiformes* was 1.73; in October it increases to 2.73 for *Siphonaptera*, and 1.30 for *Sarcoptiformes*; in November it was 1.08 for *Siphonaptera* and 2.46 for *Sarcoptiformes*; in December 0.67 and 1.34 respectively.

The curve of changes in the mean intensity of infection on *Muridae* had two peaks in 1971, and one in 1972. In 1971 the peaks occurred in May (9.60) and November (7.38). A deep regression in numbers was recorded from August till October, and in December (minimum 2.80; Fig. 6). In 1972, the mean intensity of infection was gradually increasing from March till the only peak in August (25.0), and then it was evenly decreasing till December. The minimum was recorded in March (4.00). Therefore, the maximum in August 1972 corresponds to minimum in 1971. Also in August 1972 the numbers of *Sarcoptiformes*, *Mesostigmata* and *Anoplura* were high. In August of 1971 only *Mesostigmata* occurred in somewhat large numbers, but even so, their numbers were three times smaller than



6. Mean intensity of infection of *Microtidae* (1), *Muridae* (2) and *Soricidae* (3), in 1971 and 1972 with *Arthropoda*

in August 1972. *Sarcoptiformes* were poorly represented on *Muridae* of Góry Sowie in both years. An exceptionally high number in August (mean intensity of infection 10.11) resulted from collection of 180 *A. apodemi* on one *A. tauricus*.

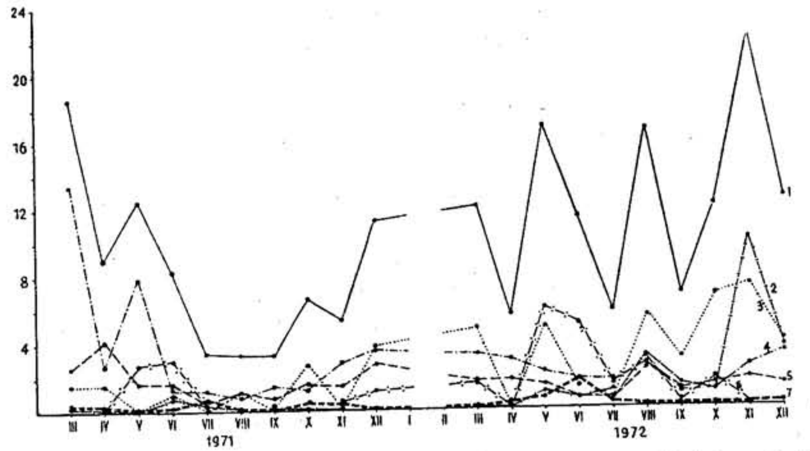
The curve of changes in the mean intensity of infection on *Microtidae* had 2 peaks in 1971, and 3 peaks in 1972. The maximum in 1971 was recorded in March (18.04), and the second peak in December (12.28), separated by a large drop in numbers in July, August and September (minimum in August — 3.21). In 1972, a small peak occurred in May (14.74). the other in August (17.30), and the maximum in November (21.84). Between May and August, in July there was a large drop (5.68), and an other in September (7.95). The differences in both years may be summarized as follows: 1) greater numbers of *Arthropoda*, especially during depression, in 1972; 2) the maximum in August 1972 corresponds to minimum in August 1971. This difference resulted from the increased numbers of *Siphonaptera*, *Anoplura*, *Trombidiformes* and *Sarcoptiformes* in August 1972. *P. silvatica* and *N. inopinata* occurred in large numbers in August, and in 1972 the numbers of *L. brevipes* and *H. edentula* were high during that month. In August of 1971 the numbers of the latter two species were very low.

The collection of *Microtidae* consisted mainly of *C. glareolus*, and the curve of changes in numbers of this species is almost identical with the curve for *Microtidae*. The peaks in 1971 were reached in March (18.55) and December (11.22); the minimum in August–September (3.26). In 1972 4 peaks were recorded: in March (12.00), May (16.70), August (16.61) and November (22.12), separated by large drops in numbers in April (5.58), July (5.80) and September (6.91; Fig. 7). These variations result from erratic changes in the numbers of *Anoplura* (*H. edentula*) and *Trombidiformes* (*N. inopinata*, *N. zachvatkini*) during the period from June till November of 1972 (Fig. 7), and increase in numbers of *Siphonaptera* (VIII — *P. silvatica*) and *Sarcoptiformes* (VIII, IX — *D. hypuadei*).

To sum up: the changes in arthropod numbers, whether for the entire collection of small mammals, or a single family or species, are uneven in the consecutive years and months. The dynamics of the numbers of individual arthropod species has its own rythm, with periods of highs and lows, repeated in time (seasons of a year), but with various strength. Overlaping of numerical peaks or depressions, especially of dominant species, is reflected in large differences in intensity and extensity of invasion of the individual seasons of a year (months), in different years. These differences are being realized simultanously, but differently in different families and species of small mammals, particularly if they differ considerably in the presence of specific species occurring in large numbers. The population dynamics of arthropods is regulated by many, simultanously acting, factors. An interaction of the individual species is one of these factors.

ARTHROPOD FAUNA IN THE VERTICAL ZONES OF GÓRY SOWIE

In the previous parts of this study (Haitlinger, 1975, 1976a, b, 1977) the faunistic composition of *Siphonaptera*, *Anoplura* and *Acarina* in two vertical zones of Góry Sowie, submontane (300–500 m a.s.l.) and montane (600–900 m a.s.l.), and the changes in population dynamics of *Arthropoda* on *Microtidae*, *Muridae* and *Soricidae*, have been discussed. The greater diversity of the material collected in the montane zone has its source in the greater habitat diversity of this region. The area studied was smaller in submontane zone, and this fact must have also been of some importance. There were 20 *Siphonaptera* species found in the montane zone, and 14 species in the submontane zone. The differences are distinct when one family of mammals is being considered. On *Muridae* of montane zone, there were 38 arthropod species found, 10 more than in the submontane zone.



7. Mean intensity of infection of *Clethrionomys glareolus*, in 1971–1972, with *Arthropoda* (1) and *Sarcoptiformes* (2), *Trombidiformes* (3), *Mesostigmata* (4), *Siphonaptera* (5), *Anoplura* (6) and *Ixodides* (7)

The arthropods collected exclusively in the montane zone may, with few exceptions, occur in the submontane zone as well. These relations are better characterized by the numerical data, especially in the cases of *Siphonaptera*, *Ixodides* and some species of *Trombidiformes*.

The following belong to the common species, having constant large population (mean intensity of infection) in the montane zone: *P. silvatica* (on *Microtidae* 4 times more numerous in the summer), *P. bidentata* (6 times more numerous in the autumn), *N. zachvatkini*, *N. inopinata* and *I. trianguliceps*.

The following belong to the species, of which the mean intensity of infection was high in the montane or submontane zone, in different seasons of a year: *L. clethrionomydis* (in spring 3 times more numerous in the montane zone, and in the autumn 6 times in the submontane zone) and *L. agilis* (in spring and summer more numerous in the montane zone, and in the autumn 3 times more numerous in the submontane zone).

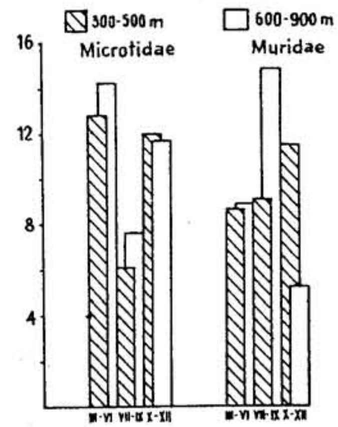
H. edentula belongs to the species that were more numerous in the submontane zone, during all seasons of a year (in spring 6 times more numerous).

The mean intensity of infection of *Siphonaptera* on *Microtidae* was higher in the montane zone, in spring, summer and autumn. The value

for *Mesostigmata* was higher in the montane zone, in spring and summer, and in the submontane zone in the autumn.

On *Muridae*, the value for *Siphonaptera* was higher in the submontane zone, in spring, summer and autumn, and for *Mesostigmata* and *P. serrata* it was higher in the montane zone, in spring and summer, and in the submontane zone in the autumn.

The mean intensity of infection on *Microtidae* and *Muridae*, in relation to all arthropods, is different in both zones. On *Muridae* (in both years), between July and September, the mean intensity of infection was 9.17 in the submontane zone, and 14.84 in the montane zone (Fig. 8). This difference is connected with high numbers of *A. apodemi*, *P. serrata* and *H. affinis* in the montane zone. Between October and December, the mean intensity of infection in the submontane zone was 11.55, and in the montane zone only 5.17. The difference resulted from the numerous occurrence of *L. agilis*, *P. serrata* and *H. affinis* in the submontane zone.



8. Mean intensity of infection of *Microtidae* and *Muridae* with *Arthropoda* in three seasons of the year, in submontane and montane zones

No such differences between seasons of a year were recorded on *Microtidae*, although the numbers of both zones varied considerably. The mean intensity of infection (for both years) on *Microtidae* and *Muridae* is very simliar in both zones (10.21–10.92 and 9.61–9.49). *N. zachvatkini*, one of the most numerous species in the collection, was scarce in the submontane zone. This also refers to other common species, such as *I. trianguliceps*, *P. bidentata* and *P. silvatica*. In spite of that, the mean intensity of infection of *Microtidae* is similar in both zones. The low numbers of these species were compensated by greater numbers of other arthropods. It turned out, that the „flow" of arthropods through the population of small mammals is in both zones almost identical, as far as the numbers are concerned in spite of distinct differences in the particular seasons of a year.

MIXED INVASIONS

Small mammals, by and large, are infected by a small number of arthropods. Moreover, the migratory part of population is not as strongly infected as sedentary population (JANION, 1968). Part of arthropods is made up of the permanent parasites, or those remaining on host for a longer period of time (several days), i.e., representatives of the genera *Ixodes*, *Neotrombicula*, *Cheladonta*. For periodic parasites, consuming blood, most likely the time of attack (day–night) is important, in connection with rhythmicity of blood content (PIOTROWSKI, 1972). Therefore, the rhythm of blood taking, in a permanently occupied nest, could, in different parasite species, be different in time. Probably the moment of capturing the mammals in the trap is also important. However, these problems are practically unknown.

The frequency of the mutual occurrence of the common arthropod species on small mammals of Góry Sowie have been observed.

In case of *C. glareolus*, 13.3% of specimens were without arthropods. Among the infected, 19.5% of specimens had 3 arthropod species, 15.1% had 2 species, 14.8% — 4, 10.9% — 1, 8.7% — 5, 6.7% — 6, 4.6% — 7, 3.6% — 8, 1.5% — 9, 0.7% — 10, and 0.6% had 11 species. Rarely, there were over 14 arthropods on a single individual. Considering the infected specimens only, 10.4% of *C. glareolus* was infected with 3 arthropod specimens, 9.6% with 4 specimens, 9.2% with 2, 0.3% with 1, 6.6% with 5, 5,7% with 8 and 11, and 4.4% with 10 specimens. On 4.9% of *C. glareolus* there were over 40 arthropods. The largest number of arthropods found on a single *C. glareolus* was 164. The next lower number was 98.

The mechanisms regulating the numbers of external parasites on a host are not precisely known. It is considered that the regulation of numbers of permanent external parasites (mainly lice) takes place by their active removal from the body surface in the process of shedding the host's hair, and by high mortality of hosts (VYSOCKAJA, 1967). Mass, pure or mixed infections of small mammals are rare. On *Rodentia* and *Insectivora* of body weight up to 60 g, rarely over 100 lice were collected (192, 116, 318, 274; WEGNER, 1957; SZCZĘŚNIAK, 1963; SKIBIŃSKI, 1970; SOSNINA, 1970). Sometimes, the hypopial deutonymphs of *D. hypuadei* and *O. soricis*, or specimens of the genera *Myocoptes* and *Listrophorus* were collected in large numbers (DUBININ, 1953; WEGNER, 1957).

Only 4 times, over 30 *H. edentula* were collected on *C. glareolus* of Góry Sowie (maximum 68).

Under certain conditions, the regulating mechanisms fail, and the mass invasions occur. The author collected in the north-eastern Bulgaria, near Šabel, on a single *M. arvalis*, unbelievable number of 2392 external parasites, including 1907 *H. acanthopus*, in all developmental stages. Thus, on a single *M. arvalis*, there were almost twice as many lice, as on 1388 small mammals collected in Góry Sowie in two years. This case shows how great is a potential of small mammals as hosts. It turned out, that such high number of *H. acanthopus* did not hinder the development of other arthropods, since on this host representatives of the genus *Myocoptes* (453) and *Oribatidae*, *Trombidiformes*, and others, were also found.

At the mass occurrence of 2–3 parasite species on one host, the parasite species are localized separately (SOSNINA, 1967a), but this was not the case with *M. arvalis*, mentioned above.

There are opinions of mutual exclusion of some arthropods, especially *Siphonaptera* and *Anoplura* (WEGNER, 1970; BARTKOWSKA, 1973). This interdependence was observed on *C. glareolus*. *Siphonaptera*, more frequently than other arthropods, occupy the host body alone (13.5% of all collections), *Mesostigmata* (8.8%), *Anoplura* (6.4%), *Ixodides* (5.3%), *Trombidiformes* (3.7%) and *Sarcoptiformes* (2.6%).

Siphonaptera were most frequently collected together with *Mesostigmata* (66.9%), *Trombidiformes* (41.2%), *Sarcoptiformes* (32.8%), *Anoplura* (25.7%) and *Ixodides* (14.2%). This, more or less, corresponds to the numbers of these arthropod groups in the collection.

For *Anoplura*, there were 53.9% of mutual collections with *Siphonaptera* (together with the presence of other groups). *Siphonaptera* were only collected together with *Anoplura*, and in respect to lice such collections made 4.3%. In all collections, over 10 lice on a host, (with the exception of two cases) the *Siphonaptera* were present.

Composition of fleas, occurring together with large number of *H. edentula*, does not correspond to the numerical proportions in the collection. Most frequently it was collected together with *M. turbidus*, *C. agyrtes* and *P. silvatica*. Other common species, such as *P. bidentata*, *R. integella*, were exceptionally collected with *H. edentula*.

On 470 infected *C. glareolus*, only 18 times (3.8%), there were more than 10 specimens of 2 or more different species collected on a single animal. For example, 23 *H. edentula* occurred with 23 *L. clethrionomydis* and 2 specimens of other species; 41 *H. nidi* occurred with 11 *C. agyrtes*, 11 *R. integella* and 11 specimens of other species; 53 *D. hypuadei* occurred with 24 *N. zachvatkini*, 10 *R. integella* and 11 other arthropods; 53 *N. ino-*

pinata occurred with 10 *P. silvatica* and 18 others; 12 *H. nidi* occurred with 11 *D. hypuadei*; 8 *N. zachvatkini* with 8 *R. integella* and 4 others.

Among other *Microtidae*, and in *Muridae*, the infections usually consisted of many species. The percentage of single species infections is higher on *Muridae* (*A. sylvaticus* 23.7%, *A. agrarius* 20.9%, *A. tauricus* 20%) than on *Microtidae* (*P. subterraneus* 10.8%, *M. agrestis* 9.3%, *M. arvalis* 3.5%).

Usually there are 2–4 species infecting the host. At the most, on *P. subterraneus* and *M. arvalis*, there were 13 species, and on *M. agrestis* 10 species; on *A. tauricus* 9 species; *A. agrarius* 7 species, *A. sylvaticus* 6 species. On *A. tauricus* 20 specimens of *L. agilis* and 16 specimens of *P. serrata* occurred along with 5 specimens of different *Acarina* species and *C. agyrtes*. Three more times *L. agilis* occurred together with *P. serrata* in large numbers (41 : 23, 78 : 9, 98 : 20), but always along with single specimens of other *Acarina* and twice with other fleas: *C. agyrtes* and *M. turbidus*. Eight fleas (5 *C. agyrtes*, 2 *C. solutus*, 1 *C. assimilis*) were collected with 8 *L. agilis* and 1 *I. ricinus*. Collections of *P. serrata* with *Siphonaptera* made 34.5% of all lice collections on *A. tauricus*. Fleas, without company of other arthropods were only 4 times collected on *A. tauricus*.

Only once a large number of *H. affinis* (68) was collected on *A. agrarius*, along with 1 specimen of *E. stabularis*. 17 *Siphonaptera* were accompanied by 5 *Acarina* (*H. nidi*, *E. stabularis*), and 7 other *Siphonaptera* occurred along with 4 *H. affinis* and 2 *Acarina*.

Once, on *A. sylvaticus*, large number of *L. agilis* (77) was collected with *P. serrata* (40).

There were 71.4% of common collections of *H. acanthopus* with *Siphonaptera* (9 *H. acanthopus* and 4 *Siphonaptera*; 4 : 23, 5 : 13) on *M. agrestis*.

64.7% of *H. acanthopus* collection on *M. arvalis* occurrep along with *Siphonaptera*. There were many cases of numerous occurrences, for example 8 *H. acanthopus* + 6 *Siphonaptera* + 11 *Acarina*, and 14 + 6 + 20, 6 + 4 + 24, 11 + 3 + 25, and 7 + 7 + 15.

On *P. subterraneus*, out of 9 collections of *H. acanthopus*, 7 were together with *Siphonaptera*: 29 *H. acanthopus* and 1 *H. edentula* with 8 *Siphonaptera* 7 *C. agyrtes* and 20 *Acarina* (9 species).

The mammal species differ in respect to percentage of infections involving large number of arthropods. On *M. arvalis*, infections involving more than 20 parasites on one host made 38.6% of collection, and on *A. agrarius* only 3.0%. Out of only 3 *A. tauricus*, *C. glareolus* and *A. sylvaticus* there were over 100 arthropods collected. The largest number of arthropods collected on a single host (*A. tauricus*) was 199 (Table 3).

The examples, given above, show that the joint occurrence of *Siphonaptera* and *Anoplura*, and the other groups of *Arthropoda*, is frequent, at least in the studied material. The actual set of arthropods on a host is a resultant of many factors. One of them is an interaction of the species involved. Along with a high infection with one parasitic species, there is an increase in the numbers of other parasites on a given host (Edler, Nilsson, 1973). This is not so distinct in the material from Góry Sowie. However, frequently, high numbers of the dominant species occurred together with high numbers of other arthropods.

Large surface of host body and rich food supplies reduce in most cases, antagonistic relations between species. The variability in parasite numbers also reflects the situation in host's nest. However, the relations existing there, are not adequately known, and the role of individual components has not been adequately explained. Sosnina (1967a, b), Vysockaja (1967) stress the regulatory role of predacious *Coleoptera* and *Mesostigmata*, chiefly in the nest, but also on the host. All *Mesostigmata* occurring on *C. glareolus* in Góry Sowie may be "suspected" of attacking other arthropods, but they occur as single specimens, and the accompanied arthropod fauna varied. Moreover, the length of time for which these *Mesostigmata* remain on a host is unknown, and their role in parasitocoenosis and degree of their „interest" in other parasites may only be suspected. It is known that the length of time when periodic parasites remain on host depends on temperature and humidity. For example, *P. silvatica*, at low temperature and high humidity rarely takes blood and spends less time on a host (Korneev, Gibet, Nikiforov, 1974), which is reflected in variability of its numbers on small mammals.

It is possible, that a regulatory role is played by larvae of *Siphonaptera*, which may feed on small insects and mites, eggs and smaller larvae of their own species, and also attack adult fleas (Reitblat, Belokopytova, 1974).

The above examples illustrate the difficulties in interpretation of the problems under discussion, especially that species composition of invertebrates in the nest is 3 times as diverse as that of arthropods on a host (Mrciak, Daniel, Rosický, 1966; Vysockaja, 1967).

The above relations, in respect to the most common species, illustrate the shift of activity on a host in time. These shifts are observed in sphere of groups under discussion. In *Siphonaptera* they concern spring *C. con-*

gener, summer *P. silvatica*, autumn *P. bidentata* and *R. integella*; in *Ixodides* — *I. trianguliceps*, *I. ricinus*; in *Trombidiformes* — *N. zachvatkini*, *N. inopinata*.

Antagonistic situations occur as a result of high occurrence of some of the species taking place at the same time, which is more important at the higher ecological specialization. For example *N. zachvatkini* and *N. inopinata* in 98–99% occur in ears of rodents (KOLEBINOVA, 1974). Antagonistic relationship of *L. clethrionomydis* and *H. nidi* was observed by HAITLINGER (1976, b).

The numerical peaks of dominant species of different ecological requirements, overlap each other.

Small mammals were collected on the boundary of two environments, which permitted observation of the extent of transfer of specific fauna onto the accidental hosts. The number of accidental hosts varies, and depends on the parasite numbers and the numbers, activity and contact possibilities of the host. Exceptionally, a specific parasite occurs in great numbers on an accidental host. Only 0.8% of *L. clethrionomydis* were collected outside *C. glareolus*, 4.9% of *L. agilis* outside *A. sylvaticus* and *A. tauricus*. *L. jettmari* was only 3 times collected outside *A. agrarius*

EXTENSITY AND INTENSITY OF INVASION DEPENDING ON HOST'S SEX

There are opinions that the infection indices depend on host's sex. Usually males are more strongly infected with *Siphonaptera* than females (BRINCK-LINDROTH, 1968; ULMANEN, MYLLYMÄKI, 1971; MAHNERT, 1972; PEUS, 1972; HAITLINGER, 1974b). Higher infection of males of some species of *Rodentia* with *Anoplura* was observed by COOK, BEER (1958), and in respect to *Mesostigmata* and *Ixodides* by COTTON, WATTS (1967), EDLER (1972, 1973) and ULMANEN (1972). However, not all arthropods were investigated in this respect.

In Góry Sowie the differences in the extensity of invasion are distinct only in case of *Muridae* (*Soricidae* were not investigated). The *A. tauricus* males were more frequently infected than females (by 11.1%), while in case of *A. agrarius* and *A. sylvaticus* higher invasion was recorded on females. There were no differences in the extensity of invasion of the sexes in case of *Microtidae*. The males and females of *M. agrestis* and *P. subterraneus* were infected in 100% (Table 8). On males of all species of *Rodentia*, with an exception of *A. agrarius*, a higher intensity of invasion was recorded. The greatest difference existed between sexes of

Table 8. Extensity and intensity of invasion on males and females of some rodent species

Clethrionomys glareolus (SCHREB.)		*Microtus agrestis* (L.)		*Microtus arvalis* (PALL.)		*Pitymys subterraneus* (DE SEL. LONG.)		*Apodemus tauricus* (PALL.)		*Apodemus sylvaticus* (L.)		*Apodemus agrarius* (PALL.)	
♀	♂	♀	♂	♀	♂	♀	♀	♀	♂	♀	♂	♀	♂
Extensity of invasion													
84.0	87.5	100	100	93.7	93.3	100	100	80.5	91.6	94.7	83.3	85.7	75.5
Intensity of invasion													
10.12	12.62	13.65	15.45	8.54	29.64	8.65	19.25	11.55	16.73	7.22	12.80	7.27	3.89

M. arvalis (by 21.10) and *P. subterraneus* (by 10.60). The smallest were recorded on *C. glareolus* and *M. agrestis*. The intensity of invasion was by 3.38 higher on males of *A. agrarius* (Table 8).

These differences are effected by many factors, difficult to detect. Different arthropod species vary in this respect. The intensity of invasion of *H. edentula* on both sexes of *C. glareolus* undergoes considerable changes during a year. In July and August (jointly) the intensity of invasion on females was 3.31 and on males 8.00; in May and June (jointly) the values are equal (8.47 and 8.48). In respect to *Mesostigmata*, the differences in intensity of invasion on *C. glareolus* were recorded in the autumn. In the autumn of 1971 the higher intensity of invasion was recorded on males (2.57 ♀♀; 6.59 ♂♂), and in the autumn of 1972 on females (4.17 ♀♀; 3.16 ♂♂). The extensity of invasion on males was higher in all seasons of the year by 8.1–11.7% (HAITLINGER, 1976b). Large differences were recorded on *Ixodides*. The extensity of invasion was higher on males, and intensity on females. *N. zachvatkini* (*Trombidiformes*) had higher extensity of invasion on males of *C. glareolus* between October and December, while there were no differences between March and June. The same results were obtained in both years (HAITLINGER, 1977).

The examples, quoted above, show, that the host's males and females are not equally attractive to different parasitic species. However, many facts indicate that activity of males, numbers and structure of host's population and population of parasite, as well as season of a year effect this phenomenon. This is supported by the different results from different regions but for the same hosts (EDLER, 1973). More observations are required in order to make general conclusions.

EXTENSITY AND INTENSITY OF INVASION DEPENDING ON HOST'S BODY SURFACE (AGE)

The numbers and faunistic composition of arthropods depend on body surface and age of their host. This is supported by SMIT (1962); BRINCK (1966); ULMANEN, MYLLYMÄKI (1971). COOK, BEER (1958) reported correlation between infection with *Anoplura* and host's age only in the case of *Microtus pennsylvanicus*. Certain correlations were reported by EDLER (1969, 1972) for *Mesostigmata*.

The problem has been studied on *C. glareolus* of Góry Sowie, with respect to all arthropods. The mammals were classified into three size groups roughly corresponding to age classes (HAITLINGER, 1965), and both sexes were analized separately.

The annual extensity of invasion of both sexes was smallest in size group I (80.1–95 mm), and the highest (100%) in size group III (above 105 mm). The strongest individuals, occupying the best shelters, are infected in 100%. The extent of infection, more likely, depends on the place of residence of mammals and not on their body surface (it mainly concerns periodic parasites). This is indicated by observations in different seasons of a year. Between March and June, in all three size groups, the extensity of invasion reached 100% on females; on males of the group I 91%, and in the other two 100%. Between VII–IX and X–XII the extensity of invasion in groups I and II (95.1–105 mm) varies: on males 67.6%–90%, on females 70%–100%; in group III it always reached 100%. Between VII–IX on males of group I it reached 67.6%, and in group II 84.8%. Between X–XII the situation is reversed: 90% in group I and 81.8% in group II. A similar situation was observed on females.

The intensity of invasion on males was similar in all three size groups (the highest in group II 13.0). A similar situation existed on females of group I (9.87) and II (11.68), but in group III the intensity of invasion on females was twice as small (6.95). These relationships, analized for individual arthropod groups and species, have been presented in previous parts of this report (HAITLINGER, 1975, 1976a, b, 1977).

ZOOGEOGRAPHIC CHARACTERISTICS OF *ARTHROPODA* OCCURRING ON SMALL MAMMALS OF GÓRY SOWIE

The number of publications on zoogeography of parasitic *Arthropoda* is small in European literature. The best information concerns *Siphonaptera* (ROSICKÝ, 1966; SUCIU, HAMAR, 1968; SMIT, 1969; SUCIU, 1973). The interpretation of actual ranges of some fleas is given by BRINCK-

-LINDROTH (1972, 1974). The distribution of *Anoplura* in Europe was discussed by BEAUCOURNU (1968). A zoogeographic analysis of European *Trombiculidae* was carried out by KEPKA (1968), and of mites of vertebrates of Roumania, by SOLOMON (1973).

There is no zoogeographic information concerning these arthropods in Polish literature. Lately BARTKOWSKA (1973) has published such information for *Siphonaptera* of Tatras.

Góry Sowie occupy small area, and according to division of Poland into zoogeographic regions, are the transition zone between Western and Eastern Sudetes. Only two zones, submontane and montane, may be distinguished in Góry Sowie, where the elevation is only in over 1000 m at one point. Spruce dominates in the forest stands, and in some places beech is a dominant forest species. There are also mixtures of spruce with beech, birch, sycamore maple and oak. The faunistic compositions of small mammals of Góry Sowie and Karkonosze are same (HAITLINGER, 1973 b; CHUDOBA, HAITLINGER, HUMIŃSKI, 1973). Therefore, the faunistic description of arthropods occurring on small mammals of Góry Sowie may be assumed as representative for the entire Western Sudetes. There are some differences between Góry Sowie and Karkonosze, but the knowledge of arthropods connected with small mammals of the latter region is small. There are less species of *Siphonaptera* known from Polish Karkonosze than from Góry Sowie (HAITLINGER, 1970b). In Czech Karkonosze, 3 mountain species were found that are not present in Góry Sowie: *Haemogamasus bregetovae* MRCIAK, *Amphipsylla sibirica* (WAGN.), *Peromyscopsylla fallax* (ROTHS.) and *Ctenophthalmus uncinatus* (WAGN.) (MRCIAK, 1959; ROSICKÝ, 1959).

The present analysis is introductory, and further studies on external parasites of predaceous and hoofed mammals, bats, birds and reptiles, including the alpine zone of Karkonosze, will make the full zoogeographic description of Sudetes possible. But, at this time already may be stated that the fauna of Sudetes was formed differently from the fauna of the Western Carpathians. This is indicated by the distribution of many animal groups, e.g., the differences in flea fauna between Sudetes and Tatras are greater than between Tatras and Eastern Carpathians (BARTKOWSKA, 1973).

Four zoogeographic elements were distinguished among *Siphonaptera* of Góry Sowie. At the closer examination of the whole flea fauna of small mammals of this region, most likely a holarctic element could be distinguished: *Tarsopsylla octodecimdentata* (KOL.), known from Lower Silesia (SKURATOWICZ, 1964).

I. Cosmopolitan species: *L. segnis*, *N. fasciatus*. These are faunistic elements rare in the mountains, limited to the lowest regions, remaining in the direct neighbourhood of people communities, and only exceptionally occurring in large numbers in the higher parts of mountains (Haitlinger, 1971).

II. European species: *H. talpae*, *C. agyrtes*, *C. obtusus*, *C. solutus*, *R. pentacantha*, *P. silvatica*, *P. soricis*, *P. kohauti*, *P. similis*. They make, beside Eurosiberic element, the basic group of species.

III. Eurosiberic species: *H. orientalis*, *C. assimilis*, *C. congener*, *R. integella*, *P. bidentata*, *M. turbidus*, *M. arvicolae*, *M. penicilliger*, *M. sciurorum*, *D. dasycnema*.

IV. Mountain species: *A. nuperum*.

Siphonaptera of Polish mountains are not adequately known, and the data are limited. The main structure of *Siphonaptera* of small mammals of four, better known mountain ranges: Góry Sowie, Beskid Żywiecki, Tatra and Pieniny, is made up of European and Eurosiberic elements. The *Siphonaptera* fauna of Carpathians and Sudetes was formed in different ways. This is indicated by ranges of some species that terminate within Tatras (Bartkowska, 1973). The attempt of interpretation of actual distribution of 4 subspecies of *M. penicilliger* was presented by Brinck-Lindroth (1974). According to this author Sudetes are the border area for population of *M. p. mustelae* and *M. p. kratochvili*. *M. p. kratochvili*, migrating from east and south, occupied Carpathians, and in Sudetes got in contact with *M. p. mustelae*. It is more difficult to explain the actual distribution of *P. silvatica* and *C. congener*. *P. silvatica*, known from northern and central Poland, and from Czechoslovakia, Roumania and Bielorussia, omits Polish Carpathians. This is also true of *C. congener*, found only in Beskid Żywiecki, as far as Polish Carpathians are concerned. This disjunction is not explained by the attachement of *C. congener* to warm habitats (oak and hornbeam forests). In Góry Sowie, they occur in spruce and mixed stands, while in Pieniny, Gorce and Beskid Wyspowy there are many hornbeam stands. Covering of Poland by these two species probably took place from east and west. *P. silvatica* occupies also northern parts of Poland, but the southern populations have not joined.

Rich fauna of *Siphonaptera* is characteristic of Góry Sowie, as well as, lack of (other than *A. nuperum*) mountain species and borealmountain species, which is explained by low elevation of these mountains and the historic causes of elimination from Sudetes *Megabothris rectangulatus* (Wahl.) and *Rhadinopsylla mesoides* Smit.

After elimination of elements, mutual for Tatras and Góry Sowie, and the species undoubtaly occurring in both regions, such as *Archeopsylla erinacei* (Bouché), *Tarsopsylla octodecimdentata*, *Pulex irritans* L., *L. segnis*, *N. fasciatus*, *C. bisoctodentatus*, it turns out that the difference between two ranges has 1) an ecological basis: warmth loving *C. solutus* omits Tatras, Beskid Żywiecki, and occurs frequently in Pieniny (Haitlinger, 1974b); high mountain *A. sibirica* omits low Sudetes; 2) a historical basis: lack of *P. silvatica*, *C. congener*, *P. kohauti* and *R. pentacantha* in Tatras, and high mountain *M. rectangulatus*, *R. mesoides* and *P. steini* in Sudetes, and lack of *C. uncinatus* in Góry Sowie and Karkonosze cannot be explained by the ecological factors.

The elimination of high mountain species permits to note that the fauna of *Siphonaptera* of small mammals of Góry Sowie is richer than at the corresponding elevations of Tatras and Beskid Żywiecki.

Anoplura

6 lice species of Góry Sowie belong to 4 zoogeographic elements: I. Boreal-mountain: *Polyplax hannswrangeli* Eich., *H. edentula*; II. Holarctic: *H. acanthopus*; III. Palearctic: *P. serrata*, *H. affinis*; IV. Palaearctic, Ethiopian, Oriental: *P. reclinata*.

Four species have very wide geographic range and practically occur in agreement with distribution of hosts. Only *P. reclinata*, connected with the genus *Crocidura*, occurs rarely under our climatic conditions.

Out of two boreal-mountain species, *P. hannswrangeli* is connected with Alps and Sudetes. In Carpathians it occurs in Slovac Tatras. It is also present on Polish lowland and in Bielorussia. *H. edentula*, in spite of its numerous occurrence in Poland and Europe, it is known from only few localities: Alps, Sudetes, Roumanian Carpathians, Pieniny and northern Poland (Beaucournu, 1968; Haitlinger, 1974a). The distribution of *H. edentula* is not limited to Alps, Sudetes and Carpathians, because the author has collected it also in Balcan massif and in Bulgarian Rodopes.

Acarina

Beside the parsites, other *Acarina*, occuring on small mammals accidentally are rare and of unknown distribution in Europe. The following list, therefore, does not include all collected species.

I. Cosmopolitan species: *A. fahrenholzi*, *A. casalis*, *E. stabularis*, *P. pygmaeus*, *P. quisquiliarum*, *P. longicornis*, *A. farris*, *M. musculinus*.

II. Holarctic-neotropical: *D. hypuadei*.

III. Holarctic species: *H. nidi*, *H. microti*, *H. isabellinus*, *H. carnifex*, *M. japonensis*, *R. lemnina*, *P. claparedei*.

IV. Palaearctic species: *L. agilis*, *H. horridus*, *E. emarginatus*, *P. necrophori*, *V. kochi*, *P. onoi*, *B. bavarica*, *P. spinosus*.

V. Eurosiberic species: *L. hilaris*, *L. jettmari*, *M. rossicus*, *C. mucronatus*, *I. trianguliceps*.

VI. Euronearctic species: *O. soricis*, *A. pedispinifer*, *N. autumnalis*, *M. musculi*, *P. magnus*.

VII. European species: *H. hirsutus*, *H. hirsutosimilis*, *H. sardoa*, *H. heselhausi*, *H. oblonga*, *H. soricis*, *H. apodemi*, *C. minor*, *M. tardus*, *M. montanus*, *G. longispinosus*, *H. pseudoperforatus*, *H. intermedius*, *P. brevicornis*, *P. alpestris*, *P. runciger*, *P. distinctus*, *P. kraepelini*, *P. remberti*, *P. lunulatus*, *E. ostrinus*, *P. furcifer*, *N. zachvatkini*, *N. inopinata*, *Ch. costulata*, *P. soricis*, *P. microti*, *B. cultrata*, *A. elongatus*, *X. krameri*, *T. tenax*, *L. brevipes*, *A. apodemi*, *I. ricinus*.

VIII. Mountain species: *G. alpinus*.

IX. Boreal-mountain species: *L. clethrionomydis*, *M. ingricus*.

X. Westeuropean species: *X. punctatus*, *P. forcipatus*, *P. erlangensis*, *P. krczali*, *P. stammeri*.

Almost half of *Acarina* collection is made up of European species (34), and the next are holarctic species of very wide ranges (10), and cosmopolitan species (8). There were 8 palaearctic species, 5 Eurosiberic, 5 Euronearctic and 5 Westeuropean. Boreal-mountain (2) and mountain (1) are the smallest groups. These proportions undergo changes along with better knowledge of distribution of rare species.

Among *Trombidiformes*, the most numerous are European elements (7), Westeuropean (5), and holarctic, palaearctic, Euronearctic (2 each). The species from the family *Myobiidae*, connected with the hosts *R. lemnina* and *P. claparedei*, have the greatest holarctic range.

Among the most poorly represented *Trombidiformes*, there is a lack of elements with wide distribution. KEPKA (1968), working on the distribution of *Trombiculidae* in Europe, noticed, that most of the species have holomediterranean range (atlanto-, adriato-, pontomediterranean), and only few species, such as *N. zachvatkini*, *N. autumnalis* and *N. inopinata* have a wider range. Compact range of southern elements ends in southern Hungary and Roumania.

Among *Sarcoptiformes*, there were 4 European species, 2 Euronearctic, 2 cosmopolitan, 1 holarctic-neotropical, 1 holarctic and 1 Westeuropean.

Among *Ixodides*, there is 1 Eurosiberic and 1 European species.

Almost half of *Mesostigmata* collection is made up of European species (22). There are 6 cosmopolitan, 7 holarctic, 5 palaearctic, 4 Eurosiberic, 1 Euronearctic, 2 boreal-mountain, and 1 mountain species.

The review of zoogeographical elements of *Acarina* of Góry Sowie permits the following conclusions: 1) the mountain and boreal-mountain species of parasitic mites or mites accidentaly connected with small mammals are poorly represented. The mountain and boreal-mountain elements are rare in this group not only in Sudetes, but also in Tatra Mountains, from which MRCIAK (1958) reported boreal-mountain *Hirstionyssus tatricus* MRCIAK and mountain *Haemogamasus bregetovae*; 2) there is a large percentage of elements which are very widely distributed — 50% of all collected species (cosmopolitan, holarctic, palaearctic and other); 3) no natural ranges of any species terminate in Poland, with the exception of northern boundary of *Ch. costulata*, and western boundary of *L. jettmari*, and the species occurring in Góry Sowie may probably be found in the most of the regions of this country.

The European element was most numerous (40.1%), the next was Eurosiberic (14%) and Holarctic (10.3%) (Table 9). There are 5 numerous and 3 medium numerous species in the Eurosiberic group. There are 4 numerous or medium numerous species in each, *Holarctic* and *Palaearctic* groups. Out of boreal-mountain species, 2 are numerous (*L. clethrionomydis* and *H. edentula*), and 2 mountain species were represented

Table 9. Zoogeographical elements in arthropod fauna of small mammals in Góry Sowie

Zoogeographical elements	*Siphonaptera*	*Anoplura*	*Mesostigmata*	*Trombidiformes*	*Sarcoptiformes*	*Ixodides*	*Total*	%
European	9		22	7	4	1	43	40.1
Eurosiberic	10		4			1	15	14.0
Mountain	1		1				2	1.9
Boreal-mountain		2	2				4	3.8
Palaearctic		2	5	2			9	8.4
Holartic		1	7	2	1		11	10.3
West European				5	1		6	5.7
Euronearctic			1	2	2		5	4.7
Holarctic, neotropical					1		1	0.9
Cosmopolitan	2		6		2		10	9.3
Palaearctic, Ethiopian		1					1	0.9
Total	22	6	48	18	11	2	107	100.0

by single specimens. The cosmopolitan elements were scarce, and they were grouped close to buildings. Only *E. stabularis* and *P. pygmaeus* were collected more frequently, and far away from the buildings.

RESULTS

The studies, carried out in Góry Sowie, in 1971 and 1972, are the first attempt to determine the species composition of all arthropod groups occurring permanently, periodically and accidentally on small mammals of one region (with the exception of some *Acarina* families, e.g., *Demodecidae* and *Psorergatidae*). They supplemented the knowledge of Polish fauna, especially the fauna of *Acarina*. Out of 106 species of *Arthropoda*, there were 61 species collected for the first time in Polish Sudetes, including 1 *Siphonaptera* species, 1 *Anoplura*, 32 *Mesostigmata*, 15 *Trombidiformes*, 10 *Sarcoptiformes*, and 2 *Ixodides*. There were 19 species new to the Polish fauna, including 12 *Mesostigmata*, 6 *Trombidiformes*, and 5 *Sarcoptiformes*.

Many ecological and biological data were obtained for the common arthropod species. The period of their occurrence, the increases and regressions of their numbers were established, as well as their connections with small mammals.

The dominant species and the species of greatest stability of occurrence were distinguished in each group of *Arthropoda* under discussion. The peaks of abundance of individual species of one group occur at different times. However, the peaks of species of different systematic groups overlap one another. The dominance is seasonal and concerns a short period of time (a month), or along period (3–6 months). The degree of dominance and stability has been established for most of the small mammals of Góry Sowie.

The faunistic diversity of arthropods of small mammals of Góry Sowie is very rich, as compared with other associations. This fact is probably responsible for the low numbers of individual species, out of which only two make over 10% of the collection.

Mesostigmata were the most strongly diversified group, but almost half of them are nonparasitic species. Only 7 *Mesostigmata* species made up over 1% of the collection (Table 1).

Out of *Siphonaptera* 6 species made up over 1% of the collection, from *Trombidiformes* 2 species, *Sarcoptiformes* 4 species, *Anoplura* 3, and *Ixodides* 2 species.

The dominance of individual species of the families *Microtidae*, *Muridae* and *Soricidae* varies with season of the year.

Small mammals living in a forest or at its edge, but in the moist habitat have a more diversified fauna than the species of open area or edge of a forest but in dry places. The number of arthropod species on a host depends on its numbers, area occupied, valency and activity.

The following have the most diversified arthropod fauna: *C. glareolus* (80 species), *S. araneus* (66) and *A. tauricus* (63 species). The poorest was found on *S. minutus* (14 species).

Fauna of *Microtidae* of border habitats in Góry Sowie may be practically identical, but individual host species are differentiated by the composition of dominants and the percentage of 6 arthropod groups under discussion. A high extensity of invasion of *Mesostigmata* and *Siphonaptera* is characteristic for *Microtidae*. The species of the genera *Microtus* and *Pitymys* differ from *C. glareolus* in Góry Sowie by their greater extensity of *Sarcoptiformes* and smaller of *Trombidiformes*. Only 4–6 arthropod species had a high extensity of invasion on all *Microtidae*.

Among *Muridae*, there is a large faunistic similarity between *A. tauricus* and *A. sylvaticus*. Both species are characterized by high dominance of *Mesostigmata* (the highest among small mammals of Góry Sowie, in case of *A. tauricus*), and a high percentage of *Anoplura* and *Sarcoptiformes* and small of *Trombidiformes*.

A. agrarius is characterized by the presence of specific elements: *L. jettmari* and *H. affinis* and the low percentage of *Mesostigmata*, and high percentage of *Anoplura*, *Siphonaptera* and *Sarcoptiformes*.

Soricidae are characterized by high faunistic diversity and a different arrangement of dominance of different arthropod groups. The most outstanding is *S. minutus* with its high numbers of *Ixodides* (56.9%) and low percentage of *Siphonaptera* (10.3%). *S. araneus* and *S. alpinus* had the largest number of similar characteristics. With the exception of *S. minutus*, *Soricidae* are characterized by high percentage of *Siphonaptera*.

Soricidae were considerably less infected than *Microtidae* and *Muridae* (extensity of invasion 59.5%, 86.3% and 88.6%). *M. agrestis* and *P. subterraneus* were the most strongly infected (in 100%). *S. minutus* (35.6%) and *S. araneus* (60.8%) belong to the least strongly infected.

The highest mean intensity of infection was recorded on *M. arvalis* (17.51), and the lowest on *S. minutus* (0.98).

The numbers of the most common arthropod species considerably varied during consecutive years and in different seasons of the year. This is reflected in the population size curve of all collected small mammals. During the period when the arthropod numbers were low (1971) the curve had two peaks, when the numbers were high (1972) the curve had four peaks. The minimum of arthropod numbers in 1971 correspond in time to maximum in 1972.

1–3 arthropod species dominate during most months. Their number varies with seasons of the year. Usually it is smaller in the first half of the year.

The changes in arthropod numbers concerning the entire set of small mammals, or single family or a single host species take a different course in the consecutive years and months. Overlaping of numerical peaks and depressions, especially of dominant species, is reflected in considerable differences in intensity and extensity of invasion between different seasons of a year (months), and in different years.

The faunistic structure and changes in arthropod numbers have been observed in submontane zone (300–500 m a.s.l.) and montane zone (600–900 m a.s.l.). Smaller number of species was recorded in submontane zone, and a considerable fluctuation in numbers of most common species has been observed in both zones. It turned out, that the annual "flow" of arthropods through the population of small mammals is almost identical in both zones as far as numbers are concerned, in spite of distinct differences in particular seasons of a year.

Pure, mixed and accidental invasions have been discussed. It was concluded that infections with over one hundred arthropods on a single host are very rare (maximum 199). Mutual occurrence of *Siphonaptera* and *Anoplura*, and also other arthropod groups is frequent. Most frequently the presence of 2–4 species was recorded on a single host (maximum 13 species — *M. arvalis*, *P. subterraneus*). The percentage of single species infections is much higher on *Muridae* (*A. sylvaticus* 23.7%) than on *Microtidae* (*P. subterraneus* 10.8%). Antagonistic situations occur when high occurrence of common species, especially those that occupy identical ecological niches on a host, overlap one another in time.

Specific parasites rarely occur on accidental hosts (0.8% *L. clethrionomydis* outside *C. glareolus*, 4.9% *L. agilis* outside *A. tauricus* and *A. sylvaticus*).

Differences in arthropod numbers between both sexes of a host were also observed. As a rule, the males are more strongly infected (intensity, extensity of invasion), with the exception of *A. agrarius* and *A. sylvaticus*. The differences vary with different arthropod groups and different host species. The activity of males, as well as the activity and structure of host population, and the season of a year determine this phenomenon.

The relationship between arthropod numbers and the size (age) of

host have also been observed. This relationship is different in different arthropod groups and in different arthropod species. It is assumed that important role is played by the place of residence of mammals, and not their age or size.

The zoogeographical characteristics of the arthropod complex have been demonstrated. Góry Sowie are characterized by a small number of mountain and boreal-mountain elements, and high number of European and Eurosiberic elements. The number of cosmopolitan elements, concentrated near buildings, is very small.

STRESZCZENIE

W strefie podgórskiej (300–500 m npm) i górskiej (600–900 m npm) Gór Sowich, od marca do grudnia, w latach 1971–1972 przeprowadzono badania faunistyczno-ekologiczne nad *Siphonaptera*, *Anoplura* i *Acarina* drobnych ssaków. Z 1388 gryzoni i owadożernych należących do 17 gatunków zebrano 11 532 roztocze należące do 106 gatunków. Najliczniejsze w zbiorze są *Mesostigmata* (38,6%), najrzadsze *Ixodides* (3,5%).

Najbardziej zróżnicowane faunistycznie są *Mesostigmata*, lecz niemal połowę ich stanowią gatunki niepasożytnicze. Wyróżniono wśród stawonogów gatunki dominujące i o największej stałości występowania.

Liczba gatunków stawonogów na żywicielu zależy od jego liczebności, areału przez niego zajmowanego, zakresu walencji i ruchliwości. Najbardziej urozmaiconą faunę stawonogów w Górach Sowich posiadają: *C. glareolus* (80 gatunków), *S. araneus* (66) i *A. tauricus* (63); najuboższą *S. minutus*. *Soricidae* były zarażone w znacznie mniejszym stopniu od *Microtidae* i *Muridae*. Do najczęściej zarażonych należą: *M. agrestis* i *P. subterraneus* (w 100%); do najrzadziej *S. minutus* (35,6%) oraz *S. araneus* (60,8%). Najwyższą średnią intensywność zarażenia notowano na *M. arvalis* (17,51), najniższą na *S. minutus* (0,98).

Prześledzono zmiany liczebności stawonogów na drobnych ssakach w obu latach z uwzględnieniem pór roku. W większości miesięcy dominują 1–3 gatunki. Nakładanie się szczytów liczbowych lub depresji, zwłaszcza gatunków dominujących, znajduje wyraz w głębokich różnicach w intensywności i ekstensywności inwazji między poszczególnymi porami roku (miesiącami) w różnych latach.

Prześledzono strukturę faunistyczną i zmiany liczebności stawonogów w strefie podgórskiej (300–500 m npm) i górskiej (600–900 m npm).

Omówiono inwazje jednorodne, mieszane i przygodne, ustalając, iż zarażenia powyżej 100 stawonogów na żywicielu zdarzają się bardzo

rzadko (maksymalnie 199). Wspólne występowanie *Siphonaptera*, *Anoplura*, a także pozostałych grup stawonogów jest częste. Najczęściej notowano obecność 2–4 gatunków na jednym żywicielu; maksymalnie 13 gatunków (*M. arvalis*, *P. subterraneus*). Odsetek zarażeń jednogatunkowych jest wyższy na *Muridae* (maksymalnie u *A. sylvaticus* 23,7%) niż u *Microtidae* (maksymalnie *P. subterraneus* 10,8%).

W populacji częściej zarażone są samce, z wyjątkiem *A. agrarius* i *A. sylvaticus*. Zależność inwazji od wieku i powierzchni ciała żywiciela przedstawia się niejednoznacznie. Przyjmuje się, iż ważną rolę odgrywa przede wszystkim miejsce przebywania ssaków.

Przeprowadzono charakterystykę zoogeograficzną zespołu stawonogów. Góry Sowie cechuje mała liczba elementów górskich i borealnogórskich, a przewaga elementów europejskich i eurosyberyjskich.

Instytut Biologicznych Podstaw Produkcji Zwierzęcej AR
Zespół Zoologii
ul. Cybulskiego 20, 50–205 Wrocław

REFERENCES – PIŚMIENNICTWO

ARZAMASOV, I. T., 1969, Ektoparazitocenozy nasekomoednych Belorusii, w: Fauna i ekologija životnych Belorusii, Minsk: 212–221.

ARZAMASOV, I. T., I. V. MERKUŠEVA, O. N. MICHOLAP, I. V. ČIKLEVSKAJA, 1969, Nasekomoednye i ich parazity na territorii Belorusii, Minsk: 1–175.

BARTKOWSKA, K., 1973, *Siphonaptera* Tatr Polskich, Fragm. faun., Warszawa, **19**, 10: 227–281.

BEAUCOURNU, J. C., 1968, Les Anoplures de Lagomorphes rongeurs et insectivores dans la région paléarctique occidentale et en particulier en France, Ann. parasit. hum. comp., **2**: 201–271.

BRINCK, G., 1966, *Siphonaptera* from small mammals in natural foci od tickborne, encephalitis virus in Sweden, Opusc. ent., Lund, **31**, 3: 156–170.

BRINCK-LINDROTH, G., 1968, Host spectra and distribution of fleas on small mammals in Swedish Lapland, Opusc. ent., **33**, 3: 327–358.

BRINCK-LINDROTH, G., 1972, Subspecific differentiation and distribution of the fleas *Palaeopsylla soricis* (DALE) and *Malareus penicilliger* (GRUBE) in Fennoscandia, Ent. scand,. Lund, **3**, 4: 297–312.

BRINCK-LINDROTH, G., 1974, Differentiation and distribution of the fleas *Amalareus penicilliger* (GRUBE, 1851) in western and central Europe, Ent. scand., **5**, 3–4: 265–276.

CHUDOBA, S., R. HAITLINGER, S. HUMIŃSKI, 1973, Drobne ssaki Sudetów Zachodnich, Przegl. zool., Wrocław, **17**, 1: 111–121.

COOK, E., J. BEER, 1958, A study of louse populations on the meadow vole and deer mouse, Ecology, **39**: 645–659.

COTTON, J., C. WATTS, 1967, The ecology of the tick *Ixodes trianguliceps* BIRULA (*Arachnida*, *Acarina*, *Ixodidae*), Parasitology, **57**: 525–531.

DANIEL, M., 1969, Nest of small terricolous mammals as the environment of nidicolous ectoparasites, Folia parasit., Praha, **16**: 137–142.

DANIEL, M., 1970, Effects of the microclimate on nest parasites of the bank vole, *Clethrionomys glareolus*, in summer season, Acta, Sc. nat., Brno, **4**: 1–48.

DUBININ, V. B., 1953, Parazitofauna myševidnych gryzunov i ee izmenenia v delte Volgi, Parazit. Sb., **15**: 252–301.

EDLER, A., 1972, Ectoparasitic mites (*Acarina*) from small mammals in Southern Sweden, Ent. Tidskr., Stockholm, **93**, 1–2: 100–112.

EDLER, A., 1973, Seasonal changes and host relationships of mites on small mammals in southern Sweden, Folia parasit., Praha, **20**: 75–87.

EICHLER, W., 1960, Die Läuse Schlesiens, Acta parasit. pol., Warszawa, **8**: 1–23.

GERWEL, G., 1954, Materiały do fauny wszy (*Anoplura*) Polski, Acta parasit. pol., Warszawa, **2**, 8: 171–208.

HAITLINGER, R., 1965, Morphological analysis of the Wrocław population of *Clethrionomys glareolus* (SCHREBER, 1780), Acta theriol., Białowieża, **10**, 18: 243–272.

HAITLINGER, R., 1970a, Przyczynek do znajomości afanipterofauny w Polsce, Przegl. zool., Wrocław, **14**, 1: 82–84.

HAITLINGER, R., 1970b, Die Flöhe (*Siphonaptera*) der Kleinsäuger aus den West- und Mittelsudeten, Pol. Pismo ent., Wrocław, **40**, 4: 749–762.

HAITLINGER, R., 1971, Die Flöhe (*Siphonaptera*) der Kleinsäuger des Gebietes Beskid Żywiecki, Pol. Pismo ent., Wrocław, **41**, 2: 327–344.

HAITLINGER, R., 1973a, Parasitological investigations on small mammals of the Sowie Mountains (Middle Sudetes). I. *Siphonaptera*, Pol. Pismo ent., Wrocław, **43**, 3: 499–519.

HAITLINGER, R., 1973b, Drobne ssaki Gór Sowich (Sudety Środkowe), Przegl. zool., Wrocław, **17**, 1: 107–111.

HAITLINGER, R., 1974a, Wszy (*Anoplura*) drobnych ssaków Pienin, Wiad. parazyt., Wrocław, **20**, 4: 559–568.

HAITLINGER, R., 1974b, Fleas (*Siphonaptera*) of small mammals of the Pieniny, Poland, Pol. Pismo ent., Wrocław, **44**, 4: 765–788.

HAITLINGER, R., 1975, The parasitological investigation of small mammals of the Góry Sowie (Middle Sudetes). II. *Siphonaptera* (*Insecta*), Pol. Pismo ent., Wrocław, **45**, 2: 373–396.

HAITLINGER, R., 1976a, Parasitological investigation of small mammals of Góry Sowie (Middle Sudetes). III. *Anoplura* (*Insecta*), Pol. Pismo ent., Wrocław, **46**, 2: 207–239.

HAITLINGER, R., 1976b, Parasitological investigation of small mammals of Góry Sowie (Middle Sudetes). IV. *Acarina* (*Mesostigmata*), Pol. Pismo ent., Wrocław, **46**, 4: 771–821.

HAITLINGER, R., 1977, Parasitological investigation of small mammals of Góry Sowie (Middle Sudetes). V. *Acarina* (*Trombidiformes*, *Ixodides*, *Sarcoptiformes*), Pol. Pismo ent., Wrocław, **47**, 3: 377–427.

HOPKINS, G. H., 1949, Host associations of the lice of mammals, Proc. zool. Soc., London **119**: 387–604.

JANION, S. M., 1968, Certain host-parasite relationships between rodents (*Muridae*) and fleas (*Aphaniptera*), Ekol. pol., S. A., **16**, 28: 561–606.

KEPKA, O., 1968, Zur Tiergeographie der *Trombiculidae* im Mittelmeerraum, Verh. dtsch. zool. Gesell., Innsbruck, **34**: 526–535.

KOLEBINOVA, M., 1974, Faunistic and ecological studies of the trombiculid larvae (*Acarina, Trombiculidae*) infesting small mammals in the district of Sofia, Izv. Zool. Inst. Muz., Sofia, **39**: 99–131.

KORNEEV, V. A., L. A. GIBET, L. P. NIKIFOROV, 1974, Ekologia *Leptopsylla silvatica* (*Aphaniptera*) v Marijskoj ASSR, Zool. Ž., **53**, 1: 66–76.

LACHMAJER, J., 1967, Species composition and distribution of *Ixodoidea*, Wiad. parazyt. Wrocław, **13**, 4–5:

MAHNERT, V., 1972, Zum Auftreten von Kleinsäuger-Flöhen auf ihren Wirten in Abhängigkeit von Jahreszeit und Höhenstufen, Oecologia, **8**: 400–418.

MRCIAK, M., 1958, Roztoče z radu *Parasitiformes* (*Acari*) z drobnych čičavcov Vysokich Tater, Zool. Listy, Brno, **7**, 1: 65–86.

MRCIAK, M., 1959, Die Milben der Ordnung *Parasitiformes* (*Acarina*) der Kleinsäuger des Riesengebirges, Sborn. Nat. Musea, Praha, **15**, 3–4: 170–176.

MRCIAK, M., M. DANIEL, B. ROSICKÝ, 1966, Parasites and nest inhabitants of small mammals in the western Carpathians. I. Mites of the superfamily *Gamasoidea* (*Parasitiformes*), Acta F. R. N. Univ. Comn., **12**, Zoologia, Bratislava, **13**: 81–116.

PEUS, F., 1972, Zur Kenntnis der Flöhe Deutschlands (*Insecta, Siphonaptera*). IV. Faunistik und Ökologie der Säugetierflöhe, Zool. Jb. Syst., **99**: 408–504.

PIOTROWSKI, F., 1972, Rytmy biologiczne w życiu stawonogów pasożytniczych, Wiad. parazyt., Wrocław, **18**, 4-5-6: 491–499.

REITBLAT, A. G., A. M. BELOKOPYTOVA, 1974, O kanibalizmie i hiscničestve ličinok bloch, Zool. Ž., **53**, 1: 135–137.

ROSICKÝ, B., 1959, Die Aphanipterofauna des Riesengebirges in ökologischer und zoogeographischer Hinsicht, Sb. nar. Musea v Praze, Praha, **15**, 3–4: 150–155.

ROSICKÝ, B., 1966, On the structure of the distribution area of flea species (*Aphaniptera*) of the superfamily *Ceratophylloidea*, Folia parasit., Praha, **13**: 64–72.

SKIBIŃSKI, J., 1970, Przyczynek do znajomości fauny wszy (*Anoplura*) nornika północnego, *Microtus oeconomus* (PALL.), Wiad. parazyt., Wrocław, **16**, **4**: 479–485.

SKURATOWICZ, W., 1964, Pchły – *Aphaniptera*, w: Katalog fauny Polski, Warszawa.

SKURATOWICZ, W., 1966, Materiały do fauny pcheł (*Aphaniptera*) Polski, II, Fragm. faun., Warszawa, **13**, 11: 201–220.

SMIT, F. G., 1962, *Siphonaptera* collected from males and their nests at Wilp, Netherland, by Ihr. W. C. VAN HEURN, Tijdschr. v. Ent., Amsterdam, **105**, 2: 29–44.

SMIT, F. G., 1969, A catalogue of the *Siphonaptera* of Finland with distribution maps of all Fennoscandian species, Ann. zool. fenn., Helsinki, **6**, 1: 47–86.

SOLOMON, L., 1973, Considérations zoogéographiques sur quelques Gamasides ectoparasites des mammifères et des reptiles de Roumanie, Ann. Stiin. Univ. Al. L. Cuza, Iaşi, Biologia, **19**, 2: 365–371.

SOSNINA, E. F., 1967a, The dependence of the infestation and species composition of rodents ectoparasites on the hosts' habitat (on the example of *Rattus turkestanicus*), Wiad. parazyt., Wrocław, **13**, 4–5: 637–641.

SOSNINA, E. F., 1967b, Opyt biocenotičeskogo analiza kompleksa členistonogich obnaružyvaemych na gryzunach, Parazit. Zb., **23**: 61–99.

SOSNINA, E. F., 1970, Zaražennost všami massovych myševidnych gryzunov v lesnom pojase gornogo Krima, Parasitologia, **4**, 4: 371–374.

SUCIU, M., Quelques considérations zoogéographiques sur les puces (*Siphonaptera*) de Roumanie en fonction de leurs hôtes, Rev. roum. Biol., Sér. Zool., Bucarest, **18**, 2: 111–118.

SUCIU, M., M. HAMAR, 1968, Siphonaptères collectés dans des nids de rongeurs (*Rodentia*), Trav. Mus. Hist. nat., „Gr. Antipa", **8**, 2: 927–938.

SZCZĘŚNIAK, N., 1963, Badania nad ektoparazytofauną drobnych ssaków na terenie Bieszczadów, Wiad. parazyt., Wrocław, **9**, 3: 243–248.

ULMANEN, I., 1972, Distribution and ecology of *Ixodes trianguliceps* BIRULA (*Acarina, Ixodidae*) in Finland, Ann. zool. fenn., Helsinki, **9**: 11–115.

ULMANEN, I., A. MYLLYMÄKI, 1971, Species composition and numbers of fleas (*Siphonaptera*) in a local population of the field vole *Microtus agrestis* (L.), Ann. zool. fenn., Helsinki, **8**: 374–384.

VYSOCKAJA, S. O., 1967, Biocenotičeskie otnošenia meždu ektoparazitami gryzunov i obitatelami ich gnezd, Parazit. Sb., **23**: 19–60.

WASYLIK, A., 1965, Studies on the European hare. VIII. Dynamics of occurrence of *Listrophorus gibbus* PAGENSTECHER, 1862, Acta theriol., Białowieża, **10**, 3: 27–54.

WEGNER, Z., 1957, Wszy występujące na małych ssakach w woj. szczecińskim, Acta parazyt. pol., Warszawa, **5**: 163–176.

WEGNER, Z., 1966, Wszy (*Anoplura*), w: Katalog fauny Polski, Warszawa.

WEGNER, Z., 1970, Lice (*Anoplura*) of small mammals caught in Dobrogea (Roumania), Soc. Sţiin. Biol. Rep. Soc. Rom., Zoologia, **20**: 305–314.