ACTA THERIOLOGICA
Vol. 34, 32: 465—477, 1989

Food Eaten by Four Species of Rodents in Polluted Forests

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Gębczyńska Z., Gębczyński M., Morzuch K. & Zielińska D. M., 1989: Food eaten by four species of rodents in polluted forests. Acta theriol., 34, 32; 465—477 [With 6 Tables]

The composition of diet was studied in *Clethrionomys glareolus, Apodemus agrarius* and *Apodemus flavicollis* in forests of Upper Silesia (southern Poland). The rodents were obtained from two polluted forested sites (Aniołki and Szczygłowice, the first site much more heavily polluted) except for *M. agrestis* which was collected only on more polluted site (Aniołki). The composition of diet within particular rodent species was fairly similar on both sites nevertheless differed from diets reported for other populations. *C. glareolus* fed on green parts of plants (45—67% of diet) and on seeds and fruits (21—38%). The absence of animal food and lack of seasonality distinguished these populations from all previously studied populations. *A. agrarius* fed mainly on green parts of plants (90—94% in spring, 56—67% in autumn) while seeds constituted 24% of autumn diet. Thus this species elsewhere taking mainly seed and animal food changed its food habits entirely. *A. flavicollis* apart from seeds and animal food fed also on underground parts of plants (up to 50% of food volume). *M. agrestis* showed similar food preferences on Silesian locatios as in other parts of its range of distribution. In spring, the green parts constituted 78% while in autumn its fraction fell to 43% with seeds making up 22%. The presence of fungi (26% of the diet in autumn) seems to be peculiar for the populations under study. Thus, there were alterations in diet in all four species compared with many European populations studied so far. In *C. glareolus, M. agrestis,* and *A. flavicollis* the changes occurred as shifts in proportions of principal components while in *A. agrarius* there were profound changes in the principal composition of diet.

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1. INTRODUCTION

The effects of industrial activity on the environment are diverse. Dustfall and gaseous emission entail air, water and soil contamination. Wherever mines operate, heaps of waste material accumulate, ground subsides, sometimes artificial water reservoirs are created. Such disruption to the environment can easily be noted throughout Upper Silesian region. All these effects precipitated by the development of heavy industry and mining bring about drastic changes in vegetation cover (Celiński & Wika 1980; Celiński *et al.,* 1982), and invertebrate populations (Dąbrowska-Prot, 1982), and also in vertebrate populations including rodents (Walkowa *et al.,* 1982; Chełkowska *et al.,* 1985). Changes in plant species composition, the age structure of plant populations and also in fruit and seed production cause direct

changes in composition and volume of food supply for herbivores inhabiting such areas. It may be thus presumed that such changes will alter the diet in local rodent species. The aim of this study was to study any effects which environmental pollution might exert on feeding relationships in four most common species of forest rodents.

2. STUDY AREA, MATERIAL AND METHODS

The study was carried out in Rybnik Coal Basin of Upper Silesian region of southern Poland. There were two plots involved. First, at Aniołki, covered by a transformed form of *Tilio-Carpinetum* with *Carex bryzoides* L., *Rubus caesius* L. and *Pteridium aquilinum* L. This area was heavily inundated because of earth subsidence. Second plot, at Szczygłowice, at 10 kilometre distance from the first one, is also covered by *Tilio-Carpinetum* with *Carex bryzoides* and *Pteridium aquilinum*.

The effects of industrial activity and related disruption to environment varied between the two plots (Table 1). The Aniołki plot had (a) much more degraded vegetation, (b) different number of plant species, (c) higher degree of coverage by herbs and (d) higher degree of coverage by fallen trees and branches.

Both plots were inhabited by the same species of rodents: the bank vole *Clethrionomys glareolus* (Schreber, 1780), the field vole *Microtus agrestis* (Linnaeus, 1761), the yellow-necked mouse *Apodemus flavicollis* (Melchior, 1834), and the striped field mouse *Apodemus agrarius* (Pallas, 1771). The harvest mouse *Micromys minutus* (Pallas, 1778), the dormouse *Muscardinus avellanarius* (Linnaeus, 1758), and the domestic mouse *Mus musculus* Linnaeus 1758 were found in the area in much lesser numbers (Walkowa *et al.*,1982; Chełkowska *et al., 1985)*. First four species were abundant although their numbers on two plots differed. Several years of trapping revealed that Aniołki rodent fauna is dominated by *M. agrestis* (up to 70 inds ha^{-1}) and *A. agrarius* (up to 30 inds ha^{-1}). At Szczygłowice *C. glareolus* dominated (up to 70 inds ha^{-1}). *A. flavicollis* was relatively scarce on both plots (Walkowa *et al.*, 1982; Chełkowska *et al.*, 1985).

The rodents for this study were collected in spring and autumn by means of baited snap traps. Their stomachs were removed and kept in 4% formaldehyde solution. The total number of 249 stomachs were examined. The contents of each stomach were placed on a watch-glass with a few drops of water and Lugol reagent (J_2 in KJ) for starch staining. After mixing, four microscopic glycerin slides were prepared from each stomach. The microscopic ocular fitted with 100-square grid was used to determine the number of squares occupied by a given food type to determine its relative abundance.

Histological preparations, drawings of various types of epidermis and test slides obtained from stomach contents of rodents fed in the laboratory were used for identification of plant species. Animal food was identified by features of undigested remnants of chitin covers, parts of extremities and single complete specimens.

3. RESULTS

3.1. The Bank Vole

In spring, the bank voles collected at Aniołki fed on 24 plant species, most frequently on *Betula sp.* and *Majanthemum bifolium* (Table 2).The green parts of plants made 64% of the volume, seeds and fruits — 23%, with roots and tree-bark (4%) and animal food (2%) making

Table 1
Characteristics of Aniołki and Szczygłowice study plots (after Walkowa, Adamczyk & Chełkowska, 1982).

Index	Aniołki	Szczygłowice
Dust fall, t/km^2 per year[1]	450	165
Mean number of all plant species per trapping point	12.8	8.4
Mean number of plant species in herb layer per trapping point	10.2	5.4
Sum per cent herb layer coverage[2] per trapping point	157	101
Per cent undergrowth coverage per trapping point	18.1	49.0
Per cent coverage with fallen trees and dry branches	26.9	10.8

[1] After Foik (1978) and Warteresiewicz (1979).
[2] Percentage cover by individual plant species were summed.

up total. In autumn, out of 19 plant species eaten most frequent were *Pteridium aquilinum* and *Sorbus aucuparia*. The quantitative make-up of diet volume was similar to that in spring with green parts contributing in 59%, seeds and fruits — in 21%, fungi — 5%, and other components below 0.3%.

At Szczygłowice, the voles fed mainly on green parts (52%), also on seeds and fruits (36%), roots and tree-bark (3%), and animal food below 1%. The list of eaten species covered 18 species with *Frangula alnus*, *Betula* sp. and *Sorbus aucuparia* on top. In autumn, the green parts constituted 45% of diet, seeds and fruits — 38%, roots and tree-bark — 2% and fungi 0.7%. *Betula* sp. and *Sorbus aucuparia* were the most preferred species from the list of 17 species (Table 2). It should be added that some species were eaten in large quantities by almost all individuals. In particular, there were some seeds and fruits found in almost every stomach examined. However, some plant species, although found in small quantities, occurred in many species (*e.g. Carex bryzoides, Impatiens* sp., Table 2).

3.2. The Field Vole

The specimens were collected only at Aniołki site and were found to eat 78% of green parts, 9% bark, and 3% of animal food. *Calamagrostis* sp. and *Rubus* sp. were most preferred plant species (Table 3). In autumn, the percentage of green parts in diet dropped significantly (to 43%) with simultaneous increase in fungi (as much as 26%) and seeds (22%). Animal food constituted 1.3% of the diet. The most preferred plant species in autumn were *Carex bryzoides, Deschampsia caespitosa* and other grasses. The list of species found in stomachs covered 18 species in all.

Table 2

Percentage and frequency of occurrence of food components in *Clethrionomys glareolus* in spring and autumn at Aniołki and Szczygłowice forest sites.
Number of samples (n) is shown. A, percentage of diet component in stomach contens; B, percentage of stomachs containing given component.

Kind of food	Aniołki		Szczygłowice	
	Spring n=31 A/B	Autumn n=24 A/B	Spring n=23 A/B	Autumn n=31 A/B
Ajuga reptans L.	1.2/ 3	—	—	—
Amelanchier ovalis Med.	—	—	1.0/12	0.7/23
Athyrium filix-femina (L.)	1.0/13	3.4/25	0.2/ 4	0.5/13
Betula sp.	14.3/45	6.5/17	9.2/57	12.8/55
Calamagrostis sp.	1.6/26	2.0/ 7	—	—
Carex brizoides L.	1.0/13	0.4/13	1.3/22	1.5/45
Drypoteris sp.	1.2/19	1.9/42	1.1/ 9	—
Equisetum sp.	0.1/ 7	—	—	—
Evonymus europaea L.	—	—	—	0.5/ 7
Festuca gigantea (L.) Vill.	0.4/10	—	0.2/ 9	0.6/ 9
Frangula alnus Mill.	3.1/23	0.3/13	20.5/83	5.6/68
Galeopsis sp.	1.5/ 3	—	0.1/ 4	—
Impatiens sp.	1.0/32	2.5/21	0.8/30	2.0/39
Luzula pilosa (L.) Willd.	—	0.8/ 4	—	—
Lysimachia vulgaris L.	1.0/10	0.4/ 4	0.1/ 4	0.2/ 7
Majanthemum bifolim (L.)	8.6/32	—	0.04/ 4	—
Moeohringia trinervia (L.)	0.4/10	—	—	—
Oxalis acetosella L.	1.2/23	2.0/25	0.3/ 9	0.3/ 9
Populus tremula L.	—	—	0.4/ 9	—
Potentilla sp.	—	2.5/13	—	—
Pteridium aquilinum (L.)	6.2/65	15.2/75	4.2/52	5.1/55
Quercus robur L.	6.3/65	4.0/21	3.5/57	0.2/13
Rubus sp.	3.3/23	1.0/13	0.6/ 9	3.5/39
Scrophularia nodosa L.	0.9/13	1.7/17	—	0.1/ 3
Senecio sp.	0.9/13	1.6/17	—	0.2/ 3
Sorbus aucuparia L.	6.8/32	8.0/54	8.5/44	11.2/65
Stachys silvatica L.	0.5/10	2.8/ 7	—	0.3/10
Trientalis europaea L.	0.3/16	0.8/ 8	—	—
Urtica dioica L.	0.8/25	—	—	—
Seeds and fruits	23.3/75	20.6/100	35.6/91	37.5/100
Roots and bark	3.8/42	0.3/ 8	3.3/70	2.1/16
Fungi	—	5.2/21	1.5/ 9	0.7/10
Animal food	1.7/10	0.2/ 8	0.8/22	—
Unidentified	7.7/65	15.9/71	6.4/52	14.4/68

3.3. The Striped Field Mouse

The green parts of plants dominated decisively in the diet of this species (in spring at Aniołki it constituted almost 90% of diet). Among the species preferred were: *Rubus* sp., *Pteridium aquilinum* and *Frangula alnus* with each constituting no less than 10% of the diet (Table 4). The animal food made 7% of the spring diet. In autumn, the preferences followed similar pattern but the percentage of seeds and fruits increased markedly (to 24%) although the green parts of plants still dominated at 66.8% (Table 4).

Table 3
Percentage and frequency of occurrence of food components in *Microtus agrestis* in spring and autumn at Aniołki forest sites. Explanations see Table 2.

Kind of food	Spring n=13 A/B	Autumn n=16 A/B
Agrostis canina L.	0.8/15	0.3/ 17
Betula verrucosa Ehrh.	1.8/31	—
Calamagrostis epigeios (L.) Roth	1.6/46	0.9/ 33
Calamagrostis villosa Gmel.	11.5/69	—
Calamagrostis sp.	0.9/15	—
Carex bryzoides L.	2.3/46	7.6/ 67
Chamaenerion angustifolium (L.) Scop.	—	1.2/ 17
Cirsium palustre (L.) Scop.	6.7/31	—
Deschampsia caespitosa (L.) P.B.	0.0/ 8	9.7/ 67
Epilobium palustre L.	—	0.6/ 17
Equisetum sp.	—	0.2/ 17
Festuca gigantea (L.) Vill.	0.1/15	—
Frangula alnus Mill.	1.4/23	0.4/ 17
Galeopsis tetrachit L.	0.2/ 8	—
Impatiens parviflora DC.	5.1/77	3.9/ 50
Lysimachia vulgaris L.	—	0.8/ 17
Majanthemum bifolium (L.) F. W. Schm.	2.8/ 8	—
Molinia coerulea (L.) Moench.	1.7/23	—
Oxalis acetosella L.	9.7/54	3.5/ 33
Picea excelsa (Lam.) Lk.	1.7/ 8	—
Populus tremula L.	—	0.3/ 17
Quercus robur L.	—	0.8/ 17
Rubus caesius L.	4.1/23	—
Rubus idaeus L.	10.8/54	0.3/ 33
Rubus sp.	0.9/46	—
Sambucus nigra L.	3.3/46	—
Sambucus racemosa L.	0.8/23	—
Scrophularia nodosa L.	—	0.4/ 17
Senecio Fuchsii Gmel.	0.3/ 8	0.1/ 17
Solanum dulcamara L.	0.1/ 8	0.2/ 17
Sorbus aucuparia L.	1.9/15	—
Trientalis europaea L.	0.5/ 8	3.8/ 33
Grasses	7.2/92	8.4/ 67
Bark	9.4/62	—
Seeds and fruits	0.0/ 8	22.0/100
Fungi	—	26.5/ 50
Animal food	2.8/85	1.3/ 17
Unidentified	9.8/92	6.8/ 83

At Szczygłowice the percentage of green parts was even higher than that at Aniołki and reached 94% of the diet. The list of preferred species included *Betula* sp., *Rubus* sp., *Amalanchier ovalis*. In autumn, the fraction of green parts dropped to 56%, with 25% of seed and fruits and 7% of fungi. *Betula* sp. again appeared on the list of preferred plant species which provided green parts (Table 4).

In general, the striped field mouse had the longest list of plant species in the diet (37 species) with most of them found in autumn at Aniołki.

3.4. The Yellow-necked Mouse

The number of plant species whose green parts were eaten by *A. flavicollis* was much smaller than that in the remaining rodents and cov-

Table 4
Percentage and frequency of occurrence of food components in *Apodemus agrarius* in spring and autumn at Aniołki and Szczygłowice forest sites. Explanations see Table 2.

Kind of food	Aniołki		Szczygłowice	
	Spring n=13 A/B	Autumn n=10 A/B	Spring n=10 A/B	Autumn n=25 A/B
Agrostis alba L.	—	—	1.1/30	—
Amelanchier ovalis Med.	—	—	10.5/20	7.1/48
Ajuga reptans L.	—	—	0.0/10	—
Athyrium filix-femina L.	1.0/23	3.6/33	—	0.0/ 4
Betula sp.	16.4/54	12.6/57	22.1/90	15.9/60
Brachypodium silvaticum (Huds.)	—	—	0.7/10	0.0/ 4
Calamagrostis sp.	0.1/15	3.4/67	—	—
Carex bryzoides L.	0.7/54	0.1/10	0.3/20	0.3/36
Chamaenerion angustifolium (L.)	2.2/15	1.0/13	—	—
Cirsium palustre (L.) Scop.	—	0.2/ 3	—	—
Deschampsia caespitosa (L.)	—	0.4/ 7	—	—
Dryopteris filix-mas (L.)	—	0.2/ 3	—	—
Dryopteris spinulosa (Müll.)	4.2/15	1.6/30	—	—
Equisetum silvaticum L.	—	0.4/10	—	—
Festuca gigantea (L.)	—	0.4/13	1.4/20	1.4/36
Frangula alnus Mill.	10.3/77	3.7/37	1.8/50	5.0/88
Galeopsis tetrachit L.	—	0.1/ 7	—	—
Impatiens parviflora DC.	—	3.6/30	—	—
Impatiens noli-tangere L.	7.0/31	—	2.2/40	2.2/44
Lysimachia vulgaris L.	1.0/23	1.8/20	—	0.1/ 8
Majanthemum bifolium (L.)	—	1.4/17	—	—
Moechringia trinervia (L.)	—	—	—	0.1/ 4
Oxalis acetosella L.	2.4/31	0.6/17	—	0.1/ 4
Populus tremula L.	3.6/ 8	0.6/ 7	8.5/40	1.8/12
Polygonatum multiflorum (L.)	—	1.4/ 7	—	—
Pteridium aquilinum (L.)	12.2/62	8.5/63	4.2/20	6.0/68
Quercus robur L.	0.1/ 8	0.9/ 7	4.1/20	2.2/76
Rubus sp.	17.1/69	5.9/77	14.1/80	5.8/76
Sambucus sp.	3.1/39	5.2/47	4.7/40	0.2/12
Scrophularia nodosa L.	—	1.2/10	—	—
Senecio Fuchsii Gmel.	—	2.5/17	—	—
Solanum dulcamara L.	—	—	—	0.0/ 4
Sorbus aucuparia L.	—	2.4/27	6.2/50	6.7/52
Stachys silvatica L.	—	—	1.5/30	0.4/ 8
Trientalis europaea L.	2.9/15	1.0/ 7	—	—
Urtica dioica L.	0.3/ 8	0.6/17	0.0/10	0.5/ 4
Vaccinium myrtillus L.	—	0.1/ 3	—	0.2/ 8
Viola Riviniana Rchb.	—	0.1/ 3	—	—
Seeds and fruits	0.9/23	25.6/100	3.8/70	24.9/92
Bark	2.2/70	1.1/17	1.9/50	0.5/48
Roots	0.2/15	1.2/ 7	0.0/10	0.1/16
Spores	0.2/23	0.2/ 3	—	0.1/ 8
Fungi	—	5.2/47	—	7.2/52
Animal food	7.6/46	—	0.5/10	6.9/20
Unidentified	4.3/62	1.2/ 7	10.2/50	4.3/20

ered 7 to 12 species depending on site and season. In spring at Aniołki the green parts constituted 24% (with *Betula verrucosa*), seeds and fruits 19%, rhizomes 5%, and animal food making up 31% of diet (Table 5). In autumn the composition of diet changed to 13% of green parts, 50% of seeds and fruits, 31% of rhizomes, and 3% of animal food (Table 5).

At Szczygłowice, the green parts of plants constituted mere 6% of the diet. Rhizomes made the bulk of diet (51.8%) with animal food (18.4%) and tree bark (4%). Seeds and fruits were almost absent from the diet (0.1%). In autumn, the percentage of green parts dropped still further (to 4%), with seeds and fruits, rhizomes, and animal food at 2.51 and 2%, respectively.

There was striking variability in percentages of seeds and fruits, rhizomes, and animal food at both sites during the two seasons. At Szczygłowice the seed and fruits class were absent from spring diet only to make as much as 42% of in autumn. At Aniołki the percentage of animal food decreased tenfold from spring to autumn, accompanied by a simultaneous increase by six and a half times in percentage of rhizomes (Table 5).

Table 5
Percentage and frequency of occurrence of food components in *Apodemus flavicollis* in spring and autumn at Aniołki and Szczygłowice forest sites. Explanations see Table 2.

Kind of food	Aniołki		Szczygłowice	
	Spring n=5 A/B	Autumn n=5 A/B	Spring n=6 A/B	Autumn n=16 A/B
Agrostis canina L.	0.3/ 20	—	—	—
Amelanchier ovalis Med.	—	—	—	0.1/ 6
Betula verrucosa Ehrh.	10.3/ 40	0.1/20	0.2/ 17	—
Calamagrostis villosa Gmel.	—	3.1/40	—	—
Carex brizoides L.	0.3/ 20	—	0.1/ 17	0.1/ 6
Cirsium palustre (L.) Scop.	—	0.1/20	—	—
Dryopteris spinulosa (Müll).	—	0.6/20	—	—
Frangula alnus Mill.	1.8/ 40	0.1/20	5.2/ 83	0.6/19
Galium saxatile L.	—	1.5/20	—	—
Impatiens noli-tangere L.	—	—	—	1.2/13
Oxalis acetosella L.	4.2/ 40	—	—	0.1/ 6
Picea excelsa (Lam.) Lk.	—	0.1/20	—	—
Pinus silvestris L.	0.1/ 20	1.3/20	—	—
Pteridium aquilinum(L.)	—	4.1/20	—	—
Rubus caesius L.	—	0.1/60	—	—
Rubus idaeus L.	7.1/ 80	—	—	—
Rubus sp.	—	—	0.2/ 17	0.9/25
Sambucus nigra L.	—	0.1/20	0.1/ 17	0.0/ 6
Sambucus racemosa L.	—	1.5/20	—	—
Sorbus aucuparia L.	—	—	0.0/ 17	—
Seeds and fruits	19.1/ 60	50.4/80	0.1/ 17	41.8/88
Bark	0.2/ 40	0.4/20	4.4/ 33	0.3/13
Underground parts	4.8/100	31.2/40	51.8/ 83	51.3/81
Animal food	31.4/100	3.1/80	18.4/ 83	2.3/63
Unidentified	20.4/100	2.2/80	19.4/100	1.3/56

Table 6

Basic food components, in percentage of occurrence, in four species of rodents at Aniołki and Szczygłowice forest sites.

Kind of food	Aniołki		Szczygłowice	
	Spring	Autumn	Spring	Autumn
	Clethrionomys glareolus			
Green parts	63.5	59.3	52.4	45.3
Seeds and fruits	23.3	20.6	35.6	37.6
	Microtus agrestis			
Green parts	78.0	43.3		
Bark	9.4			
Seeds		22.0		
Fungi		26.5		
	Apodemus agrarius			
Green parts	89.1	66.8	93.8	55.6
Seeds and fruits		24.4		24.5
	Apodemus flavicollis			
Green parts	24.1			
Seeds and fruits	19.2	50.4		41.7
Underground parts		31.1	51.8	51.2
Animal food	31.4		18.3	

4. DISCUSSION

Since long, the studies carried out in various parts of distribution ranges revealed that the diets of the four rodent species vary in respect to both its composition and the list of preferred plant species. As the changes in diets associated with living in polluted forests of Silesia were species-specific, they should be discussed separately.

The bank vole is a species of an enormously large range of distribution. This implies high variability in diet related to prevailing ecological conditions. Nevertheless, the bank voles always feed principally on the green parts of plants, seeds, and animal food and show seasonal changes in food composition everywhere (for review of trophic status of this species see Gębczyńska, 1983). Both Aniołki and Szczygłowice populations displayed striking stability of the diet without much of seasonality. The green parts of herbaceous plants, grasses, shrubs and trees amounted to 45—65% and, together with 21—38% of seeds and fruits make up 80—88% of total diet irrespective of seasons. In some other, not very distant regions (environs of Cracow — Zemanek, 1972 and Moravia — Obrtel & Holišova, 1978), the diets changed along a seasonal rhythm. In lowland forests of Moravia seeds made up 11.7 of spring diet and increased to 34.4% in autumn (Obrtel & Holišova, 1978). Even more striking was the difference in animal food category

which in spring made no more than 1.8% of diet in Silesia whereas in other populations from Poland (Zemanek, 1972; Gębczyńska, 1976) and from Czechoslovakia (Holišova, 1966; Obrtel & Holišova, 1978) it reached 7—21% in spring. Again in the polluted forests in Silesia there have been no basic seasonal changes in the diet of *C. glareolus* found at other sites in autumn. There, the proportion of green parts of forbs, grass, and leaves of shrubs and trees declined drastically while that of seeds and fruits increased. Such shift were observed in Czechoslovakia, Great Britain, Poland, Sweden and on Kola Peninsula of the USSR (Gębczyńska, 1983). At Aniołki and Szczygłowice, the percentage of seeds and fruits did not change much from spring to autumn (23 and 21%, 36 and 38% respectively on the two plots).

Thus, in the diet in bank voles living in polluted forests of Upper Silesia this seasonality disappear. Almost total absence of animal food and reduction in number of species eaten were the remaining features of the diet.

In *M. agrestis* the diet has not been studied in too much detail. It is only known that in Sweden (Hansson, 1971; Stenseth *et al.*, 1977) and Finland (Stenseth *et al.*, 1977) this species feeds upon grasses, forbs and grass seeds. There, a distinct seasonal pattern was found in changes of diet composition. In spring, grasses made about 80% of diet while in summer and early autumn grasses and forbs shared this amount almost in halves. Seeds could make as much as 19% of the diet (Hansson, 1971), a figure similar to that found at Aniołki site. Treebark that participated 9% of diet at Aniołki had also been found in studies of *M. agrestis* in Scandinavia (Stenseth *et al.*, 1977). Only fungi that contributed significantly to the overall diet at Aniołki (26%) made rather negligible appearance in the diet of this species at Sweden and Finland.

Some previous reports on *A. agrarius* indicated domination by seeds which were the principal component of the diet (50 to 90%) (Holišova, 1967; Babińska-Werka, 1981; Obrtel & Holišova, 1981).There was also a significant fraction of animal food which, in some cases (Opava region), made 40% of the diet (Holišova, 1967), and 8 to 12% in various types of urban green areas (Babińska-Werka, 1981). It was thus quite surprising that one of populations living at Białystok had completely different food preferences. Inhabiting the city centre, this population fed mainly on green parts of plants (71%), seeds (19%), and animal food (9%) (Gębczyńska *et al.*,1987). The trophic relationships found in Aniołki and Szczygłowice populations seem to have altered still further. Green parts of plants constituted as much as 90 and 94% of spring diets respectively. Not before autumn did seeds and fruits share

up to 24% of the diet, with green parts still dominating at 56—67% of its composition. Also the animal component of diet differed from anything found in that species so far. This kind of food appeared in spring only at Aniołki site (7%) while in autumn it was simply absent from *A. agrarius* diet at Aniołki and Szczygłowice alike.

Hence both populations of *A. agrarius* at Silesian sites fundamentally changed their food preferences. It is not clear why *C. glareolus* feeds on seeds on both sites in spring and autumn while *A. agrarius* refrains from using that kind of food. One may presume that it is spatial interspecific relationships that decide about such arrangement as indicated by a four-year ecological study in the area (Chełkowska *et al.*, 1985). When comparing one of Białystok populations and the two Silesian populations, a hypothesis that this particular species is able to restructure profoundly its diet seems quite viable. It is done by way of modifications in alimentary tract related to the shift from high-energy food to bulk food of low calorific value. The ability to replace highly nutritive seeds and animal food with low-energy green parts of plants is probably based on actual changes in alimentary tract. This physiological plasticity is of fundamental importance for the ecological variability of this murid (Andrzejewski *et. al.*, 1978) enabling it to colonize new habitats such as urban green areas, polluted forests, *etc.*

Available information about diet of *A. flavicollis* indicate that it includes mainly seeds and animal food. These categories contribute to the spring diet to the tune of about 40% each with green parts of plants taking mere 10% (Obrtel & Holišova, 1983). It is also known that the yellow-necked mouse feeds on fewer species than, for example, *C. glareolus* living in the same biotopes (Obrtel & Holišova, 1974). Our observation at Aniołki and Szczygłowice confirmed these finding as the lists of plant species eaten by *A. flavicollis* were shorter by half or more than those found in the remaining rodent species. Again, seeds made substantial part of the diet in *A. flavicollis*. In autumn seeds satisfied 50 and 42% of feeding requirements at Aniołki and Szczygłowice. The animal food varied widely: although in spring it was about as much as 31% at Aniołki, and 18% at Szczygłowice, in autumn dropped to a mere 3% at both sites. However, there was a significant increase in importance of underground parts of plants which at Szczygłowice provided no less than half of diet, both in spring and autumn. Obrtel and Holišova (1983) found that this kind of food contributed only 4% of diet in Moravian populations. It should be noted that in polluted Silesian forests this species increased significantly feeding upon underground parts. There were no major shifts in diet although proportions of various kinds of food changed.

The investigation of rodent diets at Aniołki and Szczygłowice indicated marked changes in food composition (Table 6). In *C. glareolus* they showed as disappearance of seasonality and withdrawal of animal food. Such depletion of animal food component, found also in other rodent species under study, was undoubtedly associated with decimation of invertebrate fauna at polluted forests (Dąbrowska-Prot 1982). In *M. agrestis* the change was manifested by increased proportion of fungi in diet. *A. agrarius* has altered its diet completely, turning to green food as basic component and lowering the proportion or even abandoning seeds or animal food. *A. flavicollis* consumed large quantities of underground parts supplemented by seeds and animal food. There is no doubt that the ability to change diet flexibly allowed *A. agrarius* inhabit Aniołki and Szczygłowice sites (along with *C. glareolus*) and reach high numbers there (Walkowa *et al.*,1982; Chełkowska *et al.*, 1985). It seems that especially *A. agrarius* and *M. agrestis*, the species that normally occur in the Polish forests in rather small numbers, could adopt themselves well to living conditions prevailing in polluted Silesian forests. The differences in population densities found at more degraded forest at Aniołki and less disturbed Szczygłowice site indicate enormous ecological plasticity of *A. agrarius* and high ecological potential of *M. agrestis*. Such were the features that helped them to dominate over *C. glareolus* and *A. flavicollis*.

Finally, when starting the research we envisaged relations between the degree of pollution (and indeed the disturbance to the vegetation cover, see Table 1) and the composition of diet in rodents. The only result though is that the sole fact of pollution can force changes in the diet not necessarily proportional to the degree of pollution of actual sites.

Acknowledgements: We would like to extend sincere thanks to Drs W. Walkowa, K. Adamczyk and D. Chełkowska for their help in obtaining material for this study. Ms. I. Jabłonowska identified the diet components in *C. glareolus*. We are grateful to Dr. R. Tertil for valuable comments on the manuscript.

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Received 11 January 1989, Accepted 24 June 1989.

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POKARM CZTERECH GATUNKÓW GRYZONI BYTUJĄCYCH W ZANIECZYSZCZONYCH LASACH

Streszczenie

Badania prowadzono w Rybnickim Okręgu Węglowym (górny Śląsk) w lasach obok Aniołków i Szczygłowic. Na obu obszarach dominują silnie zanieczyszczone i zdegradowane zespoły *Tilio-Carpinetum,* przy czym w rejonie Aniołków zmiany w środowisku są większe (Tabela 1). Próby do oznaczania diety u *Clethrionomys glareolus, Apodemus agrarius* i *Apodemus flavicollis* pozyskiwane były wiosną i jesienią na obu powierzchniach, a okazy *Microtus agrestis* łapane były w obu sezonach, ale tylko koło Aniołków.

Clethrionomys glareolus odżywia się podobnym pokarmem (tak samo jak i dwa pozostałe gatunki) na obu powierzchniach. Pokarm tego gatunku składa się głównie z zielonych części roślin (45—65%) oraz nasion i owoców (21—38%). Brak tu jest natomiast pokarmu pochodzenia zwierzęcego (Tabela 2), a także nie zaznaczają się zmiany sezonowe. Obie te cechy różnią dietę *C. glareolus* ze Śląska w porównaniu do wszystkich innych poznanych populacji tego gatunku.

Microtus agrestis ma na Śląsku podobny skład pokarmu jak na innych obszarach swego występowania; wiosną pokarm zielony stanowi 78% diety, a jesienią 43%. Udział nasion jesienią wynosi 22%. Natomiast grzyby stanowią jesienią aż 26% diety (Tabela 3), co jest cechą właściwą tylko tej populacji.

Apodemus agrarius na Śląsku odżywia się głównie zielonymi częściami roślin, które wiosną stanowią 90—94% składu diety, zaś jesienią ich udział wynosi 56—67%. Nasiona w tym sezonie stanowią 24% (Tabela 4). Oznacza to przebudowę stosunków pokarmowych w porównaniu do większości poznanych populacji tego gatunku gryzonia, gdzie podstawą diety są nasiona.

Apodemus flavicollis w obu populacjach w lasach Śląska żywi się nasionami i pokarmem pochodzenia zwierzęcego, czyli podobnie jak w innych zbadanych dotychczas populacjach tego gatunku. Natomiast na Śląsku w pokarmie myszy leśnej wzrasta, do 50% objętości diety, udział podziemnych części roślin (Tabela 5) co stanowi swoistość w porównaniu z innymi poznanymi populacjami tego gatunku.

Ogólnie zatem można powiedzieć, że u wszystkich gatunków gryzoni zamieszkujących silnie zdegradowane pod wpływem zanieczyszczeń lasy na Śląsku, nastąpiły zmiany w składzie diety w porównaniu do populacji bytujących w środowiskach naturalnych lub nie tak silnie odkształconych. U *C. galerolus, M. agrestis* i *A. flavicollis* wyrażają się one zmianą udziału poszczególnych składników diety, natomiast u *A. agrarius* nastąpiła wyraźna zmiana preferencji pokarmowych (Tabela 6). Zmiana diety u zbadanych gatunków nie była zależna od stopnia zanieczyszczenia (Tabela 1) obu powierzchni, zatem można sądzić, że sam fakt odkształceń szaty roślinnej już powoduje przebudowę stosunków pokarmowych gryzoni bez zachowania spodziewanej proporcji do zmian środowiska.