ACTA ZOOL. CRACOV.	32	15	631—652	KRAKÓW, 31. X. 1989

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Small mammals of Gorce National Park

[with 5 text-figs.]

Drobne ssaki Gorczańskiego Parku Narodowego

Abstract. Small mammals of Gorce National Park have been studied and an analysis of their communities in various plant associations is presented. 17 species (N = 2526) have been recorded: *Talpa europaea*, *Sorex araneus*, *S. minutus*, *S. alpinus*, *Neomys fodiens*, *N. anomalus*, *Clethrionomys glareolus*, *Arvicola terrestris*, *Pitymys subterraneus*, *Microtus agrestis*, *M. arvalis*, *Mus musculus*, *Rattus norvegicus*, *Apodemus agrarius*, *A. flavicollis*, *Dryomys nitedula*, and *Muscardinus avellanarius*. The trapability index is positively correlated with the fertility of a plant association. The number of *Sorex minutus* increased with the altitude as compared to *S. araneus*. *Clethrionomys glareolus* clearly outnumbered *Apodemus flavicollis* in coniferous woods. The greatest participation (100%) of the genus *Microtus* among all the rodents is in non-utilized economically *Vaccinium myrtillus* association, while the smallest in *Cirsietum rivularis* (87.9%) and *Gladiolo-Agrostietum* (87.5%).

I. INTRODUCTION

Gorce National Park was founded in 1981. It encompasses an area characteristic for the Gorce range, that of relatively only slightly damaged Polish Carpathians (Kornaś & Medwecka-Kornaś 1981). The extent of man-made natural environment transformation is small in comparison to other ranges of the Beskid Mts.

Small mammals of the Gorce range have been studied till now by Haitlinger & Szyszka (1977); yet the two authors' data do not permit a complete quantitative evaluation of the material because of the trapping method used.

Relationships between the type of plant association and the number of small mammals and the structure of their communities in both forest and non-forest biotopes have been pointed at by many authors (Koshkina 1967, Aulak 1970, Mazurkiewicz & Rajska-Jurgiel 1979, Grant & Birney 1979, Grant et al. 1982, Barry 1984, Morris 1984, Steele et al. 1984). In this respect, the case in the mountains is similar to that in the lowlands, for the vertical position of a region is less important to the determination of the range of small mammals than the type of environment (Chudoba & Haitlinger 1971), though, on the

other hand, this former dependence is indirectly present. This results from the fact that the altitude above sea level does influence the occurrence of particular plant associations.

The aim of this work consists in presenting species of small mammals occurring in the Gorce range, and in an analysis of selected ecological parameters concerning populations of these animals in various plant associations of this region of the Carpathians.

II. RESEARCH AREA

Research has been carried out within the area of Gorce National Park (5908 ha acc. to GAWŁOWSKA 1981) and in areas adjacent to the Park. Of all forest plant associations in the Gorce, in which research has been carried out, the most characteristic ones are:

(a) Riverine Carpathian alderwood — *Alnetum incanae* AICH. et SIEGR., 1930 — constituting the first stage of forest succession in riverine boulder fields (KORNAŚ & MEDWECKA-KORNAŚ 1981). A highly hygrophile, eutrophic riverine carr of mountain regions dominated by the grey alder, *Alnus incana* (L.) MNCH., with an admixture of the spruce *Picea abies* KARST, and of the brittle willow, *Salix fragilis* L. The herb layer is rich and abundant, scrub-like in character. The optimum altitude for this association is between 400 and 600 m a.s.l. (MATUSZKIEWICZ 1982).

(b) Fir-spruce forest of the lower montane zone — *Abieti-Piceetum montanum* SZAF., PAWŁ. et KUL., 1923 em. J. MAT., 1978 — connected with the poorest podsolic soils in the lower montane zone (KORNAŚ & MEDWECKA-KORNAŚ 1981). A mesotrophic association dominated by the spruce or the fir *Abies alba* MILL., with occasional admixtures of the beech, *Fagus silvatica* L. The herb layer, of a definitely forest type, is dominated by the whortleberry, *Vaccinium myrtillus* L. This association usually occurs between 600 and 900 m a.s.l. (MATUSZKIEWICZ 1982).

(c) Carpathian beechwood and fir-beech forest of the lower montane zone — *Fagetum carpaticum* (syn. *Dentario glandulosae-Fagetum* KLIKA, 1927 em. Mat., 1964). These associations are connected with meso- and eutrophic soils. The tree layer is dominated by the beech, usually with a significant participation of the fir and a small one of the spruce. The herb layer of this association is rich, with its characteristic herbaceous plants, the toothwort *Dentaria glandulosa* W. K., and *Polistychum brauni* (SPENN.) (KORNAŚ & MEDWECKA-KORNAŚ 1971). The optimum of occurrence for this association is between 800 and 1150 m a.s.l. (MATUSZKIEWICZ 1982).

(d) The association of the Carpathian spruce forest of the upper montane zone — *Piceetum tatricum* (SZAF., PAWŁ. et KUL., 1932) BR.-BL., VLIEG. et SISS., 1939 em. J. MAT., 1978. An acidophilic, oligotrophic association with a specifically uniform stand. The herb layer is dominated by the whortleberry,

ferns, and club-mosses (KORNAŚ & MEDWECKA-KORNAŚ 1981). This association occurs between (1100) 1200 and 1500 m a.s.l. (MATUSZKIEWICZ 1982).

Gorce meadows are the result of "clearing" the land for pasture uses; they date back to before the 18th c., when this activity was finally forbidden(KORNAŚ 1955). Captures of small mammals were also made in the following non-forest plant associations relatively well-represented in Gorce meadows:

(a) *Cirsietum rivularis* RALSKI, 1931 — an association belonging to the group of wet eutrophic meadows (allowing mowing twice per year), with a massive participation of the thistle *Cirsium rivulare* (JACQ.) (MATUSZKIEWICZ 1982).

(b) *Gladiolo-Agrostietum* (BR.-BL., 1930) PAWŁ. et WAL., 1949 — montane bent-grass and corn flag meadows in rich, regularly fertilized clearings (KORNAŚ & MEDWECKA-KORNAŚ 1981). They are the most common associations of eutrophic meadows permitting multiple mowing in a year; they are also of the greatest economical importance. They occur between 600 and 1350 m a.s.l. (MATUSZKIEWICZ 1982).

(c) *Valeriano-Caricetum flavae* PAWŁ. (1949 n.n.) 1960 — eutrophic sedge fens. An association dominated by the yellow sedge, *Carex flava* L. Common especially in the lower montane zone, utilized as meadows allowing a single mowing each year (MATUSZKIEWICZ 1982).

(d) *Vaccinium myrtillus* — whortleberry meadows — included in the order *Vaccinio-Piceetalia* BR.-BL., 1939 as a non-hierarchic phytocenon. These associations constitute a phase of spruce forest degeneration and are dominated by the whortleberry (MATUSZKIEWICZ 1982).

(e) *Hieracio-Nardetum* KORNAŚ, 1955 n.n. — mat-grass meadows. Association very poor in flora, situated in exhausted, unfertilized clearings (KORNAŚ & MEDWECKA-KORNAŚ 1981). Acidophilic; it occurs on a very poor and acidic soil with various degrees of moisture dominated by the mat-grass, *Nardus stricta* L. Mat-grass meadows can be utilized as unfertilized sheep-grazing ground, or (rarely) as low-yielding meadows permitting mowing once per year (MATUSZKIEWICZ 1982).

III. MATERIAL AND METHODS

Small mammals were captured by means of standard trap-lines, permitting a comparison of relative densities of captured animals, during three consecutive years (ANDRZEJEWSKI 1967, SMITH et al. 1975, CHEŁKOWSKA & GOSZCZYŃSKI 1983). The number of set trap-lines is given below:

Year	Trapping date	Number of trap-lines in:	
		forest plant associations	non-forest plant associations
1981	02.09—16.09	26	2
1982	25.08—06.09	11	11
1983	28.08—14.09	22	7

Each line consisted of 20 trapping stations set at intervals of about 12 m. Each station was outfitted with one pitfall and two kill-traps (snap-traps), each of the latter situated at opposite sides of the former, at 1 to 1.5 m from it. The kill-traps were baited with wicks soaked in browned oil and flour. The functioning periods of all stations were the same — six days (360 trapnights). The trap-lines were mainly situated in homogeneous plant associations. Some of the lines (8) were placed in transition zones between *Abieti-Piceetum montanum* and *Fagetum carpaticum*, and between *Fagetum carpaticum* and *Piceetum tatricum*, in such a way that each of those lines were situated in the transitional association. Several snap-traps were also placed outside trap-lines, i. e. in the AR Cabin (tourist refuge of the Cracow Academy of Agriculture) and in the Turbacz tourist hostel. Thus, 79 lines (28440 trapnights) were set in all; their distribution within the Park is shown in Fig. 1.

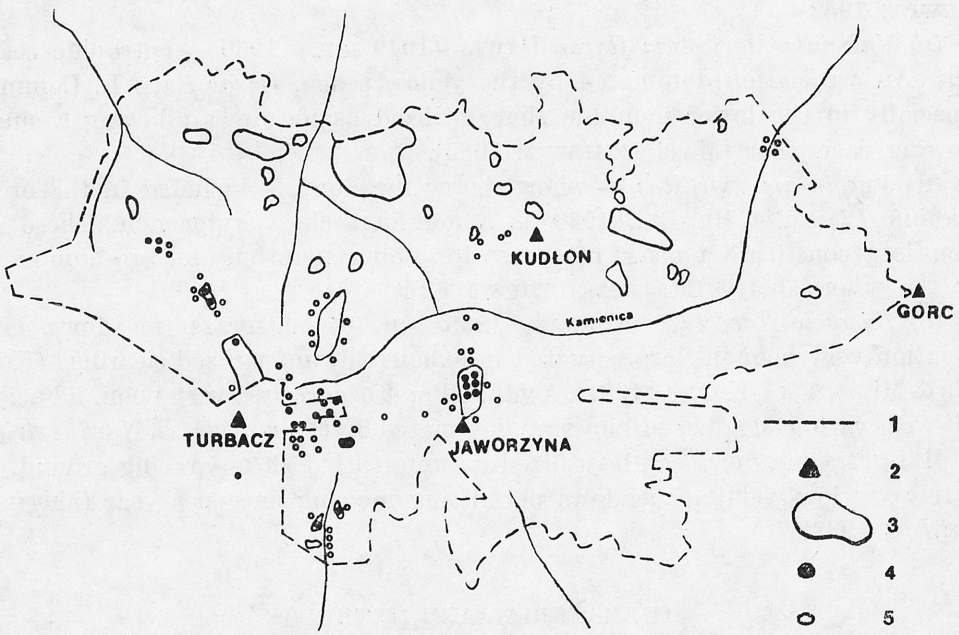

Fig. 1. Map of Gorce National Park, showing locations of trap-lines where small mammals were captured; 1 — Park boundary, 2 — mountain tops, 3 — clearings, 4 — trap-lines in non-forest plant associations, 5 — trap-lines in forest plant associations

Captured mammals (2526 individuals) included representatives of 17 species (Table I).

The structure analysis of associations of small mammals excluded several species from the consideration: *Talpa europaea* (6 specimens), *Dryomys nitedula* (1 specimen), and *Muscardinus avellanarius* (29 specimens), for the traps used mainly captured small terrestrial mammals, and the above species cannot be considered as members of epigenic fauna (Aulak 1970, Pucek 1984). Also,

Table I

List of species of small mammals captured in Gorce National Park between 1981 and 1983, their number (N) and the percentage participation in the overall number of mammals captured (%)

Species, with abbreviation		N	%
Talpa europaea	*Te*	6	0.24
Sorex araneus	*Sa*	354	14.01
Sorex minutus	*Sm*	349	13.82
Sorex alpinus	*Sal*	31	1.23
Neomys fodiens	*Nf*	23	0.91
Neomys anomalus	*Na*	10	0.40
Clethrionomys glareolus	*Cg*	796	31.50
Pitymys subterraneus	*Ps*	50	1.98
Arvicola terrestris	*At*	1	0.04
Microtus agrestis	*Mag*	153	6.06
Microtus arvalis	*Mar*	81	3.21
Mus musculus	*Mm*	1	0.04
Rattus norvegicus	*Rn*	1	0.04
Apodemus agrarius	*Aa*	93	3.68
Apodemus flavicollis	*Af*	547	21.65
Dryomys nitedula	*Dn*	1	0.04
Muscardinus avellanarius	*Ma*	29	1.15
Total		2526	100.00

one rat, *Rattus norvegicus*, and one house mouse, *Mus musculus*, captured outside trap-lines, and one individual of *Arvicola terrestris* were excluded from the analysis.

In calculation of dominance relationships and mammals' preferences for particular plant associations, the material gathered during the three years has been treated as a whole. On the other hand, the analysis of relative densities of small mammals in forest biotopes included animals captured in 1981 and 1983 only, for trap-lines functioned in only two types of forest biotopes in 1982: *Fagetum carpaticum* and *Piceetum tatricum*; 1982 was a year of low population density of small mammals, so the results obtained might have been lowered excessively. Similarly, small mammals captured only in 1982 and 1983 were taken into account in the case of non-forest plant associations — trap-lines functioned in all types of non-forest biotopes in those years. In 1981 — a year of high density of the mammals — trapping took place in *Vaccinium myrtillus* and *Hieracio-Nardetum* only, and this might have caused a relative increase of results obtained in those plant associations. Comparisons between relative densities of small mammals in forest and non-forest biotopes are subject to error for the reasons above.

Trapability index (ω_k), defined as the number of captured mammals in one trap-line in a given plant association, was calculated as a weighted average.

The preference (P_k) for a particular biotope by a given species of small mammals was determined according to the formula:

$$P_k = \frac{\omega_k}{\sum_{i=1}^{i=n} \omega_i} \times 100(\%),$$

where ω_k is the trapability index in a given plant association, ω_i is the trapability index in other subsequent plant associations, and n is the number of plant associations.

In order to evaluate the relationship between the number of a given species and the biotope, the χ^2 test was used, assuming that the probability of capturing individuals belonging to a particular species increases with the number of trap-lines set in a particular plant association. This test was only used in the cases of species represented in adequately large numbers in captures.

IV. RESULTS AND DISCUSSION

A systematic survey of species of small mammals captured in Gorce National Park

Talpa europaea LINNAEUS, 1758

Six individuals were caught (Table I), mainly in the vicinity of Kudłoń, at the altitude of about 1200 m a.s.l. The occurrence of the mole in the Gorce range has already been established by WOJTUSIAK (1931). *T. europaea* occurs in mountains up to the top parts of alpine meadows (CHUDOBA & HUMIŃSKI 1968, BUCHALCZYK & MARKOWSKI 1979), where it might be fairly numerous (CHUDOBA & HAITLINGER 1971, CHUDOBA & HUMIŃSKI 1968). According to GRODZIŃSKI (1957), the mole is quite numerous in meadows and alpine meadows in the West Bieszczady Mts, much more so than in subalpine forests in that range.

Sorex araneus LINNAEUS, 1758

The common shrew is a species occurring in large numbers in all plant associations in the Gorce Mts (Table I). It prefers *Abieti-Piceetum montanum* and *Alnetum incanae* ($\chi^2 = 64.18$; $p<0.001$) from other forest biotopes, and *Cirsietum rivularis* ($\chi^2 = 14.96$; $p<0.01$) from other non-forest plant associations (Fig. 2). HAITLINGER & SZYSZKA (1977) consider this species and the bank vole to be the two most numerous in the Gorce Mountains, even though the former one does not occur in forests with rich moss undergrowth and in mat-grass meadows.

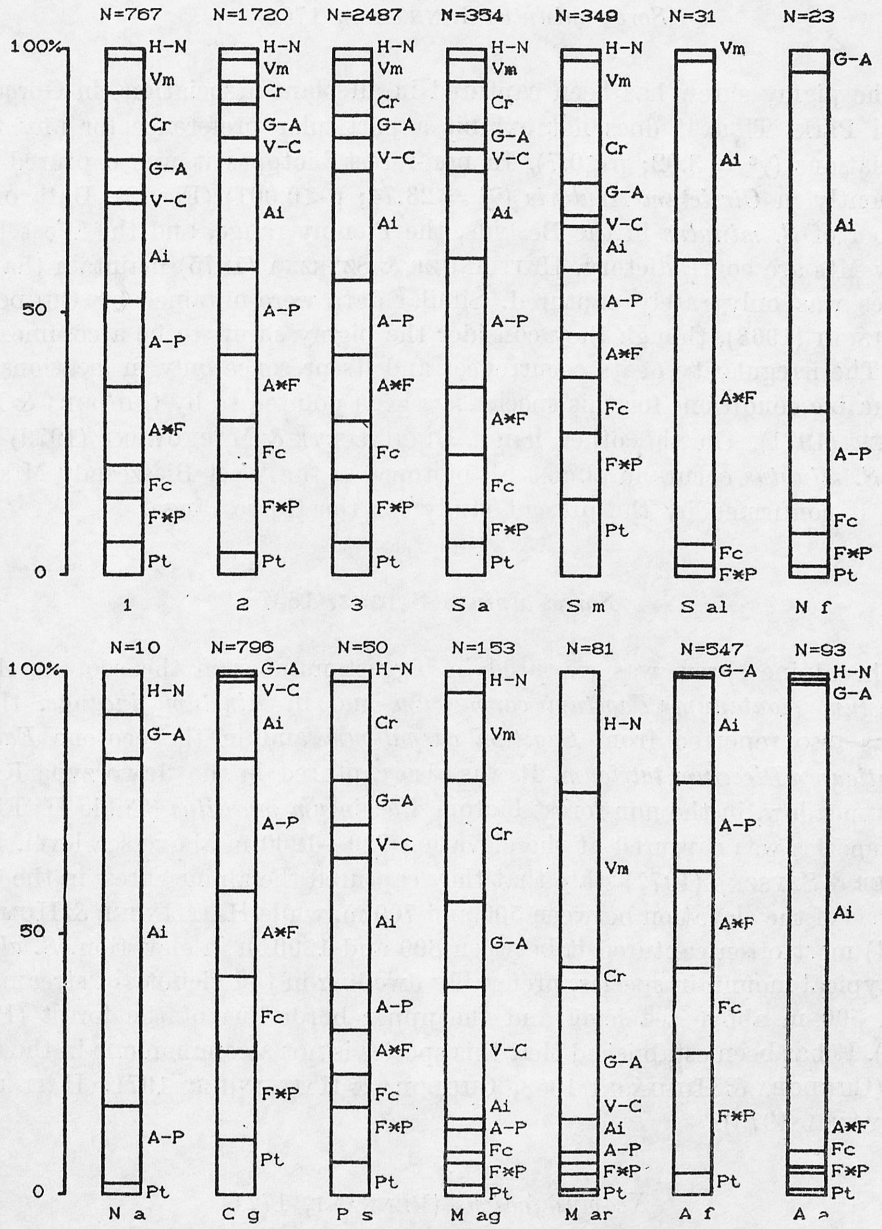

Fig. 2. Preference of various plant associations by particular species of small mammals between 1981 and 1983 (pooled), calculated on the basis of formula for P_k. Abbreviations of names of species of mammals as in Table I. Abbreviations of names of plant associations as in Table II. 1 — *Insectivora*, 2 — *Rodentia*, 3 — *Micromammalia* (pooled)

The data gathered by the present study do not confirm this statement, as the common shrew was captured in *Hieracio-Nardetum* (though, it is true, in a relatively small number).

Sorex minutus LINNAEUS, 1766

The pigmy shrew has been captured in all plant associations in Gorce National Park. Thus it does not exhibit a particular preference for any forest associations ($\chi^2 = 3.92$; $p<0.7$). In non-forest biotopes it was captured most frequently in *Cirsietum rivularis* ($\chi^2 = 23.74$; $p<0.001$) (Fig. 2). Data on the number of *S. minutus* in the Beskids, the Pieniny range, and the West Bieszczady Mts are contradictory. HAITLINGER & SZYSZKA (1975) maintain that this species was only rarely captured. Similar data were obtained by CHUDOBA & HUMIŃSKI (1968), though they consider the pigmy shrew to be a common species. The irregularity of its occurrences and its presence only in locations with favourable conditions for this species has been pointed to by CHUDOBA & HAITLINGER (1971). On the other hand, BUCHALCZYK & MARKOWSKI (1979) state that *S. minutus* occurs in almost all biotopes of the West Bieszczady Mts. The same is confirmed by the present study for the Gorce range.

Sorex alpinus SCHINZ, 1837

The alpine shrew was captured in biggest number in the ecotone *Abieti-Piceetum montanum***Fagetum carpaticum* and in *Alnetum incanae*, though it was also reported from *Fagetum carpaticum* and in the ecotone *Fagetum carpaticum***Piceetum tatricum*. It was also captured in the Jaworzyna Kamienicka meadow, in the non-forest biotope *Vaccinium myrtillus* (Table II; Fig. 2). This species was captured at the elevation 720—1200 m above sea level. HAITLINGER & SZYSZKA (1977) state that they captured the alpine shrew in the Gorce in areas of the elevation between 500 and 700 m, while HAITLINGER & HUMIŃSKI (1964) most often captured it between 800 and 1200 m in elevation. *S. alpinus* is a typical mountain species, preferably dwelling in the vicinity of streams between 500 m above sea level and the upper borderline of the forest (PUCEK 1984). It has been established that this species is not a common one in the Gorce Mts (CHUDOBA & HUMIŃSKI 1968, CHUDOBA & HAITLINGER 1971, HAITLINGER & SZYSZKA 1975).

Neomys fodiens (PENNANT, 1771)

The European water shrew was captured in almost all forest plant associations, though the frequency of captures was small. It was the most numerous in *Alnetum incanae*, a biotope at the altitude of 720 m a.s.l. at the stream Kamienica. *Gladiolo-Agrostietum* was the non-forest biotope where captures of this animal were most frequent (Table II, Fig. 2). HAITLINGER & SZYSZKA (1977) stated that the species is common in Gorce; it is connected with larger streams. This connection, however, might be less strict in summer, when individuals of that species might move around the whole forest area, as established in Białowieża National

Table II

The number of small mammals captured (n_0) and the trapability index (ω — the number of mammals per a trap-line in various plant associations in Gorce National Park between 1981 and 1983 (pooled). *H-N — Hieracio-Nardetum, Vm — Vaccinium myrtillus, Cr — Crisietum rivularis, G-A — Gladiolo-Agrostietum, V-C — Valeriano-Caricetum flavae, Ai — Alnetum incanae, A-P — Abieti-Piceetum montanum, A*F* — ecotone *Abieti-Piceetum/Fagetum carpaticum, Fc — Fagetum carpaticum, F*P* — ecotone *Fagetum carpaticum/Piceetum tatricum, Pt — Piceetum tatricum*

Species	Non-forest plant associations											
	H-N		*Vm*		*Cr*		*G-A*		*V-C*		Pooled	
	n_0	ω	n_0	ω	n_0	ω	n_0	ω	n_0	ω	n_0	ω
Sorex araneus	7	1.2	8	2.7	12	6.0	14	2.8	8	2.0	49	2.5
Sorex minutus	4	0.7	11	3.7	12	6.0	15	3.0	5	1.3	47	2.4
Sorex alpinus	0	0	1	0.3	0	0	0	0	0	0	1	0.05
Neomys fodiens	0	0	0	0	0	0	1	0.2	0	0	1	0.05
Neomys anomalus	1	0.2	0	0	0	0	1	0.2	0	0	2	0.1
Insectivora total	12	2.0	20	6.7	24	12.0	31	6.2	13	3.3	100	5.0
Clethrionomys glareolus	0	0	0	0	0	0	1	0.2	2	0.5	3	0.2
Pitymys subterraneus	1	0.2	0	0	3	1.5	4	0.8	2	0.5	10	0.5
Microtus agrestis	11	1.8	17	5.7	19	9.5	31	6.2	43	10.8	121	6.1
Microtus arvalis	24	4.0	20	6.7	2	1.0	20	4.0	6	1.5	72	3.6
Apodemus agrarius	1	0.2	0	0	0	0	1	0.2	0	0	2	0.1
Apodemus flavicollis	0	0	0	0	0	0	1	0.2	0	0	1	0.05
Rodentia total	37	6.2	37	12.3	24	12.0	58	11.6	53	13.3	209	10.5
Micromammalia total	49	8.2	57	19.0	48	24.0	89	17.8	66	16.5	309	15.5
Number of lines	6		3		2		5		4		20	

Species	Forest plant associations											
	Ai		*A-P*		*A*F*		*Fc*		*F*P*		*Pt*		Pooled	
	n_0	ω	n_0	ω	n_0	ω	n_0	ω	n_0	ω	n_0	ω	n_0	ω
Sorex araneus	36	9.0	49	12.3	7	7.0	81	5.4	23	3.8	109	3.8	305	5.2
Sorex minutus	14	3.5	22	5.5	4	4.0	71	4.7	30	5.0	161	5.6	302	5.1
Sorex alpinus	15	3.8	0	0	6	6.0	8	0.5	1	0.2	0	0	30	0.5
Neomys fodiens	12	3.0	3	0.8	0	0	4	0.3	2	0.3	1	0.03	22	0.4
Neomys anomalus	6	1.5	1	0.3	0	0	0	0	0	0	1	0.03	8	0.1
Insectivora total	83	20.8	75	18.8	17	17.0	164	10.9	56	9.3	272	9.4	667	11.3
Clethrionomys glareolus	62	15.5	99	24.8	16	16.0	224	14.9	105	17.5	287	9.9	793	13.4
Pitymys subterraneus	9	2.3	3	0.8	1	1.0	8	0.5	5	0.8	14	0.5	40	0.7
Microtus agrestis	1	0.3	5	1.3	0	0	5	0.3	3	0.5	18	0.6	32	0.5
Microtus arvalis	2	0.5	1	0.3	0	0	0	0	3	0.5	3	0.1	9	0.2
Apodemus agrarius	81	20.3	0	0	1	1.0	1	0.1	4	0.7	4	0.1	91	1.5
Apodemus flavicollis	65	16.3	55	13.8	15	15.0	219	14.6	104	17.3	88	3.0	546	9.3
Rodentia total	220	55.0	163	40.8	33	33.0	457	30.5	224	37.3	414	14.3	1511	25.6
Micrommalia total	303	75.8	238	59.5	50	50.0	621	41.4	280	46.7	686	23.7	2178	36.9
Number of lines	4		4		1		15		6		29		59	

Park (Borowski & Dehnel 1953). *N. fodiens* can occur up to the alpine zone (Pucek 1984). It is rarer than *N. anomalus* in the Pieniny range (Haitlinger & Szyszka 1975), and even very rare in the Beskid Żywiecki range (Chudoba & Haitlinger 1971).

Neomys anomalus Cabrera, 1907

The Mediterranean water shrew was mostly captured in *Alnetum incanae* and *Abieti-Piceetum montanum* as well as in *Hieracio-Nardetum* and *Gladiolo-Agrostietum* clearings (Table II, Fig. 2). The study confirmed the finding of Haitlinger & Szyszka (1977), who had stated that *N. anomalus* is more than twice less numerous than *N. fodiens* in captures carried out in the Gorce range. On the other hand, one cannot agree with suggestions of Chudoba & Haitlinger (1971) and Haitlinger & Szyszka (1975), that the Mediterranean water shrew appear along mountain streams only very rarily, and that its locations in mountain conditions are situated at higher altitudes. *N. anomalus* is but scarcely represented in the Beskid Sądecki range (Chudoba & Humiński 1968), and that species is a great rarity in the mountain range of Beskid Żywiecki (Chudoba & Haitlinger 1971). In the West Bieszczady range, specimens of this species were also captured in the Carpathian alder thicket, though captures were also reported from alpine meadows, at the approximate elevation of 1200 m (Buchalczyk & Markowski 1979).

Clethrionomys glareolus (Schreber, 1780)

The bank vole was the most often captured species of small mammals in all plant associations in Gorce National Park. Sporadic trapping was also made in non-forest associations: *Gladiolo-Agrostietum* and *Valeriano-Caricetum flavae* (Table II; Fig. 2). Penetration of the bank voles into the alpine meadows in the Bieszczady range was also observed by Grodziński et al. (1966a) and Buchalczyk & Markowski (1979). *Abieti-Piceetum montanum* is *C. glareolus*'s preferred forest plant association ($\chi^2 = 76.77$; $p<0.001$) (Fig. 2). Other authors are of the opinion that this species is the dominant one in the Gorce and adjacent regions (Chudoba & Humiński 1968, Chudoba & Haitlinger 1971, Haitlinger & Szyszka 1977, Buchalczyk & Markowski 1979).

Arvicola terrestris (Linnaeus, 1758)

One individual of this species was captured in the non-forest association *Gladiolo-Agrostietum*. So far, a location of the water vole in the Gorce region was reported from Łopuszna (Haitlinger & Szyszka 1977). The water vole is much connected with water and the area of its feeding ground does not surpass the zone of 1 m to each side of the water course (Ashby & Vincent 1976). It commonly occurs in the Beskid Sądecki, where it often damages orchards (Chudoba & Humiński 1968). Captures were also made in the Pieniny range

(HAITLINGER & SZYSZKA 1975). Its numerous presence in the Pieniny region can be confirmed by the fact that it constituted as much as 17% of all mammals found in eagle-owl pellets (BOCHEŃSKI 1960). The captured specimen was classified as belonging to the subspecies *A. t. exitus* (MILLER, 1910) on the basis of its external dimensions.

Pitymys subterraneus (DE SELYS-LONGCHAMPS, 1836)

The European pine vole was captured in all plant associations, i. e. in forest as well as non-forest ones ($\chi^2 = 0.748$; $p<0.5$), except in *Vaccinium myrtillus*. It was the most frequently captured in *Alnetum incanae* (of forest associations), and in *Cirsietum rivularis* in clearings (Table II, Fig. 2). HAITLINGER & SZYSZKA (1977) recorded this species to occur in rather small numbers in the Gorce range. It belongs to the rarest species in the region (CHUDOBA & HUMIŃSKI 1968, CHUDOBA & HAITLINGER 1971, HAITLINGER & SZYSZKA 1975). On the other hand, the pine vole is considered to be a common species in all biotopes of the West Bieszczady Mts (BUCHALCZYK & MARKOWSKI 1979), where it is even the dominant species in the alpine meadows (GRODZIŃSKI et al. 1966a). *P. subterraneus* is known to occur in high altitudes, up to 1700 m a.s.l. (KOWALSKI 1960).

Microtus agrestis (LINNAEUS, 1761)

The field vole occurs in all plant associations of the Park, but it clearly prefers non-forest biotopes ($\chi^2 = 233.99$; $p<0.001$), especially *Cirsietum rivularis* and *Valeriano-Caricetum* flavae ($\chi^2 = 36.26$; $p<0.001$) (Table II, Fig. 2). HAITLINGER & SZYSZKA (1977) described that species as not numerous in the Gorce, occurring only as high as 900 m a.s.l. The present study shows that it occurs in the Park up to the altitude of 1200 m a.s.l., and that its numbers there are by no means small. Information on adjacent regions, i. e. the mountain ranges of Beskid Średni (GRODZIŃSKI 1959), Beskid Sądecki (CHUDOBA & HUMIŃSKI 1968), and Pieniny (HAITLINGER & SZYSZKA 1975), point to the rarity of that species. CHUDOBA & HAITLINGER (1971) report that *M. agrestis* does not occur in continuous distribution in the Beskid Żywiecki Mts, and that its presence in a given biotope is connected with humidity and particular types of vegetation. These authors also maintain that the field vole occurs exclusively in the top parts of high mountain ranges. *M. agrestis* is common, however, in clearings in the Bieszczady range (GRODZIŃSKI 1957, GRODZIŃSKI et al. 1966a, BUCHALCZYK & MARKOWSKI 1979).

Microtus arvalis (PALLAS, 1779)

The common vole was captured, less frequently than the field vole, in almost all plant associations of the Gorce Mts; it was mainly connected with non-forest biotopes ($\chi^2 = 116.08$; $p<0.01$), with a preference for *Vaccinium myrtillus*,

Hieracio-Nardetum, and *Gladiolo-Agrostietum* ($\chi^2 = 16.98$; $p<0.01$) (Table II, Fig. 2). HAITLINGER & SZYSZKA (1977) captured fairly large numbers of individuals of that species in the Gorce range, which fact might suggest a periodically numerous presence of *M. arvalis* in mountain conditions. The Gorce region is to a large extent a forest-covered area, and this might be the reason why *M. arvalis*, basically an openlandscape species (with an ability, nevertheless, to migrate into forest biotopes; PELIKAN et al. 1964), does not find favourable conditions in Gorce National Park. *M. arvalis* occurs in large numbers in SW and W Poland (CABOŃ-RACZYŃSKA & RUPRECHT 1977); it might exhibit significant fluctuations in number in mountain regions (BUCHALCZYK & MARKOWSKI 1979), sometimes even to the point of mass appearance (HAITLINGER & HUMIŃSKI 1963). It is very common in regions adjacent to that of the Gorce Mts. (CHUDOBA & HUMIŃSKI 1968; HAITLINGER & SZYSZKA 1975), though its occurrence in the top parts of the Beskid Żywiecki range is insular and scarce (CHUDOBA & HAITLINGER 1971). GRODZIŃSKI et al. (1966a) does not include that species among the dominants of Bieszczady alpine meadows.

Mus musculus LINNAEUS, 1758

One specimen of the house mouse was trapped in the AR Cabin in the Hala Długa meadow, at the altitude of 1200 m a.s.l. The materials of the Institute of Systematic and Experimental Zoology, Polish Academy of Sciences, Kraków, include 4 specimens of *M. musculus* captured in the Turbacz tourist hostel in the Gorce Mts. (after HAITLINGER & SZYSZKA 1977). The house mouse is a synanthropic species, which can move into areas distant from human settlements. *M. musculus* was captured 2 km from settlements in the Beskid Sądecki range (CHUDOBA & HUMINSKI 1968). The presence of that species in the Beskid Żywiecki Mts. has been recorded neither from tourist hostels nor their vicinity (CHUDOBA & HAITLINGER 1971).

Rattus norvegicus (BERKENHOUT, 1769)

One specimen of the species was captured in the Turbacz tourist hostel. The presence of the common rat in the Gorce region was reported from the village of Rzeki (HAITLINGER & SZYSZKA 1977). So far it has never been recorded from higher parts of the Gorce range (PUCEK & RACZYŃSKI 1983).

Apodemus agrarius (PALLAS, 1771)

The striped field mouse was captured in almost all forest plant associations, and occasionally also in some non-forest ones, i. e. in *Hieracio-Nardetum* and *Gladiolo-Agrostietum*. It preferred forest biotopes ($\chi^2 = 26.39$; $p<0.001$). An overwhelming majority of the captured specimens come from *Alnetum incanae* (Table II, Fig. 2), a biotope in the vicinity of Rzeki. BUCHALCZYK &

MARKOWSKI (1979) also captured the field mouse in the Bieszczady Mts., obtaining the best results in the Carpathian alder grove and in *Deschampsietum*. The present data confirm the opinion of HAITLINGER & SZYSZKA (1977) to the effect that that species is not a common one in the Gorce range. *A. agrarius* is a new species in high mountain environment, but it adapts well to its conditions, and other species of mammals permanently present there are in no way its competitors (CHUDOBA & HAITLINGER 1971). HAITLINGER & HUMIŃSKI (1963) report a very rare occurrence of the field mouse at high altitudes. The species is common in the Beskid Sądecki range, yet it occurs only occasionally deep in forests (CHUDOBA & HUMIŃSKI 1968). It is not numerous in the Pieniny range, and its occurrence there is of insular kind (HAITLINGER & SZYSZKA 1975). CHUDOBA & HUMIŃSKI (1968) and HAITLINGER & SZYSZKA (1977) agree that it is the extensive forests, and not the altitude, that inhibit the spreading of *A. agrarius*. As the Gorce range is covered with extensive natural forests, this might be the reason why the striped field mouse is scarce in the region.

Apodemus flavicollis (MELCHIOR, 1834)

The yellow-necked field mouse is a species common in all forest biotopes of Gorce National Park. One specimen was captured in the non-forest plant-association *Gladiolo-Agrostietum*. The emergence of *A. flavicollis* into mountain meadows is probably connected with search for food (GRODZIŃSKI et al. 1966a). The species was mainly captured in all forest plant associations, with a visible preference for those including the beech ($\chi^2 = 243.17$; $p<0.001$) (Table II, Fig. 2). The association where the smallest number of the yellow-necked field mouse was captured was that of *Piceetum tatricum*. The suggestion that this species does not find favourable conditions in the associations with spruce-fir mountain forest, as proposed by CHUDOBA & HAITLINGER (1971), seems to hold good. According to other authors, that species is one of the most common small mammals in the Gorce Mts. and in all adjacent ranges of the Beskid Mts. (CHUDOBA & HUMIŃSKI 1968, CHUDOBA & HAITLINGER 1971, HAITLINGER & SZYSZKA 1975, HAITLINGER & SZYSZKA 1977, BUCHALCZYK & MARKOWSKI 1979).

Dryomys nitedula (PALLAS, 1778)

One individual of the forest dormouse was captured in the vicinity of the Hala Czoło meadow at the altitude of about 1200 m a.s.l., in the forest biotope *Piceetum tatricum*. HAITLINGER & SZYSZKA (1977) also captured one individual of that species near the source of the Kamienica River on the slope of the Turbacz. *D. nitedula* is a species most frequently encountered in deciduous forest biotopes, though it can also be found in the Carpathian coniferous forests of the upper subalpine zone (PUCEK 1984).

Muscardinus avellanarius (LINNAEUS, 1758)

29 individuals of the common dormouse were captured; the biggest number of that animal were trapped in *Fagetum carpaticum* (12 individuals) and in *Alnetum incanae* (5 individuals). Only one dormouse was captured in a non-forest biotope, *Cirsietum rivularis*. The presence of the common dormouse in the Gorce Mts. had earlier been recorded by HAITLINGER & SZYSZKA (1977), though in scant quantity (2 individuals). That species is rare in the Pieniny range (HAITLINGER & SZYSZKA 1975). It occurs in some parts of the Beskid Żywiecki range (CHUDOBA & HAITLINGER 1971). It is also fairly frequent in the Beskid Sądecki meadows (CHUDOBA & HUMIŃSKI 1968). CHUDOBA & HAITLINGER (1971) associate the presence of the common dormouse with beech forests, but BUCHALCZYK & MARKOWSKI (1979) encountered it mostly in coniferous forests with the predominance of the pine, and occasionally in the Carpathian alder grove and beech forests.

Species composition of small mammals in various plant associations in Gorce National Park

A. Small mammals of forest plant associations

The highest percentage of insectivores in forest biotopes of the Park was in forest with the predominance of conifers, i. e. in *Piceetum tatricum*, *Abieti-Piceetum montanum*, and in the ecotone *Abieti-Piceetum montanum***Fagetum carpaticum* (Fig. 3a). *Insectivora* of all forest types were dominated by *S. araneus* and *S. minutus*. The calculated ratio of the numbers of the two species points to the increase of the role of *S. minutus* with the altitude of particular plant associations (Table III). The two species do not compete with each other (PERNETTA 1977, SIMIONESCU 1983, BAUEROWA 1984). Their occurrence should not be associated with the type of forest stand, but rather with the humidity of the habitat; their distribution in biotopes is a result of their requirements, and not of the supersession of weaker species by stronger ones into less favourable environments (BOROWSKI & DEHNEL 1953). A fairly important percentage of *S. alpinus* can be observed among small mammals in the ecotone *Abieti-Piceetum montanum***Fagetum carpaticum* (12%) and in *Alnetum incanae* (5%) (Fig. 3a). The species accounted for 12% of all insectivores captured by BUCHALCZYK & MARKOWSKI (1979) in the Carpathian alder grove in the West Bieszczady region. *N. fodiens* and *N. anomalus* were quite numerous among the *Insectivora* of *Alnetum incanae* (Table II, Fig. 3a). This is probably connected with the situation of that biotope in the vicinity of the Kamienica River, as the two species of voles exhibit a close connection with water courses (BOROWSKI & DEHNEL 1953).

Rodents of all forest associations are dominated by the bank vole and the

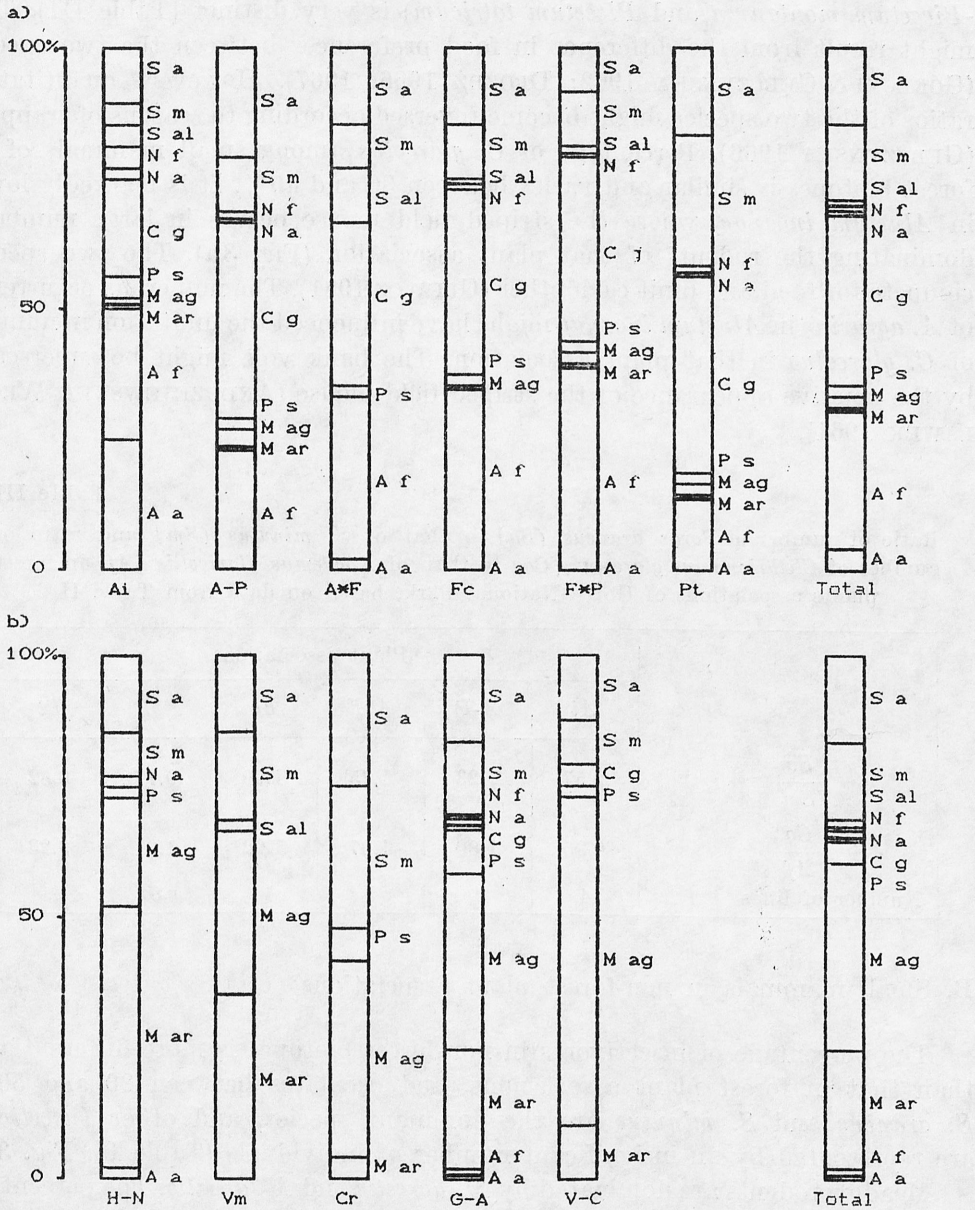

Fig. 3. Percentage of particular species of small mammals in forest (a) and non-forest (b) plant associations in Gorce National Park between 1981 and 1983 (pooled). Abbreviations of small mammals' specific names as in Table I. Abbreviations of names of plant associations as in Table II

yellow-necked field mouse. The percentage of those species is similar (Fig. 3a), and the ratio of their numbers oscillates around 1 in plant associations with a significant participation of deciduous trees, especially the beech. The domination of the bank vole in biotopes with a predominance of conifers (*Abieti-*

-*Piceetum montanum* and *Piceetum tatricum*) is very distinct (Table III). This might result from the difference in food preferences between the two species (Górecki & Gębczyńska 1962; Drożdż 1966, 1967). However, quantitative ratios of the two species might become reversed according to seasons of trapping (Gębczyńska 1966). Percentage of *C. glareolus* among small mammals of all forest biotopes is similar and varies between 30 and 40%. It is markedly lower in *Alnetum incanae*, where the striped field mouse occurs in large numbers, dominating the rodents of that plant association (Fig. 3a). The two species compete for food and limit each other (Gliwicz 1981). The numerous occurrence of *A. agrarius* in *Alnetum incanae* might have influenced the limitation in number of *C. glareolus* in that plant association. The bank vole might be superseded by the massive appearance of the striped field mouse (Andrzejewski & Wrocławek 1961).

Table III

Ratio of number of *Sorex araneus (Sa)* to that of *S. minutus (Sm)* and ratio of number of *Clethrionomys glareolus (Cg)* to that of *Apodemus flavicollis (Af)* in forest plants associations of Gorce National Park, based on data from Table II

	Plant association					
	Ai	*A-P*	*A*F*	*Fc*	*F*P*	*Pt*
$\frac{Sa}{Sm}$	2.57	2.23	1.75	1.09	0.77	0.52
$\frac{Cg}{Af}$	0.95	1.80	1.07	1.02	1.01	3.23
Number of lines	4	4	1	15	6	29

B. Small mammals in non-forest plant associations

The percentage of insectivores in non-forest biotopes is more differentiated than that in forest plant associations, and oscillates between 20 and 50%. *S. araneus* and *S. minutus* are the dominant species, and other *Insectivora* are represented by an insignificant number of individuals (Table II; Fig. 3b).

Meadow rodents are dominated by *M. agrestis* and *M. arvalis*. The percentage participation of the genus *Microtus* in non-forest plant associations among all *Rodentia* captured (assumed as 100%) might be of some interest. Their greatest participation was in *Vaccinium myrtillus* not utilized economically; it was lower in the low-yielding, poorly utilized *Hieracio-Nardetum*, and in *Valeriano-Caricetum flavae* utilized as single-crop meadows, and the lowest in *Gladiolo-Agrostietum* and *Cirsietum rivularis*, i. e. in eutrophic pastureland associations used as multiple-crop meadows (Table IV). Grant et al. (1982) suggest the composition of the community of small meadow mammals to be determined by the structure of environment attributes, and pasture might modify the composition

Table IV

Percentage of representatives of the genus *Microtus* (in comparison with the overall number of the rodents = 100%) in non-forest plant associations in Gorce National Park based on data from Table II

	Plant association				
	Cr	*G-A*	*V-C*	*H-N*	*Vm*
Microtus (%)	87.5	87.9	92.5	91.7	100.0
Number of lines	2	5	4	6	3

of those communities. It has also been established that the density of *Microtinae* is smaller in pastured meadows than in unpastured ones (HANLEY & PAGE 1982). HAITLINGER & SZYSZKA (1977) reported a quantitative domination of the common vole over the field one. Results of the present work point out that *M. agrestis* is the dominant species in clearings in the Park, although poor biotopes (*Vaccinium myrtillus* and *Hieracio-Nardetum*) are dominated by *M. arvalis*. The species *P. subterraneus* appears in almost all non-forest biotopes of the Gorce Mts., but its percentage is not large among other small mammals (Fig. 3b). One should emphasize the differences between communities of small mammals in Bieszczady alpine meadows and communities of those animals in meadows in other regions of the Carpathians including, obviously, the Gorce range, as pointed out by GRODZIŃSKI et al. (1966a), who state that the European pine vole dominates small mammals' communities of West Bieszczady alpine meadows.

The percentage of insectivores in forest plant associations (pooled) and in non-forest biotopes in similar and amounts to 30.6% and 32.4%, respectively. The participation of *S. araneus* and *S. minutus* is also similar in both groups of biotopes (Fig. 3). Research carried out by CHUDOBA & HUMIŃSKI (1968) in the Beskid Żywiecki range, by HAITLINGER & SZYSZKA (1977) in the Gorce Mts., and by BUCHALCZYK & MARKOWSKI (1979) in the West Bieszczady Mts. yielded the quantitative predominance of the common shrew over the pygmy shrew, a result that cannot be confirmed by the material of the present study. Rodents captured in forest plant associations are dominated by *C. glareolus* and *A. flavicollis*, and those of non-forest ones by *M. agrestis* and *M. arvalis* (Fig. 3).

Although dominance relationships among small mammals of forest biotopes differ from those relationships in non-forest plant associations, all species of small mammals are present in both groups of habitats.

Numbers of small mammals in various plant associations in Gorce National Park

The number of small mammals in forest plant associations in the Park, represented by the trapability index, was more than twice bigger than that in non-forest biotopes (Table II). This is true for *Rodentia* as well as *Insectivora*.

It seems that the relatively small density of rodents is characteristic for many mountain meadows in the Carpathians (Grodziński et al. 1966a, Bobek 1973). This might be connected with the higher primary production in forests as compared to grasslands (Drożdż 1967). The bigger number of hiding-places available to small mammals in forest biotopes might also be of some importance here (Koshkina 1967). The trapability index in forest plant associations in Gorce National Park is the highest in the most fertile association, *Alnetum incanae*, and reaches its smallest value in the poorest one, *Piceetum tatricum* (Table II). Of some interest is the large number of rodents in the ecotone *Fagetum carpaticum* * *Piceetum tatricum*. According to Goszczyński (1970), rodent penetration is uniform in homogeneous environments while being differentiated in mixed environments. Rodents usually move in boundary zones of plant associations.

The number of captured rodents was bigger than that of insectivores in all forest biotopes; this predominance decreases from the mountain alder grove to the spruce forest, what is illustrated by the more significant in the trapability index of rodents (from 55.0 to 19.8) than in that of insectivores (from 20.8 to 11.2) (Table II). The study by Buchalczyk & Markowski (1979) carried out in the West Bieszczady range also demonstrated that humid biotopes of *Alnetum incanae*-type were richest in the number of captured mammals. However, the quantitative predominance of *Insectivora* over *Rodentia* was found in that association and in *Piceetum tatricum* there, which result cannot be confirmed by the material from the Gorce range.

The biggest number of small mammals in non-forest associations occurred in eutrophic biotopes, and it was by far the lowest in the oligotrophic *Hieracio-Nardetum* (Table II).

In order to illustrate fluctuations in number of small mammals between 1981 and 1983, changes in the trapability index of selected species of small mammals have been presented, from plant associations where captures were made in an uninterrupted sequence throughout the three consecutive years. The smallest number of captured small mammals was recorded in 1982. The overall trapability index in forest and non-forest biotopes of that year decreased by an average factor of 4.6 (2.7 for insectivores and 6.9 for rodents) in comparison with 1981 (Figs. 4a and 5a). This might have been the result of the decrease in number of small mammals in the studied areas, as well as of drought, the influence of which on the effectiveness of capture of small mammals, especially rodents, has been recorded by several authors (Sidorowicz 1960, Mystkowska & Sidorowicz 1961, Grodziński et al. 1966b, Baumler 1975). Assuming, however, that the phenomenon was caused, mainly, by an objective decrease in density of small mammals, it might be stated that the fall in number of rodents is usually more drastic than that of the number of insectivores in mountain conditions — just as is the case in lowlands (Borowski & Dehnel 1953, Serafiński 1955, Aulak 1970). It is a regularity that rodent species with a higher trapability in the initial year of 1981 exhibit a relatively more pronounced decrease in the index in 1982 than the species with a relatively lower value of

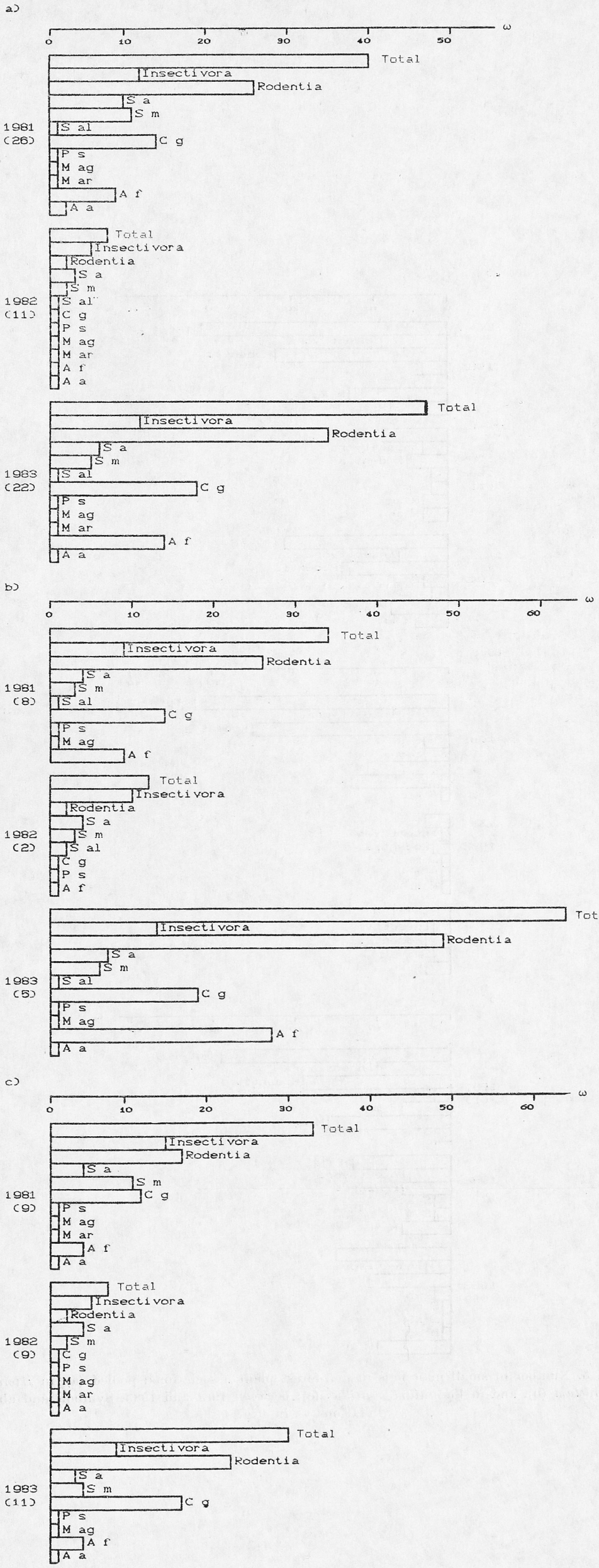

Fig. 4. Number of small mammals in forest plant associations: pooled (a), in *Fagetum carpaticum* (b), and in *Piceetum tatricum* (c); between 1981 and 1983; ω —trapability index per a trap-line. Abbreviations of small mammals' species names as in Table I. Abbreviations of plant associations names as in Table II. The number of trap-lines in each year is given in brackets

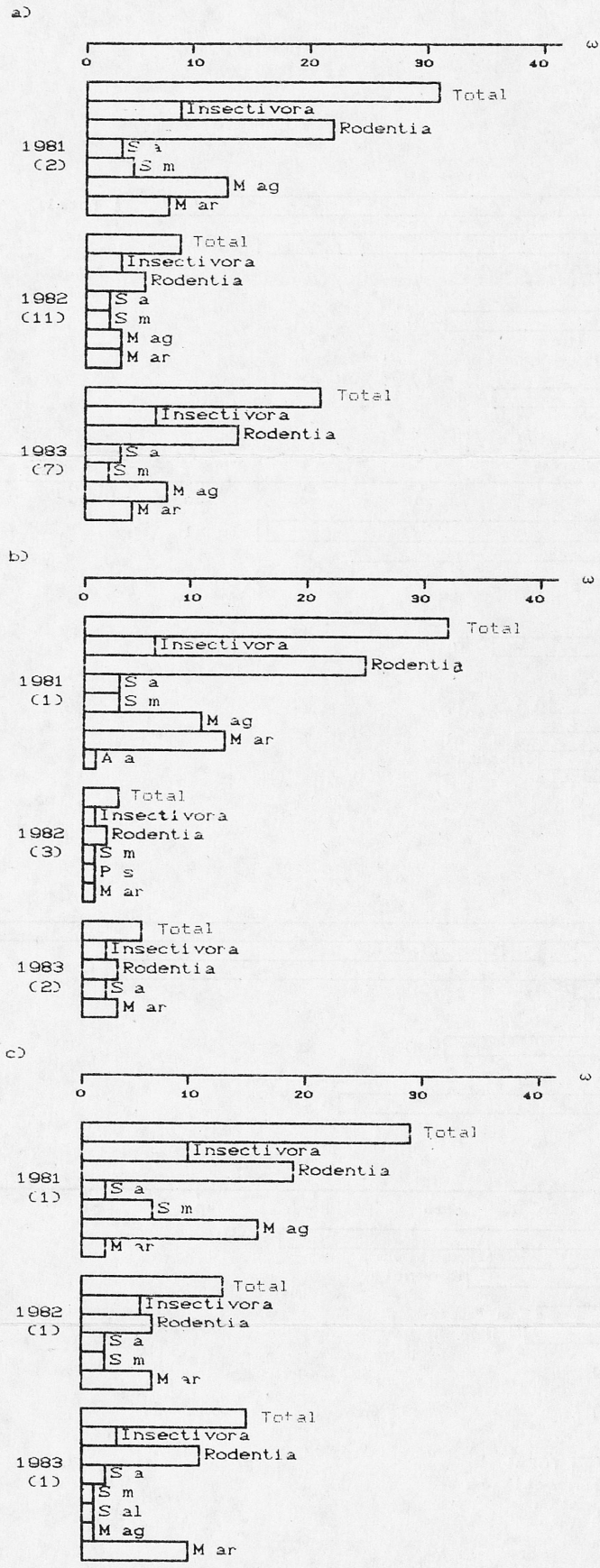

Fig. 5. Number of small mammals in non-forest plant associations: pooled (a), in *Hieracio--Nardetum* (b), and in *Vaccinium myrtillus* (c); between 1981 and 1983. Symbols and abbreviations as in Fig. 4

trapability index in 1981. The same is valid for not only for numerous or scarce captured species, but it holds good for the dominant species (*C. glareolus* and *A. flavicollis*). JENSEN (1982) wrote that differences in density of the bank vole were more marked than those in the density of the yellow-necked field mouse. It is also worthwhile noting that there exists a distinct agreement in the decrease in the trapability index in 1982 as compared with 1981, of all the dominant species of mammals both in forest and non-forest biotopes (Figs. 4 and 5).

The trapability index of small mammals in 1983 yields similar values to those in 1981. However, that index becomes different in forest and non-forest biotopes, especially in the case of the rodents. The number of small mammals captured per one trapping plot was higher in forest biotopes in 1983 than that in 1981 (Fig. 4). On the other hand, the number of captures in non-forest plant associations was always maintained below the level of 1981 (Fig. 5). The situation described occurred in four of the analysed habitats: two forest and two non-forest ones. A certain exception from this rule is seen in the increase in number of *M. arvalis* in *Vaccinium myrtillus*, accompanied by a significant decrease in that of *M. agrestis* (Fig. 5c). Also, the trapability index of insectivores was steadily increasing in *Fagetum carpaticum* between 1981 and 1983, while it exhibited a constant decrease in *Vaccinium myrtillus* in the same period (Figs. 4b and 5c). Fluctuations in the trapability index of the insectivores, another exception from the mentioned rule, are probably caused by changes in those animals' food supply difficult to establish (PERNETTA 1976). The increase in the number of the rodents in 1983 might have been influenced by the favourable feeding conditions, as 1982 was a year of a good crop of seeds.

ACKNOWLEDGEMENTS

The authors are grateful to the Management of Gorce National Park, to Mr. J. TOMASIEWICZ, M. Sc., for his help in selecting representative plant associations in the Park, and also to the student members of Biologists' Scientific Club at the Institute of Biology, Branch of Warsaw University, Białystok, for their help in capturing small mammals in rough field conditions.

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STRESZCZENIE

W latach 1981—1983 przeprowadzono badania fauny drobnych ssaków oraz podjęto próbę analizy ich zespołów w różnych zbiorowiskach roślinnych utworzonego w 1981 roku Gorczańskiego Parku Narodowego oraz terenów przyległych do Parku.

Odłowione ssaki (2526 osobników) reprezentowały 17 gatunków (tab. I). Współczynnik łowności drobnych ssaków w biotopach leśnych układał się w gradiencie żyzności siedlisk (tab. II).

Stosunki dominacyjne między *Sorex araneus* i *S. minutus* zmieniają się w biotopach leśnych ułożonych piętrowo. W coraz wyżej położonych zbiorowiskach roślinnych ryjówka malutka uzyskuje liczebną przewagę w odłowach nad ryjówką aksamitną (tab. II i III).

W lasach GPN liczebność *Clethrionomys glareolus* i *Apodemus flavicollis* jest wyrównana. Iloraz liczby odłowionych osobników tych dwóch gatunków oscyluje wokół 1 w tych zbiorowiskach roślinnych, w których w większej ilości występują drzewa liściaste, szczególnie buk (tab. II i III). W lasach iglastych nornica ruda osiąga zdecydowaną przewagę liczebną nad myszą leśną i wydaje się, że w stosunkach dominacyjnych między tymi gatunkami kluczowe znaczenie ma pokarm dostępny w poszczególnych biotopach. Stwierdzono, że w biotopie leśnym *Alnetum incanae*, położonym obok wsi Rzeki, gdzie zagęszczenie *A. agrarius* było wysokie, procentowy udział *C. glareolus* był stosunkowo niski (tab. II; ryc. 3a).

Próbowano powiązać procentowy udział osobników z rodzaju *Microtus* (w stosunku do liczby wszystkich odłowionych *Rodentia*, przyjętej za 100%) w nieleśnych zbiorowiskach roślinnych z trofią i użytkowaniem łąk. Okazało się, że jest on najwyższy (100%) w nieużytkowanym biotopie *Vaccinium myrtillus* i maleje do zbiorowisk eutroficznych łąk, osiągając najniższe wartości w *Cirsietum rivularis* (87.9%) i *Gladiolo-Agrostietum* (87,5%) (tab. IV).

W warunkach górskich, podobnie jak na niżu, wahania liczebności gryzoni w czasie są znacznie większe niż wahania liczebności owadożernych (ryc. 4 i 5). W roku 1983 współczynniki łowności były ogólnie biorąc podobne do współczynników łowności z roku 1981 (po okresie spadku w 1982 roku). W biotopach leśnych przekroczyły one jednak wartości tego wskaźnika z roku 1981, a w zbiorowiskach nieleśnych były niższe w porównaniu z pierwszym rokiem badań (ryc. 4 i 5). Liczebność dominujących gatunków gryzoni z reguły ulega większym wahaniom niż liczebność gatunków mniej licznie reprezentowanych.

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