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Parasitological investigation of small mammals of Góry Sowie (Middle Sudetes). III. *Anoplura* (*Insecta*)

Badania parazytologiczne drobnych ssaków Gór Sowich (Sudety Środkowe). III. *Anoplura* (*Insecta*)

BY

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Faunistic and ecological studies on the *Anoplura* of Poland are rare and concern only some of the regions in our country, and detailed faunistic information is available for only some of them (WEGNER, 1967, 1972). The distribution, especially of rare species, is little known.

Mountain regions are particularly neglected. With the exception of some observations by SZCZĘŚNIAK (1963) in Bieszczady, and GERWEL (1954) and EICHLER (1960) in Eastern Sudetes, information on lice of small mammals living in mountains is lacking. More recently the lice of small mammals of the Pieniny Mountains were discussed (HAITLINGER, 1974).

There is a lack of ecological studies which would analyze the dynamics of louse populations throughout the whole year or during a period of several years. It is a serious problem since the lice of small mammals play an important role in the epizootiological and epidemiological processes. Little work has been done on this subject in other countries (VYSOCKAJA, 1950; DUBININ, 1953; COOK and BEER, 1955, 1958; SMETANA,

1962). As far as mountain areas are concerned, even the partial investigations are rare (Černy, 1955, 1959; Mahnert, 1971).

Such a situation stimulated the author to undertake year round faunistic observations of the lice of small mammals in a relatively small area of Góry Sowie, situated in Middle Sudetes, during two consecutive years. The present paper is based on a continuation of studies on the ectoparasites of small mammals of Góry Sowie initiated with studies on *Siphonaptera*.

Specimens were collected in 1971 and 1972 during each month, with the exception of January and February, since heavy snow falls prevent collecting during these two months. Collections took place in the middle of each month, in the same areas, using the same number of traps.

Studies were restricted to one biotope: the edge of a forest. Localities situated outside this biotope were no more than several metres away. The areas studied were situated at different altitudes. In the foot-hill zone (300–500 m) collecting took place at the edge of spruce and mixed (spruce — birch — maple — oak) forests. In the lower montane forest zone (600–900 m) collections were made at the edge of spruce, spruce and beech, and spruce and maple forests. In most cases wet meadows were adjacent to the forest.

The investigations took place in the following localities in Góry Sowie: Rzeczka, Walim, Sokolec, Jugów, Przełęcz Jugowska, Zagórze Śląskie, Sierpnica, Lubachów, Srebrna Góra and Czerwieńczyce. Outside Góry Sowie the following localities were investigated: Złoty Las in Pogórze Wałbrzyskie and environs of Rybnica Mała and Rybnica Śląska of Góry Suche.

The Góry Sowie occupy the central part of the Middle Sudetes and are bound by Srebrna Przełęcz in the east and the Bystrzyca river valley in the west. They are low mountains: the highest are Wielka Sowa (1015 m), Grabica (942 m), Słoneczna (959 m) and Kalenica (962 m). The lower peaks are not above 700–800 m.

Vast, dense forests occur in the highest parts of the main massif. They are made up chiefly of spruce monocultures, but in some places fragments of beech forest may be found. Along the dense network of forest roads and trails various broad-leaved trees grow (maple, birch, sorb, oak, lime); the shrub and herbaceous vegetation is rich. Near Walim and Zagórze some birch and oak stands may be found. The lower parts of the massif are stripped of forest and converted into meadows and pastures.

The Góry Sowie are relatively heavily populated and intensively

managed. Such a situation permits small mammals connected with open and agricultural land to reach the highest mountain peaks. This is expressed by the composition of louse species.

During two years 1342 lice belonging to 6 species (Table 1) were collected on 1388 small mammals belonging to 17 species.

FAUNISTIC REVIEW

Family: *Hoplopleuridae*

Subfamily: *Hoplopleurinae*

Hoplopleura edentula Fahrenholz, 1916

Localities: Zagórze, Walim, Rzeczka, Sierpnica, Jugów, Przełęcz Jugowska, Srebrna Góra.

Extensity of invasion (1971+1972): 24.8%.

Intensity of invasion (1971+1972): 1–69, the mean for entire population: 1.29, mean for infested individuals: 5.9. These data refer only to *Clethrionomys glareolus* (Schreb.).

Many characteristics of *H. edentula* are similar to those of *H. acanthopus* (Burm.). Therefore information on *H. acanthopus*, especially if collected on *C. glareolus*, probably concerns *H. edentula*. Beaucournu (1968), having rich comparative material, established diagnostic criteria which permit the separation of these twin species. From the present information on the geographic distribution of *H. edentula*, it is concluded that it is a boreal and alpine species, presently known from only a few localities in France, Austria, Roumania and Poland.

H. edentula was first reported in Poland from Silesia by Eichler (1960) who identified it as a separate subspecies *H. e. silesiaca*. Beaucournu (1966) established its presence at Mikołajki on Pojezierze Mazurskie, Białowieża and Cyrla near Zakopane. Large numbers of specimens of this species were collected throughout the Pieniny mountains (Haitlinger, 1974). Moreover, the author has specimens of *H. edentula* from Wrocław area, Gorce and Beskid Wyspowy.

In spite of the relatively small number of known localities where *H. edentula* occurs in Poland, our present knowledge suggests that this species occurs throughout the entire country and has the same range as its main host *C. glareolus*.

As far as the Góry Sowie are concerned, *H. edentula* occurs throughout the entire range. It comprises 53.2% of all lice collected on small mammals

Table 1. Lice collected on small mammals in Góry Sowie in 1971–1972

Species	1971								1972								1971+1972					
	Hoplopleura edentula FAHR.	*H. acanthopus* (BURM.)	*H. affinis* (BURM.)	*Polyplax serrata* (BURM.)	*P. hannsuwrangeli* EICHLER	Number of lice	Number of mammals	Mean intensity of invasion	*H. edentula*	*H. acanthopus*	*H. affinis*	*Polyplax serrata*	*P. hannsuwrangeli*	*P. reclinata* (NITZSCH)	Number of lice	Number of mammals	Mean intensity of invasion	Number of lice	Number of mammals	Mean intensity of invasion	Intensity of invasion on infected mammals	Range of invasion	Extensity of invasion (%)
Clethrionomys glareolus (SCHREB.)	149	8	2	1	1	161	251	0.63	547			8	1		556	289	1.92	715	540	1.32	5.15	1–69	26.3
Microtus agrestis (L.)	2	12				14	29	0.52	1	95	1				97	25	3.88	112	54	2.07	7.00	1–36	29.6
M. arvalis (PALL.)		80				80	20	4.00		24					24	11	2.18	104	31	3.35	6.12	1–14	54.8
Pitymys subterraneus (DE SEL. LONG.)	1	41				42	18	2.33	1	8					9	15	0.60	51	33	1.55	5.10	1–29	30.3
Apodemus tauricus (PALL.)		1		9		10	63	0.16	6			180			186	122	1.52	196	185	1.06	6.12	1–37	17.3
A. agrarius (PALL.)			7			7	39	0.18			79	1			80	45	1.78	87	84	1.04	8.70	1–68	11.9
A. sylvaticus (L.)				9		9	21	0.43				51			51	22	2.32	60	43	1.39	8.57	1–40	18.6
Mus musculus L.							3									6			9				
Micromys minutus (PALL.)							1												1				
Muscardinus avellanarius (L.)							1									1			2				
Glis glis (L.)																3			3				
Sorex araneus L.	5					5	115	0.04	4	1	1				6	192	0.03	11	307	0.04	1.22	1–2	2.9
S. minutus L.							22									37			59				
S. alpinus SCHINZ							6									14			20				
Neomys fodiens (PENN.)							4									8			12				
N. anomalus CABR.							1												1				
Crocidura suaveolens (PALL.)							1							6	6	3		6	4	1.50		1–6	25.0
Total	157	142	9	19	1	328	545		559	128	81	240	1	6	1015	793		1343	1388				

living at the edge of the forest. 97.2% of all *H. edentula* were collected on *C. glareolus*. Six specimens were collected on *S. araneus*, six on *Apodemus tauricus* (PALL.), three on *Microtus agrestis* (L.) and two on *Pitymys subterraneus* (DE SEL. LONG). *M. agrestis* is a new host for *H. edentula* in Poland.

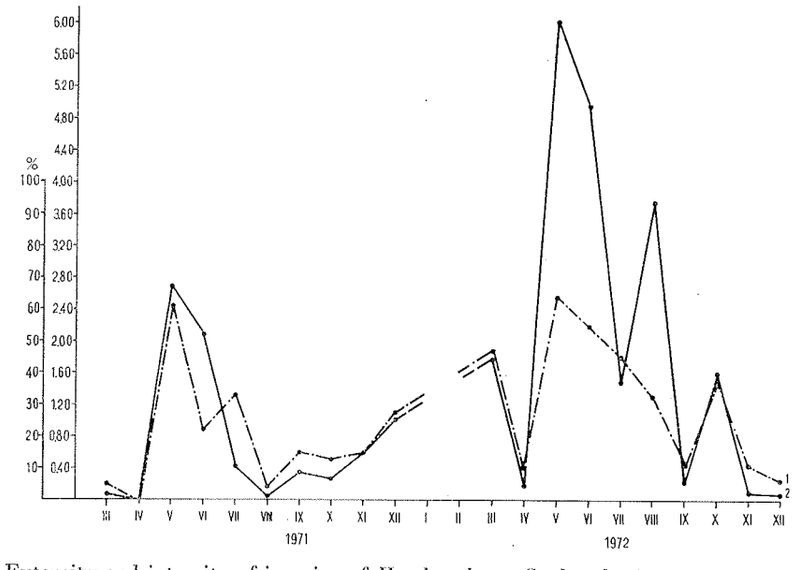
H. edentula is rarely found on small mammals other than *C. glareolus*. HAITLINGER (1974) collected *H. edentula* also on *Microtus arvalis* (PALL.) and *A. microps* KRAT. & ROS. In the literature there are no records of the occurrence of *H. edentula* on other hosts except *M. nivalis* (MARTINS) (MAHNERT, 1971). It may be assumed, therefore, that the above mentioned species make up a complete list of the known accidental hosts of *H. edentula*.

Under favourable conditions *C. glareolus* usually occurs in large numbers. It is a very active species, thus contact with other species and exchange of parasites is easy. As a rule, only single specimens of *H. edentula* were collected on the accidental hosts, and only in three cases was more than one specimen collected. On two occasions, two specimens were found on one *S. araneus* and once five specimens were collected on *A. tauricus* (1 ♀, 1 ♂, 3 nymphs of III stage).

The biology and population dynamics of *H. edentula* are unknown. Preliminary information from the Pieniny is given by HAITLINGER (1974). The mean annual invasion intensity was 2.05 and extensity of invasion was 33.6%. The data from two years of investigations in Góry Sowie are respectively lower (1.29 and 24.8%). In the Pieniny *H. edentula* was

collected only during some of the months which influenced the above data. Yearly observations carried out in Góry Sowie permit the conclusion that the population dynamics of this species undergo considerable changes during consecutive months and years (Fig. 1).

The mean invasion intensity of *H. edentula* in March and April of 1971 was low. A sudden increase in lice numbers was observed in May. The mean for this month is the highest (2.69). The high value of the mean was also observed in July, and the smallest value in August (0.05).



1. Extensity and intensity of invasion of *H. edentula* on *C. glareolus* in 1971–1972. 1 — extensity, 2 — intensity

During the autumn a constant increase in numbers of *H. edentula* was observed, and in December the mean invasion intensity reached a relatively high value of 1.12. It is probable that the high population density remained throughout the winter of 1972, which is indicated by data for March. The highest invasion intensity is reached in May (6.06) and June (4.97). Between June and December inclusively, large, sudden changes in population size were observed in consecutive months. Three successive drops and two rises in population size of *H. edentula* were observed.

During summer, autumn and winter changes in intensity of invasion and numerical values in both years differed considerably. In 1971 the population size was low, and the curve representing its changes had

two peaks, one in May and June, and one in December. In 1972 numbers of *H. edentula* were twice as high as in the previous year, and the curve of population size had four peaks, with a distinct maximum in May.

In August 1972 the mean invasion intensity (3.75) was 75 times greater than that of August 1971. Also changes during the last three months of the year assumed quite a different course. It is surprising that in spite of the high numbers in the summer and in October of 1972, the population size of *H. edentula* decreased considerably in the winter of that year, while in the previous year it increased during the winter. It may therefore be concluded that: 1) reproduction of *H. edentula* takes place throughout the entire year, 2) population size in late spring does not influence the population of autumn and winter. There is little chance to compare population dynamics of *H. edentula* in Góry Sowie with that of other areas because of lack of adequate data. MAHNERT (1971) observed the greatest percentage of *C. glareolus* infested with *H. edentula* in the Austrian Alps in May (60%). HAITLINGER (1974) states that the highest invasion extensity of *H. edentula* in the Pieniny occurs in May (60.0%) and the highest mean invasion intensity occurs in June (4.65).

Thus, it is certain, that, independent of changes in population size of *H. edentula* during a year, over different years, and in different areas, the greatest numbers of this species occur in May and June; the population size in other months may vary.

Variation in the invasion extensity and intensity in 1971 varied similarly. The highest extensity was recorded in May (61.5%), and the lowest in August (4.8%). In 1972 differences between changes of intensity and extensity of invasion were observed in July and August. In June and July the old individuals of *C. glareolus* from the last year's broods were dying out. They have a well established lice fauna which disappears upon their death. During these two months young individuals of *C. glareolus* of spring generation occur already in large numbers and become infested, but *H. edentula* does not have time to reproduce itself on these individuals. This is why in July there is high extensity and low intensity of invasion (considerable drop as compared with the situation in June). In August, there is a second surge in development of *H. edentula* on mature individuals from the previous year as well as on those from the spring generation of the current year. They do not occur, however, on young individuals of later broods.

As the population size of *H. edentula* increases, so does the percentage of larvae within the population, the highest being recorded in March, 1972 (26.5%). With the exception of April, September, November and

December, larvae were collected during every other month of 1972. The large percentage of larvae in March produced the considerable population increase in May. Four peaks in population size of *H. edentula* during a single year correspond to those for larvae numbers, although not to the same degree.

The large percentage of larvae in a population indicates favourable conditions for reproduction. However, in this respect there were considerable differences between the two years. In 1971 only one larva was collected in November. In general, with the exception of May, June and December, populations were small. The presence of larvae in November and a population increase in December, 1971, indicates that reproduction of *H. edentula* occurs throughout an entire year. Also, the presence of females with eggs during each month investigated supports this view. In 1972 they represented 86.1% of the July population and 65.2% of the August population. Even in October 47.4% of the population consisted of females with eggs. These percentages vary in different years. For example in the Pieniny, in October, 1971, females with eggs represented 39.8% of the population while in 1972, 64% (HAITLINGER, 1974). In total, larvae in the population of two years consisted of 10.1%, in 1972, 12.6%.

There are three larval stages in lice, which differ in size and certain morphological characteristics. In *H. edentula* only two stages may be easily indentified.

They differ by the presence of 1 or 2 pairs of long small bristles. The second and third stage have two pairs of these bristles. In addition to differences in size, there are folds present on the side of the abdomens of the second stage larva; these folds are particularly conspicuous posteriorly. A similar situation exists in a related species, *H. acanthopus*; COOK and BEER (1959) report that the third larval stage of this species differs from the second one only in size.

In 1972 larvae of stage I represented 86% of the entire population. They were captured most frequently in March (20.6%) and August (17.0%). In May, June, July and October their percentage varied from 1.9 to 6.8%.

In 1972 larvae of instar II represented 1.3% of the entire population. They were collected in March, May and June. Larvae of instar III represented 2.7% of population. They were collected in May, July and August. The larval dimensions are given in Table 2.

Females outnumbered males in the combined 1971 and 1972 population. The percentage of males was low: 28.9%. The sex ratio in *H. edentula* changes during consecutive months. Between March and July there was

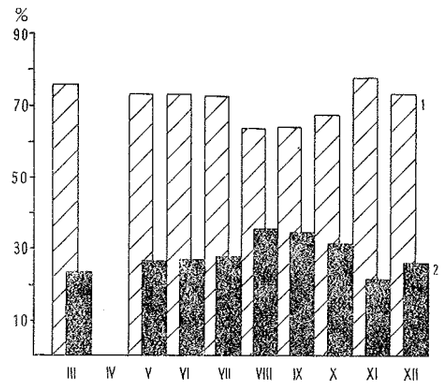
Table 2. Dimensions of females, males and larvae of lice collected in Góry Sowie

Species	Females						Males					
		Body length			Abdomen breadth			Body length			Abdomen breadth	
	n	Min.	Avg.	Max.	Min.	Avg.	Max.	*n*	Min.	Avg.	Max.	Min.	Avg.	Max.
Hoplopleura edentula FAHR.	442	0.92	1.27	1.53	0.36	0.43	0.53	182	0.78	1.02	1.18	0.34	0.38	0.45
H. acanthopus (BURM.)	85	0.98	1.35	1.56	0.42	0.49	0.53	45	0.90	1.07	1.20	0.38	0.42	0.47
H. affinis (BURM.)	46	1.03	1.25	1.33	0.40	0.44	0.48	36	0.84	0.94	1.00	0.34	0.38	0.42
Polyplax serrata (BURM.)	49	0.89	1.20	1.43	0.24	0.33	0.40	41	0.55	0.87	1.03	0.20	0.25	0.31
P. reclinata (NITZSCH.)	5	1.18	1.24	1.28	0.40	0.41	0.42	1		0.97			0.34	
Larvae of *H. edentula* FAHR.														
I instar	46	0.45	0.56	0.70	0.18	0.28	0.36							
II instar	7	0.62	0.67	0.71	0.23	0.32	0.39							
III instar	15	0.77	0.84	0.93	0.34	0.38	0.45							

Table 3. Mean intensity of invasion on males and females of some species of small mammals depending on size of host

Species	Intensity of invasion: n	80.1–95 mm	Intensity of invasion: n	95.1–105 mm	Intensity of invasion: n	over 105 mm	Localities
Females							
Clethrionomys glareolus (Schreb.)	28	4.18	33	4.64	6	6.50	Góry Sowie
	15	4.60	15	5.40	6	12.17	Pieniny, Gorce, Beskid Wyspowy
Microtus arvalis (Pall.)	15	2.93	8	6.12	6	2.50	Góry Sowie, Pieniny, Gorce, Beskid Wyspowy
Apodemus tauricus (Pall.)	9	1.78	13	3.31	2		
Males							
Clethrionomys glareolus (Schreb.)	29	5.21	49	6.02	18	4.55	Góry Sowie
	12	6.50	31	6.68	9	22.24	Pieniny, Gorce, Beskid Wyspowy
Microtus arvalis (Pall.)	16	2.88	9	7.22	9	5.18	Góry Sowie, Pieniny, Beskid Wyspowy
Apodemus tauricus (Pall.)	7	1.71	26	3.73	11		

only 23.1–27.3% of males, and between August and October 36.0–31.4%. In November and December males decrease further (Fig. 2). The highest invasion intensity of males occurs in May and June: 1.10; the lowest in November: 0.07. The highest invasion intensity of females occurs in May: 3.07, and the lowest in September: 0.20. Variability of invasion



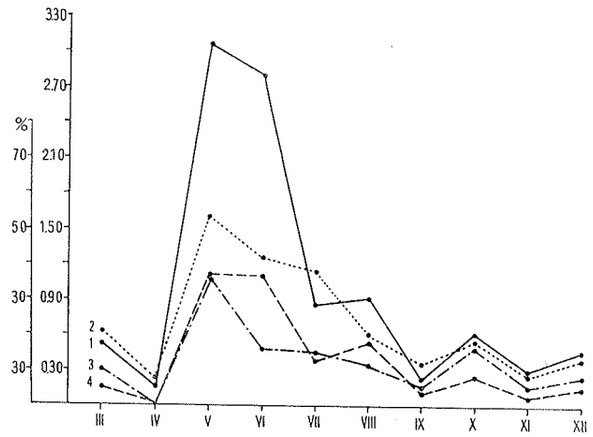
2. Changes in sex ratio during a year (in %). 1 — ♀♀, 2 — ♂♂

extensity of both sexes of *H. edentula* on *C. glareolus* is also different. In the females the highest extensity occurs in May, June and July (53.3, 42.1 and 38.3%); the lowest in November — 5.4%. The spread of males and females on the host does not change proportionally, but may be especially observed from July to October. In August and October the extensity of invasion of each sex differs (Fig. 3).

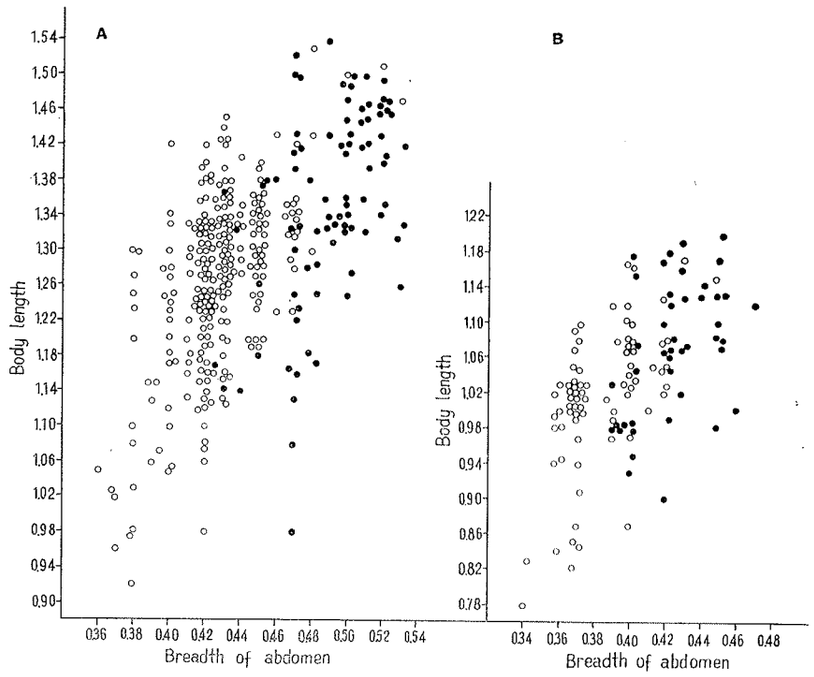
The sex ratio varies in different years. In 1971 females represented 79% of the population, while in 1972, 68.7%. There is no information in the literature on the sex ratio of *H. edentula*. Observations of the twin species *H. acanthopus* indicate that the situation is similar to that of *H. edentula*.

The dimensions of males and females are given in Table 2. Those of the females correspond to those of *H. edentula* from the Pieniny (Haitlinger, 1974), and also to the variability limits given by Beaucournu (1968) and Wegner (1972). The dimensions of the males are similar to specimens from the Pieniny (Haitlinger, 1974), and exceed those given by Beaucournu and Wegner.

Until recently *H. edentula* was not distinguished from *H. acanthopus*. Beaucournu (1968) determined the distinguishing characters of both species. In the males, the best criterium is the structure of a reproductive



3. Extensity and intensity of invasion of females and males of *H. edentula* on *C. glareolus* during a year. 1 — intensity of invasion ♀, 2 — extensity of invasion ♀, 3 — intensity of invasion ♂, 4 — extensity of invasion ♂



4. Correlation between body length and the breadth of abdomen of females and males of *H. edentula* (○) and *H. acanthopus* (●). A — ♀♀, B — ♂♂

system. The two species differ in the size of the phallosoma and especially the paramere. The limits of general body dimensions given by BEAUCOURNU for both sexes of *H. edentula* and *H. acanthopus* do not differ. However, there are distinct morphological differeneces between two species. For example, the average body length of *H. edentula* females is 1.27 mm, and of *H. acanthopus* females 1.35 mm, and the body width is 0.43 and 0.49 respectively. The average body length of *H. edentula* males is 1.02 mm, and *H. acanthopus* males 1.07 mm, and the body width 0.38 and 0.42 mm respectively. Females and males of *H. edentula* have narrower abdomens than females and males of *H. acanthopus* of the same body length (Fig. 4).

Hoplopleura acanthopus (Burmeister, 1839)

Localities: Złoty Las, Lubachów, Zagórze, Walim, Rzeczka, Rybnica, Przełęcz Jugowska.

Extensity of invasion (1971+1972): 35.5%.

Intensity of invasion (1971+1972): 1–36, mean for the entire population: 2.20, mean for the infested individuals: 6.34. Data from *Microtus arvalis* (PALL.), *M. agrestis* (L.), *Pitymys subterraneus* (DE SEL. LONG).

H. acanthopus is a most common species of louse occurring on small mammals in Poland and WEGNER (1966) reports it on 16 host species.

In Góry Sowie *H. acanthopus* represented 20.1% of the lice collected. 96.3% of the specimens were collected on its main hosts: *M. arvalis*, *M. agrestis* and *P. subterraneus*. The remaining specimens were collected on accidental hosts, 8 on *C. glareolus*, 1 on *A. tauricus* and 1 on *S. araneus*.

The percentage of *H. acanthopus* in collections of lice is low. This is connected with the type of biotope studied, and especially with the species composition of hosts: *M. arvalis* was rarely collected at the edge of forest, and only during some months, particularly in the spring and autumn. This is also true for *M. agrestis* and *P. subterraneus*. This fact influences, to a certain degree, the extensity of invasion. *H. acanthopus* rarely occurs on forest inhabitants. The invasion extensity on *M. agrestis* and *P. subterraneus* is almost twice as small as on *M. arvalis* (54.8%), and is 27.8 and 27.3% respectively. This is understandable as *M. arvalis* lives in concentrations and may more readily exchange parasites than the other two species whose populations are more widely dispersed. The high invasion extensity is also connected with the fact that most specimens of *M. arvalis* were collected in spring. Also in other areas the invasion extensity is highest during this season of the year (VYSOCKAJA, 1950; SMETANA, 1962; HAITLINGER, 1975).

The mean invasion intensity of *H. acanthopus* is highest on *M. arvalis* (3.35), and is distinctly lower on *M. agrestis* (1.98) and *P. subterraneus* (1.48). However, in infested individuals only, these values are different. The invasion intensity on *M. agrestis* is 7.13, on *M. arvalis* 6.12, and on *P. subterraneus* 5.44.

It is difficult to determine the differences between invasion intensities on hosts connected with open and forest habitats. Scant information suggests that the interrelations observed in Góry Sowie occur more frequently (WEGNER, 1970; HAITLINGER, 1974).

Of 270 specimens of *H. acanthopus* 7.3% consisted of larvae. Single larvae were collected in March, April, May, June and November and, with one exception, were in the II and III instar. This larval percentage is low. WEGNER (1957) reported 28% of larvae in a population of *H. acanthopus* on *M. arvalis* (VI–IX). COOK and BEER (1958), after detailed studies, reported an exceptionally high percentage of larvae, 45.8% on male and 32% on female hosts of *H. acanthopus*. The percentage was never lower than 10%. Undoubtedly their studies took place during a year of particularly high louse numbers. Usually the above mentioned values are much lower (1.2–10.8%) (SMETANA, 1962; WEGNER, 1970; MAHNERT, 1971; HAITLINGER, 1974).

Females are much more numerous than males. There were 66.5% females and 33.5% males on the average. Only in March and June were the numbers of both sexes about equal (50% males and 51.6% females). Opinions that females outnumber males usually concur. In relatively small populations the female percentage varies between 59.8 and 70.3% (SMETANA, 1962; WEGNER, 1970; MAHNERT, 1971; HAITLINGER, 1974). In very large populations (period of population numerical growth) these differences are small or insignificant (WEGNER, 1957; COOK and BEER, 1958).

Dimensions of females and males are given in Table 2. They are based on specimens collected from *M. arvalis*, *M. agrestis* and *P. subterraneus*. The dimensions of *H. acanthopus* specimens collected on *P. subterraneus* somewhat differ from others. The average body length of females collected on hosts belonging to the genus *Microtus* is 1.38 mm, and the body width 0.50 mm. The average body length of males is 1.09 mm, and the body width 0.43 mm. The average body length of females collected on *P. subterraneus* is 1.29 mm, and the body width 0.47 mm, and of males 1.03 and 0.41 mm respectively. Until further material is collected from *P. subterraneus* in different areas, it is difficult to judge the value of the above observations.

Hoplopleura affinis (Burmeister, 1839)

Localities: Zagórze, Walim, Rzeczka, Sierpnica, Jugów, Srebrna Góra.
Extensity of invasion (1971+1972): 10.7%.
Intensity of invasion (1971+1972): 1–68; the mean for the entire population: 1.02; the mean for the infested: 9.57. Data from *Apodemus agrarius* (PALL.) only.

In Poland this species is known from only a few localities on the Baltic coast, Pojezierze Mazurskie, Nizina Wielkopolsko-Kujawska, Białowieża Forest, Roztocze and Middle Sudetes (WEGNER, 1966). Recently it was found in the Pieniny (HAITLINGER, 1974). In all places it was collected in small numbers. The distribution of *H. affinis* depends on the occurrence of its primary host, *A. agrarius*. Since *A. agrarius* has a wide range in Poland, reaching high mountain crests (up to 1300 m), it may be assumed that, in spite of the limited number of known localities, *H. affinis* occurs throughout the entire country. It rarely occurs on other hosts. SMETANA (1962) collected it on *M. arvalis*. In Poland, *H. affinis* was found on *A. agrarius*, *A. sylvaticus* and *M. arvalis* (WEGNER, 1972; HAITLINGER, 1974), but was collected from *C. glareolus*, *M. agrestis* and *S. araneus* only in Góry Sowie. They are the new hosts of *H. affinis* in Poland. Polish, as well as other European observations, do not qualify *A. sylvaticus* to be recognized, as it has been done by WEGNER (1972), as a primary host of *H. affinis*, beside *A. agrarius*. This was also questioned by SMETANA (1962). With the exception of *A. agrarius*, all the above mentioned species are entirely accidental hosts.

In Góry Sowie *H. affinis* is a rare species. 90 specimens were captured, 68 of which were collected on a single individual of *A. agrarius*. 22 specimens of *H. affinis* were collected from other hosts. Thus, the annual extensity of invasion was unusually low: 10.7%. There is a lack of literature data on the dynamics of *H. affinis* populations throughout a year. SMETANA (1962) collected a relatively long series, but be found that only 8.9% of specimens were infested. He noted that the highest extensity and intensity of invasion occurred in May and June.

A. agrarius was collected in Góry Sowie between March and December inclusively, as well as in June. However, the material is small, and except in autumn (IX–XI), does not permit the analysis of changes in numbers of *H. affinis*. *H. affinis* was collected from *A. agrarius* only in April, August, September and November. Two specimens were collected from *C. glareolus* in March. In November one specimen was collected from *M. agrestis* and one from *S. araneus*. The highest mean intensity of in-

vasion was observed in August: 11.0. However, if the individual with 68 specimens is eliminated from the calculations for this month this index would be 1.50.

SMETANA in Ruska Poruba (1962) observed two growth peaks in development of *H. affinis* populations, in June and August, after the July drop in numbers. It seems, therefore, that increasing numbers observed in Góry Sowie in August are not uncommon for *H. affinis*. The mean annual intensity of invasion of *H. affinis* on *A. agrarius* is 1.02.

Observations of SMETANA (1962), HAITLINGER from Pieniny (1974), and from Góry Sowie refer to *H. affinis* populations in mountain regions. The mountain conditions are not too favourable for *A. agrarius*, and this animal only occurs locally in greater numbers under such conditions. It would be interesting, therefore, to investigate *H. affinis* numbers under lowland conditions.

Females represent 58.9% of population, which is a low percentage. According to SMETANA (1962) they represented 80.5 and HAITLINGER (1974) 71.4% in the Pieniny. No larvae were collected. Females with eggs represented 74.5% of all specimens collected. Only females with a body length of over 1.20 mm were found to have eggs.

Subfamily *Polyplacinae*

Polyplax serrata (Burmeister, 1839)

Localities: Zagórze, Rzeczka, Sierpnica, Jugów, Przełęcz Jugowska, Srebrna Góra.

Extensity of invasion (1971+1972): 15.8%.

Intensity of invasion (1971+1972): 1–40, the mean for the entire population 1.09; the mean for the infested: 6.92. Data only from *Apodemus tauricus* (PALL.) and *A. sylvaticus* (L.).

A very common species known from many localities in Poland (WEGNER, 1966). In Sudetes it was observed in the vicinity of Śnieżnik Kłodzki (EICHLER, 1960).

P. serrata, as a rule, lives on *A. tauricus* and *A. sylvaticus*, and in some regions frequently also on *A. agrarius* (SMETANA, 1962; WEGNER, 1970; HAITLINGER, 1974). In Góry Sowie, out of 123 specimens of *A. agrarius* only one *P. serrata* male was collected. This is striking, because in some regions most of the specimens of *P. serrata* were collected from this host (SMETANA, 1962). It occurs sporadically on hosts belonging to genera other than *Apodemus*. In Góry Sowie it was collected from *C. glareolus* (5 ♀♀, 2 ♂♂, 1 second instar larva), in March, April, September, October

and November. Moreover, throughout Poland it has been collected from *M. musculus*, *M. agrestis*, *M. arvalis*, *Micromys minutus* (PALL.), *Sicista betulina* (PALL.) (WEGNER, 1972), and also from *Apodemus microps* KRAT. & ROS. and *Sorex araneus* L. (HAITLINGER, 1974).

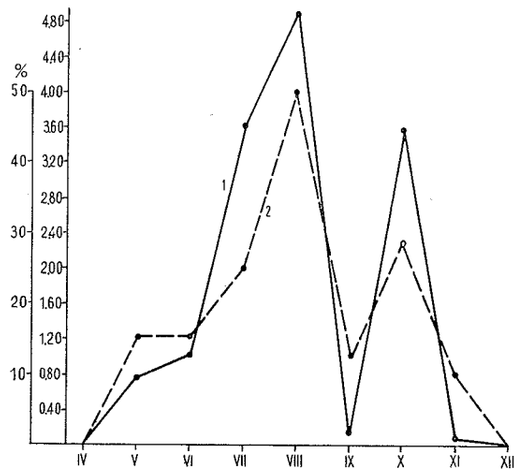
In Góry Sowie *P. serrata* is the third dominant species as far as numbers are concerned, and represented 19.3% of all lice collected. There are, however, differences between 1971 and 1972. In 1971 *P. serrata* represented only 5.8%, while in 1972 its percentage rose to 23.6%. The difference in actual numbers is no less distinct. In 1971, the mean intensity on *A. tauricus* and *A. sylvaticus* jointly was only 0.21. It is possible that the *P. serrata* population in that year was at its minimum. In 1972 the *P. serrata* population grew by 8 times, and the mean intensity of invasion was 1.60. These facts indicate that there is a distinct fluctuation in *P. serrata* numbers. Intensity of invasion in 1972 is high. SMETANA (1962), working on ample material of *P. serrata* collected from *A. agrarius* during two consecutive years, calculated low invasion indices: 0.27 and 0.48. At the same time he found that the intensity of invasion on *A. tauricus* and *A. sylvaticus* for both years jointly was 0.14. Similarly MAHNERT (1971) gives the value of 0.50, WEGNER for forest mice in Dobrudza gives 0.30, and HAITLINGER (1974) for *A. tauricus* and *A. sylvaticus* jointly gives an index of 0.60.

The extensity of invasion in 1972 is also different from that of 1971. In 1971, on *A. tauricus* and *A. sylvaticus* jointly, it was 8.3%, and in the following year 19.4%. The total percentage of infested specimens during both years (15.8%) was higher than those recorded previously. SMETANA (1962) reported that 7.2% of *A. tauricus* and *A. sylvaticus* were infested, and 11.1% of *A. agrarius*.

Numbers of *P. serrata* change with the season. SMETANA (1962) reported the highest invasion extensity in spring (April, May) on *A. agrarius* (21.6%).

In Góry Sowie, in 1972, the highest invasion extensity was observed in August (4.85), July (3.62), and October (3.57). In 1971 in May (1.10), and in June (0.56). The highest invasion extensity was observed in August (50.0%, Fig. 5). The jumps in population size are worth noting. The critical moment during the peak development of a population occurs in September. Independently of population changes taking place before that month, or in two adjoining months, the *P. serrata* population during the autumn–spring period reaches very low numbers. It is particularly evident when numbers are very high in August. The same situation was observed in *H. edentula*. The material analyzed suggests that winter is

a period when the populations of *P. serrata* are reduced to a minimum. Maximum numbers may be reached by *P. serrata* in May, June, August and October; under especially favourable conditions three times a year, twice a year (as in 1972), or once a year (as in 1971). SMETANA (1962) observed two growth peaks in population of *P. serrata* on *A. agrarius*: in May and in August.



5. Extensity and intensity of invasion of *P. serrata* during a year. 1 — intensity, 2 — extensity

There are no differences between *A. tauricus* and *A. sylvaticus* as far as annual invasion intensity and extensity of *P. serrata* is concerned (1.02, 15.7% — *A. tauricus*, and 1.32, 16.3% — *A. sylvaticus*). These differences were very distinct in the Pieniny (HAITLINGER, 1974). The exchange of lice between different species of mammals is very limited. Changes in population numbers in the same area and at the same time are independent and are frequently different in character.

Larvae represented 20.8% of the 1972 population. Of these, larvae of the first instar were 3.3%, and of the second and third instars 17.5%. No larvae were collected in 1971. The percentage of larvae in a population differs in individual months. In 1972 larvae were collected in each month between June and October inclusively. The largest percentage was observed in July, August and September, when numbers of *P. serrata* were highest. SMETANA (1962) reported the larval percentage in two consecutive years as 3.7%, MAHNERT (1971) as 10.4%, and HAITLINGER (1974) in

the Pieniny as 11.7%. The larval percentage in a population thus increases with the increase in lice numbers.

The females are much more numerous than males. On the basis of 2 year studies 70.3% are females and 29.7% are males. The ratio varies during particular months. In May and June the males are least numerous (9.5 and 4.3%). Between July and September their percentage varies from 31.8 to 37.3%. In November, out of 4 collected specimens 3 were males.

The variations in sex ratios during a year have been discussed rarely in the literature. Accoring to data collected by SMETANA at Ruska Poruba the relative increase in percentage of males also occurs in the autumn (beginning with August). HAITLINGER (1974) reported 8% males in June and 40% in October in the Pieniny population. In other areas the male percentage in *P. serrata* populations varied from 11.6 to 26.6% throughout the year (SMETANA, 1962; WEGNER, 1970; MAHNERT, 1971; HAITLINGER, 1974).

Polyplax hannswrangeli Eichler, 1952

Localities: Zagórze, Rybnica Mała.

This is a rare species, known in Europe from France, Czechoslovakia, Austria, Bielorussia and Poland (ČERNY, 1959; EICHLER, 1960; SMETANA, 1962; WEGNER, 1966; BEAUCOURNU, ARZAMASOV, 1967; BEAUCOURNU, 1968; MAHNERT, 1971). In Poland it was collected at Milicz and Wysicza in the eastern Sudetes.

In Góry Sowie only 2 females were collected from *C. glareolus*, in May and June.

Polyplax reclinata (Mitzch, 1864)

Locality: Rzeczka.

Extensity of invasion (1971+1972): 25.0%.

Intensity of invasion (1971+1972): 1.50.

It is a widely distributed species, but rare. In Europe, it was reported from FRG, GDR, Belgium, France, Czechoslovakia, Poland, USSR (BEAUCOURNU, 1968). Recently *P. reclinata* was reported from Roumania (WEGNER, 1970), and Hungary (HAITLINGER, 1973a). In Poland it is known from only a single locality in Lower Silesia (EICHLER, 1960).

According to BEAUCOURNU (1968) its primary hosts belong to the genus *Crocidura*, but WEGNER (1972) considers *S. araneus* to be the primary host of this louse. However, this is based on a misunderstanding. In Czechoslovakia, out of vast material examined, only one specimen

of *P. reclinata* was collected from the genus *Sorex* (SMETANA, 1965). BEAUCOURNU (1968) and MAHNERT (1971) did not collect it from genus *Sorex*. In Poland HAITLINGER (1974) did not find this species on 129 specimens of the genus *Sorex* examined in the Pieniny, and there were no *P. reclinata* on 386 *Sorex* specimens in Góry Sowie. On the other hand, out of only 6 specimens of *C. suaveolens* examined there were 5 ♀♀ and 1 ♂ of *P. reclinata* on one specimen collected in August.

Under European conditions this louse is mainly collected from *C. suaveolens*.

POPULATION DYNAMICS OF LICE

Population dynamics of even the most common species of lice are not adequately known. The highest numbers during the year were observed in *H. acanthopus*. However, much depends on the host species. *H. acanthopus* is less numerous on *M. agrestis* and *P. subterraneus* than on *M. arvalis*. Species living in congregations are more strongly infested. SKIBIŃSKI (1970) reported a high extensity (64.2%) and high mean invasion intensity (9.93) on *M. oeconomus* (PALL.) during the summer. These are exceptionally high values because the collections took place during the most favourable season for the numerical growth of lice.

In Góry Sowie the highest numbers of the three main species occur in May and June. Variations during consecutive years in reaching numerical maximum do not go beyond one month. There is no doubt that May and June are the months of intensified growth of lice populations.

This peak increase is usually followed by a more or less perceptible population drop, which takes place not only during consecutive summer months, but also in the early autumn. Sometimes, however, after a small drop in July, the louse population reaches high numbers again in August. In Góry Sowie this is best illustrated by the population dynamics of *H. edentula* in 1972.

Also for *P. serrata* and *H. affinis* the highest values were observed in August. In *H. acanthopus* population growth was never observed in July or August.

Changes in the numbers of *H. acanthopus* differ from those of the two remaining species (*H. edentula* and *P. serrata*). COOK and BEER (1958) reported the greatest numbers of *H. acanthopus* at the end of November and the beginning of December, and at the end of April and the beginning of May.

The additional population peak in August corresponds to considerable

growth of the *P. serrata* and *H. edentula* populations. Instead of two peaks, the greater at the end of spring and beginning of summer, and the smaller in autumn, there is a third one in August. Thus, at the end of June and beginning of July conditions are unfavourable for the development of louse populations. If they survive the population grows again.

Interpretations of seasonal variations in louse populations are rare in literature. The rhythm of development of a population of a given species is fixed and changes in numbers occur in a certain order. However, population dynamics vary with the year, resulting in a 2 or 3 peak developmental picture. The entire life cycle of lice takes place on their host, and therefore they are closely connected with all structural processes taking place in the population of that host. The death of the host usually means the death of its lice. ROSICKY (1951) mentioned the distribution of lice by migration from dead animals onto living ones. However, it is not to be expected that a large percentage of them survives. The lice of small mammals do not have much chance to survive on predators and only a small percentage is able to transfer onto accidental hosts (other rodents or herbivorous species). The presence of lice on accidental hosts is rare (WEGNER, 1957; SMETANA, 1962; MAHNERT, 1971, and others) and it is not known for how long they can survive or whether they can feed on their blood or not. Large losses are suffered, both as adults and eggs (DUBININ, 1953).

The size of a parasite population is a result of many various factors, such as the biology and structure of the host population, habitat conditions and, according to some authors, body dimensions, sex ratio and periods of moulting by a host.

Not all of the above listed factors have the same influence on parasite numbers. There are different opinions concerning the importance of some of them, e.g., body dimensions and moulting. Most likely moulting does not play an important role in regulating louse numbers. In small mammals it is a continuous process, as far as a whole population is concerned, and only during some periods does it become intensified or abated (ZEJDA, MAZAK, 1965; HAITLINGER, 1968a, b). For example, in adult *A. agrarius* the percentage of individuals shedding their fur does not drop below 20% during the period between March and December (HAITLINGER, 1968b). If young individuals were included the percentage would have been much greater. However, the periods of distinct changes in louse numbers do not correspond to the minimum and maximum in the process of fur shedding. SKIBIŃSKI (1967) reported a high infestation of lice on *M. oeco-*

nomus in June in spite of „thinned out" fur. The process of moulting assumes a different course in animals of different age, and in different seasons of the year. Rarely whole pelage is being exchanged at the same time, especially in young animals. For old specimens a diffuse fur shedding is typical. Therefore, the possibility of loosing lice along with hair is small, except in small specimens which are in the earliest developmental stages. The greatest losses occur when eggs which are attached to falling fur are being lost.

INTENSITY OF INVASION OF SPECIMENS OF DIFFERENT BODY LENGTH

There are many controversial opinions on the influence of a host's size on the intensity and extensity of its lice. PIOTROWSKI (1967) is of the opinion that the present knowledge does not permit any generalizations and that especially the investigations are frequently limited to observations based on small material and concerning only two age groups. Much attention to this subject has been given by COOK and BEER (1958), who analysed the influence of a host's body size on the degree of infestation, especially of *Microtus pennsylvanicus* by *H. acanthopus* and *Peromyscus maniculatus* by *H. hesperomydis*. The analysis of much material of many size groups did not produce univocal results. A distinct increase in louse infestation was observed only in large males of *M. pennsylvanicus*.

It is pointless to distinguish more than 3 size groups in small mammals (genera *Microtus*, *Pitymys*, *Clethrionomys*, *Micromys*, *Apodemus*), since their dimensions are small. When analysing the influence of body dimensions on louse infestation it is difficult to eliminate the influence of other factors acting at the same time. For example, the differences in biology of young and old host specimens also play an important role.

The influence of body dimensions on the size of invasion has been observed in a population of *C. glareolus* from the Middle Sudetes and showed that in females of size group 80.1–95 mm the intensity of invasion is 4.18 (material of 2 years); in females of size group above 95.1 mm it is only 4.64. In the same size groups in males the intensity of invasion is 5.21 and 6.02. In populations from the Pieniny, Gorce and Beskid Wyspowy (personal observations) the values are as follows: females: 89–95 mm 4.60; 95.1–105 mm 5.40; above 105 mm 6.50; males: 6.50, 6.68 and 4.55. In females of *A. tauricus* from Góry Sowie, Pieniny, Gorce and Beskid Wyspowy (all together) in size group 80.1–95 mm the intenisty of invasion is 1.78; 95.1–105 mm 3.31; above 105 mm 2.50, and in males: 1.71, 3.73 and 5.18 respectively. In *M. arvalis* from Gorce, Pieniny and Beskid

Wyspowy, in analogous size groups the respective values for females are: 2.93, 6.12 and 12.17, and for males: 2.88, 7.22 and 22.24 (Table 3). Small material concerning youngest individuals (below 85 mm) did not permit an analysis of the degree of infestation in this group of animals. However, in 5 *A. tauricus* males of body length less than 80 mm the invasion intensity was 13.80. There were as many as 37 lice collected from one specimen. On male *C. glareolus* with body length less than 80 mm 18 lice were collected.

Thus distinct differences in invasion intensity of animals of a different body size occur only between both sexes of *M. arvalis*. They are less distinct in *A. tauricus*. In *C. glareolus* they were observed only in females from the Beskidy population. The figures for *C. glareolus* compiled separately for spring, summer and autumn, and winter seasons present a reverse picture to that for the whole year. For instance, for females of size group 80–95 mm for the period March–August the intensity of invasion was 4.71, and for larger specimens (above 95 mm), 5.64; during the period September–December the analogous values were 3.64 and 2.64. The same situation was observed in males, suggesting that these data are accidental.

It is believed that the above differences are not connected with the body size of small mammals under discussion. This is indicated by frequent collections of even very small specimens highly infested with lice. It is supposed that the above mentioned differences are connected with longevity of the animals studied. The lice have to have sufficient time for reproduction and development in order to occur in greater numbers, and this is only possible on host which live long enough.

The distinct differences between *M. arvalis*, *C. glareolus*, and *C. glareolus* and *A. tauricus* are probably connected with differences in the biology of their lice. *H. acanthopus* reproduces very quickly and usually *M. arvalis* is more strongly infested than the other two species. This explains the existing big differences between small and large *Microtinae*.

EXTENSITY AND INTENSITY OF INVASION ON HOSTS OF A DIFFERENT SEX

The variability of extensity and intensity of invasion depending on the host's sex has been studied. There are some reports of stronger invasion on males of small mammals. Such differences were reported by COOK and BEER (1958) in *M. pennsylvanicus*; they were absent in *P. maniculatus*. SKIBIŃSKI (1970) observed them in *M. oeconomus*. Of the present material studied only *C. glareolus* is suitable for analysis. The extensity

of invasion (2 years jointly) of females was 25.0%, and of males 26.1%. There are, however, differences in intensity of invasion (for the entire population they are small: 1.10 ♀♀, 1.48 ♂♂; for infested specimens: 4.39 ♀♀ and 5.69 ♂♂). During particular seasons of the year the values for both sexes undergo considerable changes. For example, in July and August (jointly) the intensity of invasion on infested females reached 3.31, while on males 8.00. In September and October (jointly) this figure for females is 4.21 and for males only 3.06. In May and June (jointly) these figures are 8.47 and 8.48. In the Pieniny populations the higher extensity of invasion was observed in females (HAITLINGER, 1974). The jumps in figures indicate their accidental character, and they are difficult to explain on the basis of the biology of host and parasite. To a great extent they depend on the presence of a strongly infested individual in a studied group (50 to over 100 louse specimens). The average infestation amounts to only 1–2 specimens. Only strong infestation could indicate strong connections with a given sex. Single infestations depend a great deal on chance. Thus 9.7% of infested females are specimens with more than 10 lice. The data presented above do not permit with certainty the determination of differences in infestation that exist between the two sexes of *C. glareolus*. At present it may be said that this situation varies with different species of small mammals. So far adequate data showing such differences have been reported for only some species of the genus *Microtus*.

ACCIDENTAL AND MIXED INVASIONS

Lice are insects which are closely connected with their hosts and only rarely does a species become a parasite of more than 3–4 host species. Of the material collected only *H. acanthopus* and *P. serrata* possess a large number of primary hosts. The number of accidental parasites changes and depends on louse numbers, and especially on numbers, activity and contact possibilities of a host. In Góry Sowie *H. acanthopus* had the largest number of host species — 6, *H. edentula* was collected on 5 hosts, *P. serrata* and *H. affinis* on 4, and the very rare species *P. reclinata* and *P. hannswrangeli* were collected only on their primary hosts.

In Poland *H. acanthopus* has 5 primary hosts living under various environmental conditions. This explains its presence on many animal species, and not only on rodents. In Poland it has been collected from 12 species of *Rodentia*, 4 species of *Insectivora*, 1 species of *Lagomorpha*, and 1 species of *Carnivora* (WEGNER, 1972; HAITLINGER, 1974). According to WEGNER (1972) *H. edentula* is known only from *C. glareolus*. Poor

data on the accidental hosts of this species result from a lack of knowledge of its biology and its recent separation from *H. acanthopus*. In Góry Sowie *H. edentula* was collected from 4 accidental hosts, in the Pieniny from another 3. Thus, there are 8 known hosts of this louse in Poland. *H. edentula* is a common species, and its primary host *C. glareolus* is very common in Poland. The number of accidental hosts may be greater than is known at present.

P. serrata was collected in Poland from 11 host species, and *H. affinis* from 6 host species (WEGNER, 1972; HAITLINGER, 1974). Only *P. reclinata* and *P. hannswrangeli* was collected from 2 hosts, or from one primary host.

The occurrence of certain species on many, frequently systematically very remote, hosts does not change the rule that lice are insects which specifically depend on a very limited group of species only. Lice occur singly and, generally speaking, very rarely on accidental hosts, in spite of the sometimes very large group of the latter. There are known cases that lice feed on the blood of such a host; however, their reproduction has not been reported. Very rarely louse larvae occur on accidental hosts. Whether larvae can mature on accidental hosts, and how long particular louse species may remain on them still remains unanswered. There is no question, however, that accidental hosts play a certain role in the distribution of atypical parasites. This is indicated by the common occurrence of this phenomenon in the most common lice: *H. acanthopus*, *H. edentula* and *P. serrata*.

Lice usually occur on accidental hosts during the period of maximum numbers. Accidental infestation has been reported from various areas (WEGNER, 1957, 1969; SMETANA, 1962; MAHNERT, 1971), but such infestations are rare. For example, in Góry Sowie in 1971, of 83 infestations of small mammals by lice only 10.8% were accidental. In 1972, of 161 infestations of small mammals only 8.7% were accidental. In proportion to the number of specimens collected, *M. agrestis* was the most frequent accidental host (5.6%). *P. subterraneus* (3.0%), *S. araneus* (2.6%), *A. tauricus* (1.6%) and *C. glareolus* (1.5%) were also accidental hosts. These figures are low and indicate that the exchange of lice among non specific hosts occurs rarely. It probably takes place most frequently during contacts with dead hosts of other species, or during visits to abandoned nests of other hosts, in which sometimes single specimens of lice may be present. In 11 cases *H. edentula* was an accidental parasite (*A. tauricus*, *M. agrestis*, *S. araneus*, *P. subterraneus*), in 7 cases *P. serrata* (only on *C. glareolus*), in 3 cases *H. acanthopus* (*A. tauricus*, *C. glareolus*, *S. araneus*).

The above data indicate that any species of small mammal may become an accidental host if the situation permits an infestation. Such possibilities increase with increasing numbers and activity of host species occurring in the same area (biotope). Thus, infestation by *H. edentula* and *P. serrata* is most frequent. On the other hand, *H. acanthopus*, being second as far as numbers are concerned, occurs rarely in the mountains on atypical hosts, because *M. arvalis*, its most frequent host, is considerably isolated from forest species. *M. agrestis* and *P. subterraneus* are not well represented in populations of small forest mammals and have limited opportunity to become distributors of *H. acanthopus*. The situation in the Pieniny seems to indicate the same. In spite of the fact that *H. acanthopus* was abundant on *M. arvalis*, it was not observed on forest mammals (*C. glareolus* and *A. tauricus*). On the other hand, it was collected on mammals living in the open: *A. microps*, *A. sylvaticus*, *M. musculus* and *N. fodiens* (HAITLINGER, 1974).

It is difficult to find out what relationship exists between an accidental host and a parasite. Larvae were very rarely collected on such hosts. On *C. glareolus* one larva of *P. serrata* was collected; on *S. araneus* one larva of *H. edentula* and one of *H. acanthopus*, and on *A. tauricus* 3 larvae of *H. edentula*. They were all second instar larvae. However, only eggs and first instar larvae, for which transfer and living on another host could be difficult, may be taken as evidence of breeding on accidental hosts; such evidence is lacking.

Mixed invasions occur very rarely. In Góry Sowie, in 1971, only 4.8% of all infestations consisted of mixed invasions, and in 1972 only 3.1%. A similar situation existed in the populations of Gorce and Beskid Wyspowy (personal observations). The mixed invasions represented 3.0%. Only in the Pieniny (HAITLINGER, 1974) was this percentage higher: 10.1%. Mixed invasions were mainly observed on *C. glareolus* (6 cases), *M. agrestis* (2), and *P. subterraneus* (1). Most frequently *H. edentula* occurred together with *H. acanthopus* (4 cases), or with *P. serrata* (3 cases). Furthermore, *H. affinis* was observed with *P. serrata*, and *H. edentula* with *P. hannswrangeli* on *C. glareolus*. As a rule, a single accidental parasite accompanies a primary parasite. Only one exception has been recorded, e.g., 18 ♀♀ of *H. edentula* and 8 ♀♀ of *H. acanthopus* were collected from *C. glareolus*.

Mixed invasions consist of 2 species, although exceptionally 3 species occur. The latter concerns only hosts having 2 specific parasite species. Such a case was recorded in Beskid Wyspowy (personal observations) on *A. agrarius*, on which, besides *H. affinis* and *P. serrata*, 2 specimens of *H. acanthopus* were also collected.

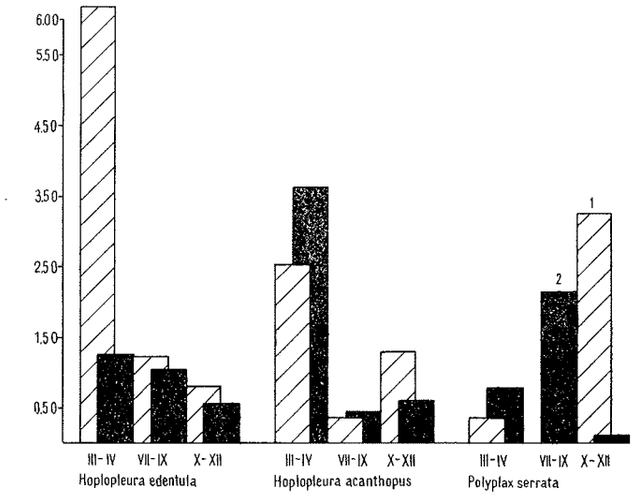
Mixed invasions are interesting, especially when 2 specific species occur on one host. In Poland it concerns *A. agrarius* and *Micromys minutus* (PALL.) and only here can the influence of two species on each other be studied. According to SMETANA's records (1962) from Ruska Poruba, *H. affinis* outnumbered *P. serrata* during most of the year. However, the total numbers in both species were very low. Moreover, the changes in numbers of *P. serrata* on *A. agrarius* assumed a different course compared with those on *A. tauricus*.

This is an interesting problem, because in the Pieniny HAITLINGER (1974) also observed the parallel occurrence of the two above mentioned species on *A. agrarius*, and *P. serrata* was more numerous. *P. serrata* occurred more numerously on *A. agrarius* (1.35) than on *A. tauricus* (0.85). *H. affinis* and *P. serrata* both occur in Góry Sowie, but *P. serrata* has been collected only from *A. tauricus* (1.02) and *A. sylvaticus* (1.39). Only one specimen of *P. serrata* was collected on *A. agrarius* (0.01), which corresponds to its occurrence on the accidental host *C. glareolus*. The absence of *P. serrata* on *A. agrarius* in Góry Sowie, in spite of the abundance of this host, and the high numbers of this parasite on other species of the genus *Apodemus*, suggest the following conclusions. It is obvious that changes in numbers of the same parasite species may be different on different hosts. It has already been pointed out that *P. serrata* populations may vary considerably in numbers during consecutive years. On *A. tauricus* and *A. sylvaticus*, which are biotopically isolated, the invasion picture was the same. Relatively high numbers of *A. agrarius* make the cause of complete lack of invasion during two years difficult to determine. In such a situation it may be concluded that *P. serrata* living on *A. tauricus* and *A. sylvaticus* is not the same as *P. serrata* living on *A. agrarius*.

Therefore, to sum up it may be concluded that lice are very specific in choosing a host. This is suggested by the low percentage of accidental infestations. Therefore, it is difficult to agree with the opinion of WEGNER (1957) about the low specificity of *H. acanthopus* because of its presence, for example, on *S. araneus*. Small mammals frequently occur in large numbers within a small area, and the above stated facts are only a reflection of frequent contacts among them. Therefore, the attempt to distinguish three categories of hosts (SMETANA, 1962): primary, secondary and accidental, does not seem correct in relation to lice. There are only two categories, a primary and an accidental host. The numerical differences in the occurrence of a given louse species, e.g., *H. acanthopus* on different hosts, is connected, to a great extent, with the mode of life, host numbers and other similar factors.

FAUNA OF LICE IN VERTICAL ZONES OF GÓRY SOWIE

The variability in numbers of the three main species, *H. edentula*, *H. acanthopus* and *P. serrata*, on the six most numerous rodent species was studied in relation to the elevation above sea level. Too few observations have been so far made in this respect. MAHNERT (1971) reported greater numbers of lice in areas at higher elevations. For example, he recorded *H. edentula* and *P. hannswrangeli* only from subalpine and alpine zones. The same situation was reported from France (BEAUCOURNU, 1968). In Poland such far reaching relations have not been observed. *H. edentula* occurs at high elevations in the mountains and is common in the lowlands. Studies on changes in numbers of *H. edentula* on *C. glareolus* in 3 seasons of the year, collected at elevations of 300–500 and 600–900 m, showed a slightly reversed relationship compared with that reported by MAHNERT. The numbers of *H. edentula* were lower during all seasons of the year on *C. glareolus* from the mountain zone (600–900 m); during spring (III–VI) these numbers were 5 times greater.



6. Changes in numbers of *H. edentula*, *H. acanthopus* and *P. serrata* during different seasons of the year in foot-hills and mountain zones. 1 — foot-hill zone, 2 — mountain zone

The numbers of *H. acanthopus* on *M. agrestis*, *P. subterraneus* and *M. arvalis* during spring and summer were higher on specimens collected in the mountain zone, and in the autumn they were two times lower than in the foot-hill zone (300–500 m). However, uneven numbers of *M. arvalis*, which is usually more strongly infested than the other two species, in catches in particular zones and seasons of the year, is important in this case. The above given values have varied depending on the number of *M. arvalis* captured.

The jumping character of changes in numbers of *P. serrata* at different elevations (Fig. 6) suggests that the influence of elevation at least within the scope of the present study, is not important. This also concerns *H. edentula*. The large number of factors which may also influence the above mentioned facts (e.g., influence of other ectoparasites which are more numerous on *C. glareolus* in the mountain zone) prevents making conclusions at the present moment. This problem requires further study.

GENERAL COMMENTS

Infestation by lice of particular host species during consecutive years may vary to a great extent (e.g., extensity of invasion on *C. glareolus* in 1971 was 18.3%, while in 1972 it was 33.2%), but on the basis of a two year study in Góry Sowie, four groups of small mammals may be distinguished on the basis of extensity and intensity of invasion.

1. Mammals strongly infested. The highest extensity (54.8%) and intensity of invasion (3.35) was recorded on *M. arvalis* at the low invasion range 1–14 (Table 1). This is due to two reasons: a) *M. arvalis* usually occurs in groups, which facilitates exchange of lice within the population; b) *H. acanthopus* is a species biologically stronger than the other two abundant species *H. edentula* and *P. serrata*.

2. Mammals moderately infested. *M. agrestis*, *P. subterraneus* and *C. glareolus* belong to this group. The first two species are mainly infested by *H. acanthopus*. The intensity and extensity of invasion, lower than those reported for *M. arvalis*, are the result of dispersal of both species and their low numbers. Another species having a different biology occurs on *C. glareolus* and this influences the observed situation.

3. In the third group species of the genus *Apodemus* may be included. Although the intensity of invasion on three species of this genus does not differ from that of mammals belonging to the second group, the extensity of invasion on *P. serrata* and *H. affinis* is much smaller.

Therefore, the small percentage of representatives of the genus *Apodemus* is being infested. The relatively high invasion intensity resulted from catching individual highly infested specimens, e.g., out of 87 lice collected on *A. agrarius* 68 were found on a single individual.

4. Mammals having no specific louse fauna belong to this group and are only accidentally infested. *S. araneus* belongs to this group. In other areas lice were also collected from other species of *Insectivora*: *S. minutus*, *S. alpinus*, *N. fodiens* (SMETANA, 1962; HAITLINGER, 1974).

As a rule the lice collected on each mammal were specific for a given species. On mammals occurring abundantly in a given area and penetrating different habitats, single specimens of other species may occur. The largest number of species was collected from *C. glareolus* — 5, the next in line are *A. tauricus*, *M. agrestis* and *S. araneus*, 3 species each. *S. araneus* most frequently contacts *C. glareolus*. This is indicated by *H. edentula* which represented 77.8% of all lice collected from *S. araneus*. *P. reclinata* does not live on *S. araneus* and probably it occurs accidentally on this host, because the habitat requirements of *C. suaveolens* and *S. araneus* rarely permit sporadic contacts affording possibilities for the exchange of this louse.

Out of 17 host species captured in Góry Sowie, only 9 were infested by lice. Of these only 8 species may be considered as permanent hosts of lice (Table 1). Six species of lice reported from Góry Sowie do not exhaust this subject. It is expected that at least another 3 species should be found there: *Schizophthirus gliris* BLAGOVESCHTCHENSKY, 1965, on *Glis glis* L., *Hoplopleura captiosa* JOHNSON, 1960, on *Mus musculus* L., and *Polyplax spinigera* (BURMEISTER, 1839), which was recently reported from Domasław situated not far from Góry Sowie (HAITLINGER, 1973a).

STRESZCZENIE

W strefie przedgórza (300–500 m npm) i regla dolnego (600–900 m npm), od marca do grudnia w latach 1971 i 1972 przeprowadzono badania faunistyczno-ekologiczne wszy drobnych ssaków. Z 1388 drobnych ssaków należących do 17 gatunków zebrano 1343 wszy należące do 6 gatunków. Stwierdzono obecność dwóch rzadkich gatunków: *Polyplax reclinata* NITZSCH i *P. hannswrangeli* EICH. Najliczniejsze w Górach Sowich są *Hoplopleura edentula* FAHR. i *H. acanthopus* (BURM.).

Zbadano fluktuację liczebności *H. edentula*, *H. acanthopus* i *P. serrata* (BURM.) w ciągu roku. Najwyższą liczebność notuje się w maju i czerwcu. Dynamika liczebności w poszczególnych latach różni się, dając na przestrzeni roku obraz rozwoju 1-, 2- lub 3-szczytowy; czasami po regresji w lipcu ponowny wzrost liczebności wszy notuje się w sierpniu. Samice u wszystkich gatunków wszy są liczniejsze od samców. W kolejnych porach roku proporcje te ulegają niewielkim zmianom.

U *H. edentula* i *P. serrata* zauważono występowanie larw wszystkich stadiów rozwojowych na przestrzeni roku. Wzrostowi liczebności populacji odpowiada wzrost odsetka larw w populacji.

Z 17 gatunków drobnych ssaków zebranych w Górach Sowich wszy notowano tylko na 9. Najwyższe inwazje stwierdzono na *Microtus arvalis* (PALL.) i *M. agrestis* (L.), najniższą na żywicielu przygodnym *Sorex araneus* L. Przedstawiciele *Microtidae* są silniej zarażeni od przedstawicieli *Muridae*.

Prawdopodobnie różnice w intensywności inwazji u zwierząt o różnej powierzchni ciała, wyraźne wyłącznie u *M. arvalis*, mają związek z długością życia tych zwierząt.

Ekstensywność i intensywność inwazji u obu płci *Clethrionomys glareolus* (SCHREB.) różni się minimalnie. Ustalono, że u różnych gatunków drobnych ssaków kształtuje się to niejednakowo.

Liczba żywicieli przygodnych jest ściśle uzależniona od liczebności wszy i liczebności, ruchliwości i możliwości kontaktowych żywiciela. Na największej liczbie żywicieli (6) notowano *H. acanthopus* i *H. edentula* (5). Inwazje przygodne są rzadkie, np. w 1972 r. stanowiły one 8,7% wszystkich inwazji. Najczęściej żywicielem przygodnym był *M. agrestis*. Inwazje mieszane są bardzo rzadkie. W latach 1971 i 1972 stanowiły one odpowiednio 4,8 i 3,1% wszystkich inwazji. Z reguły są dwugatunkowe. Wpływ usytuowania pionowego na intensywność i ekstensywność inwazji wszy na drobnych ssakach, w badanym zakresie, jest niewidoczny.

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