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ESTIMATION OF RODENT CONSUMPTION IN A MEADOW ECOSYSTEM BELONGING TO THE COMMUNITY OF *MOLINIETALIA* ORDER

(Ekol. Pol. 20: 747–761). In two successive years the consumption of rodents on a mid-forest meadow belonging to the community of *Molinietalia* order, was estimated. Few rodent species lived in this ecosystem, and among them *Apodemus agrarius* (Pall.) and *Microtus arvalis* (Pall.) dominated. In the first year of studies the consumption of rodents was 9.5 kcal/m^2/year (0.5% of net primary production of this meadow) and in the next year 12.1 kcal/m^2/year (0.6% of primary production).

1. INTRODUCTION

This paper is a part of the complex studies on the productivity of meadow ecosystem in the Kampinos National Park (Andrzejewska 1971, Andrzejewska, Wójcik 1971, Breymeyer 1971, Czerwiński 1971, Diehl 1971, Jakubczyk 1971, Kajak 1971, Kajak, Breymeyer, Pętal 1971, Makulec 1971, Nowak 1971, Olechowicz 1971, Pętal, Andrzejewska, Breymeyer, Olechowicz 1971, Traczyk 1971).

Thus this paper deals with an estimation of consumption of rodents, which mainly feed on plant food, as related to the primary productivity of meadows.

2. DESCRIPTION OF THE STUDY AREA

The examined meadows are a mid-forest enclave in the northeastern part of the Kampinos National Park. They belong to the meadow community of *Molinietalia* order similar to the community *Stellario-Deschampsietum* Freitag 1957. Traczyk gives a detail phytosociological description of this area (1966).

In 1965 Strzeleckie Meadows became included into the natural reservation and since then mowing has stopped thus forming an abundant food base consisting of green plant parts and seeds for rodents. Compact vegetation growth is maintained there during the vegetation season, non-mowed withers to form in winter a thick litter layer.

High level of ground waters on the meadows causes their periodical flooding usually in the period from late autumn to spring and after greater precipitation. Then the rodents may remain only in the highest, not flooded parts of the meadow.

The studies were conducted in 1969 and 1970, when the meadows were not flooded. In 1969 the level of ground waters on Strzeleckie Meadows was low and meadow flooding was not observed as opposed to the year 1970 – when the meadows were not flooded only from July till the end of October.

3. METHODS AND MATERIAL

To determine the species composition of rodents, their abundance and the time during which particular individuals remain on the examined area the CMR method (Catch-Mark-Release) was used. The basic test area was 1 ha of mid-meadow part not overgrown with bushes and rather uniform from the phytosociological point of view.

On the test area there were 100 trap stations arranged at intervals of 10 m in a grid. In each station two live traps were placed with an oat grain bait. The rodents were taken out of the traps twice in 24 hr at 8 a.m. and just before dusk. The catches were made in 10-day series. In 1969, between respective series of catches there were 10-day intervals, and 7 series of catches were conducted then. In 1970, on the same test area each series lasted from the 1st to the 10th day of each month, and the total of 4 series of catches were conducted.

The area of 1 ha is small in relation to the standard research areas for the estimation of rodent consumption in the forest (Grodziński, Pucek, Ryszkowski 1966), therefore, we may expect that the edge effect may influence considerably the estimation of the number of rodents on the meadow.

In order to estimate how representative is the 1 ha area a comparison of number estimations was made applying test areas of a size 2, 3, 4 ha. The gradient of the research area had to show the difference in the number of rodents per 1 ha due to the margin effect. The research method on areas of 2, 3 and 4 ha was the same as in tests carried out on 1 ha area. 10-day series of catches, one on each area, were made in 1970.

In all series the total of 611 individuals were marked and 2,867 were caught.

4. RESULTS

4. 1. Comparison of rodent density on areas of: 1, 2, 3 and 4 ha

The number of rodents in catches on research areas 1, 2 an 4 ha after being calculated per 1 ha area is similar (Tab. I). Comparing the results of investigations carried out on 1 ha area in August 2–11, 1970, on a 3 ha area from August 22 to September 1, 1970, and on 1 ha area in September 1–11, 1970, it was found that the number of rodents falling per 1 ha caught on 3 ha area is smaller than the number of rodents caught on 1 ha area during the series preceding and following the research series on 3 ha area.

Number of rodents on 1, 2, 3 and 4 ha area and their density in 1970

Tab. I

Series	Size of area (ha)	Number of rodents on each area	Density of rodents (per 1 ha)
3–12 VII 1970	1	34	34
13–22 VII 1970	2	63	32
23 VII – 1 VIII 1970	4	134	34
2–11 VIII 1970	1	92	92
22 VIII – 1 IX 1970	3	206	69
1–11 IX 1970	1	137	137
1–10 X 1970	1	60	60

The 1 ha area determines well the number of rodents at the beginning of the investigations in summer. The density of rodents on the 1 ha research area does not differ from the density of rodents on 2 and 4 ha after calculating it per surface unit (1 ha). In the research series carried out later, at the autumnal, natural increase in the number of rodents, the 1 ha area gives too high results.

4.2. Dynamics of rodents number in 1969 and 1970

Catches of rodents on 1 ha research area showed that *Apodemus agrarius* (Pall.) was the dominant species. Also found were *Microtus arvalis* (Pall.) and *Microtus oeconomus* (Pall.), which further in the paper shall be treated jointly because of the difficulties in life determination of these species in field conditions. *Clethrionomys glareolus* (Schreb.) and *Apodemus flavicollis* (Melch.) were found on Strzeleckie Meadows as migratory individuals. The catches were occasional and frequently were not repeated. During two seasons 10 bank voles were caught, among which half had one catch, while the others from 2 to 7 catches. Yellow-necked field mouse were found only in July and August, and the number of caught individuals was small (24 during two years). Two rodent species *Micromys minutus* (Pall.) and *Arvicola terrestris* L. appeared only in 1970 (Tab. II).

Number of individual-days of six rodent species per year

Tab. II

Species	1969			1970		
	resident	ephemeral	total	resident	ephemeral	total
Apodemus agrarius	3,911	99	4,010	4,880	42	4,922
Microtus sp.	1,183	76	1,259	1,385	57	1,442
Apodemus flavicollis	499	10	509	105	–	105
Clethrionomys glareolus	30	3	33	45	1	46
Micromys minutus	–	–	–	675	41	716
Arvicola terrestris	–	–	–	240	15	255
Total	5,623	188	5,811	7,330	156	7,486

The trappability of particular individuals was differentiated. Assuming as 100% the total number of rodents of a given species caught on 1 ha area during the entire season, the individuals caught only once are 17.1% in stripped field mouse, 38.0% in vole, 55.3% in *Micromys minutus*, 55.1% in *Arvicola terrestris*. Thus the most resident species are stripped field mouse and vole. Individuals belonging to other rodent species are mainly the migratory individuals.

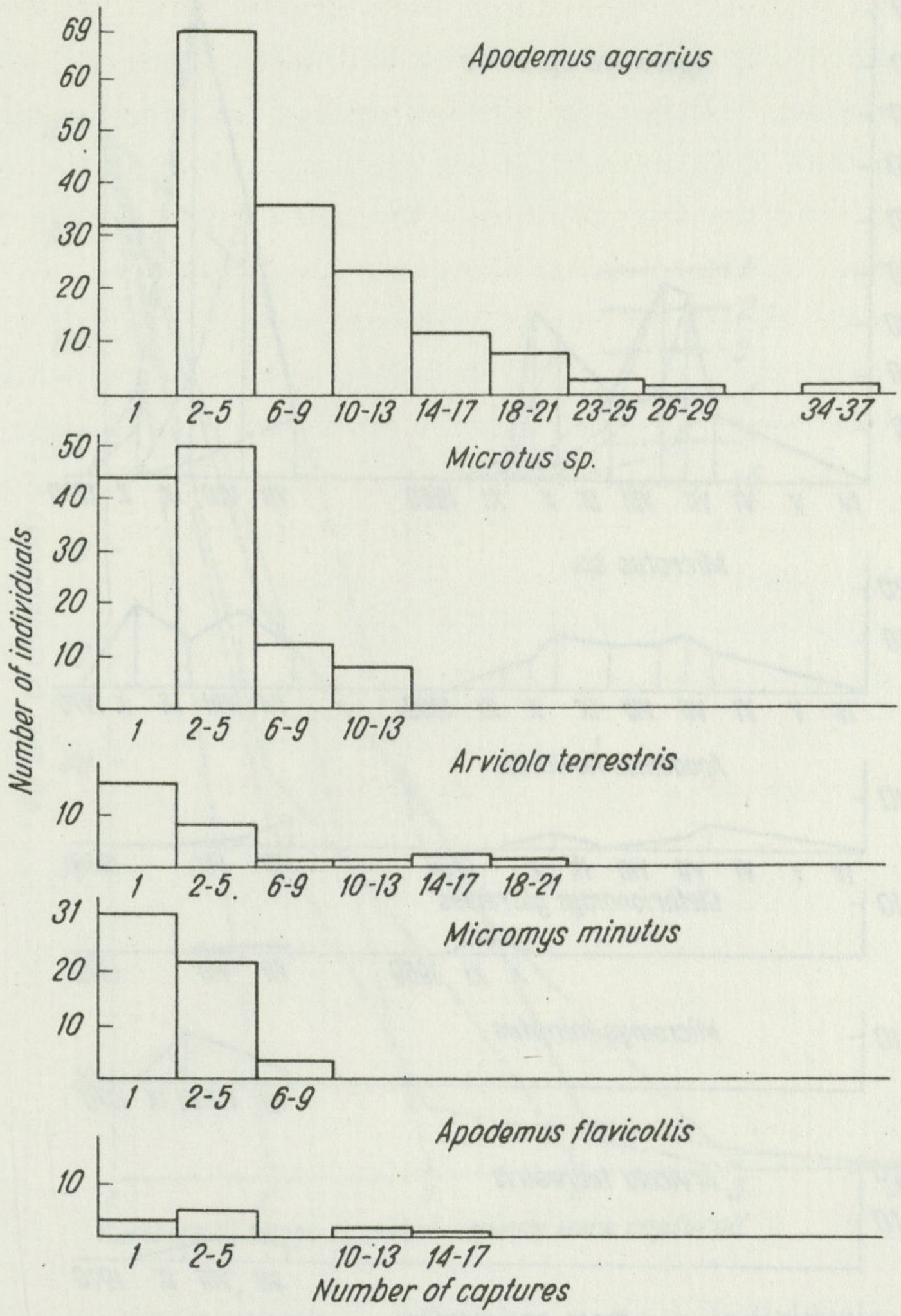

Fig. 1. Distribution of the number of individuals of a determined number of catches

The distribution of the number of individuals of a given species caught respectively during the entire period of studies is presented in Figure 1.

While analyzing the results of rodent catches according to the Calendar of Catches (CC), among the caught ones the ephemeral individuals were distinguished, i.e. species caught only once during the entire period of investigations (Petrusewicz, Andrzejewski 1962, Andrzejewski 1969). All other individuals were treated as settled individuals.

For each species of resident rodents, caught on 1 ha area during the entire period of investigations, the number dynamics were calculated (Fig. 2).

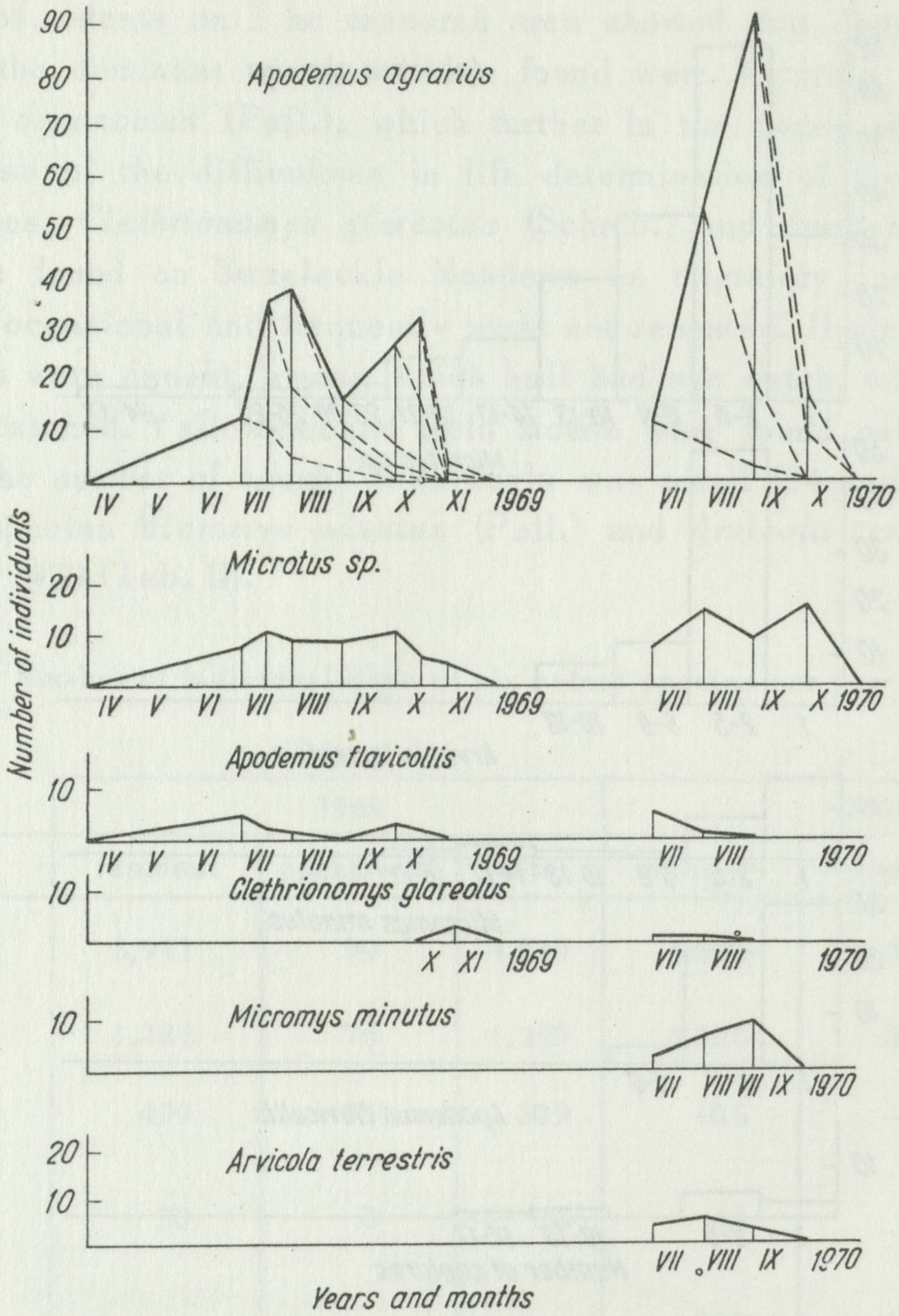

Fig. 2. Number dynamics of rodents on Strzeleckie Meadows

Vertical line — number of individuals marked in a given series of investigations; crooked solid line — curve of number dynamics of rodents; broken line — diminishing number of marked individuals in particular series of investigations as the time passes on

Furthermore, for each series of studies an average number of ephemeral individuals caught on 1 ha area in 24 hr was calculated. It has been assumed that the number of ephemeral individuals between the series is the same as during the catch series. This number has been added to the number of resident rodents. Calculated in appropriate units the field under the curve of the number dynamics of resident and ephemeral individuals is a number of individual-days

of rodents remaining on 1 ha of meadow during one year (MacFadyen, Petrusewicz 1970) (Tab. II).

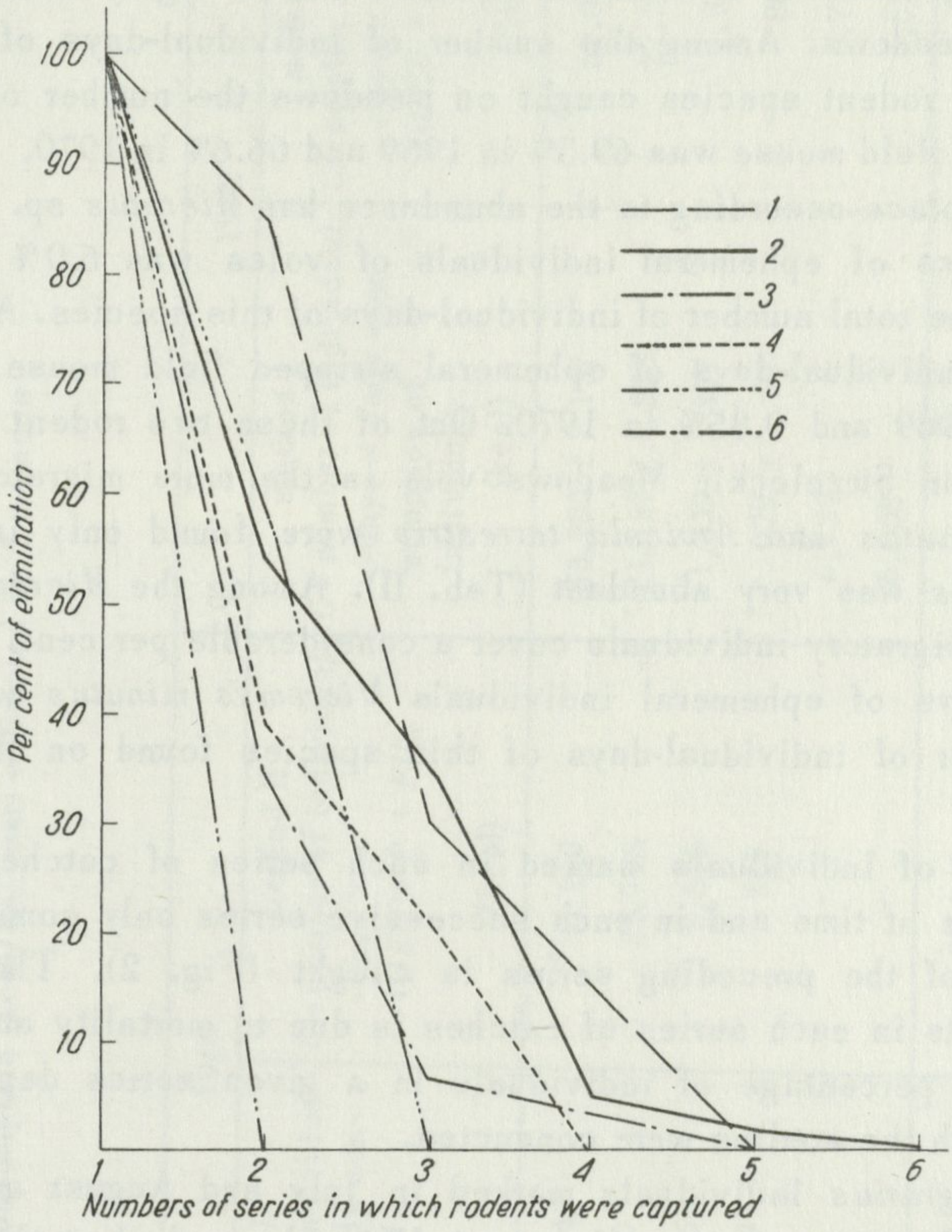

Fig. 3. Percentage of diminishing *Apodemus agrarius* individuals marked in various series of catches as the time passes on

1 – individuals marked in July 3–12, 1969; *2* – individuals marked from July 24 to August 2, 1969; *3* – individuals marked in August 13–22, 1969; *4* – individuals marked in September 7–16, 1969; *5* – individuals marked from September 25 to October 4, 1969; *6* – individuals marked in October 15–24, 1969.

As the meadows were flooded from late autumn in 1968 till March 1969, and the studies were initiated in July the assumed number of mice, which remained on the study area from April to July, was added. It was assumed that the rodents came to the meadows attaining in the first series of catches in 1969 the registered number of individuals.

The number of ephemeral individual-days was 2.9% (1969) and 2.0% (1970) of the sum of the number of resident and ephemeral individual-days of all rodent species.

Apodemus agrarius is a dominant species and a highly resident one on the examined meadows. Among the number of individual-days of settled individuals of all rodent species caught on meadows the number of individual--days of stripped field mouse was 69.5% in 1969 and 66.6% in 1970.

The second place according to the abundance has *Microtus* sp. The number of individual-days of ephemeral individuals of voles was 6.0% in 1969 and 3.9% in 1970 of the total number of individual-days of this species. Analogously, the number of individual-days of ephemeral stripped field mouse individuals was 2.52% in 1969 and 0.85% in 1970. Out of these two rodent species the most abundant on Strzeleckie Meadows vole is the more migratory species.

Micromys minutus and *Arvicola terrestris* were found only in 1970, and *Micromys minutus* was very abundant (Tab. II). Among the *Micromys minutus* individuals the migratory individuals cover a considerable per cent. The number of individual-days of ephemeral individuals *Micromys minutus* was 6.1% of the total number of individual-days of this species found on the examined meadows.

The number of individuals marked in each series of catches decreases with the passage of time and in each successive series only some percentage of individuals of the preceding series is caught (Fig. 2). The decreasing number of rodents in each series of catches is due to mortality and migration. The decreasing percentage of individuals in a given series depends on the time during which the studies were conducted.

Apodemus agrarius individuals marked in July and August are caught in three to four successive series, whereas individuals marked at the end of the season are caught only in the next series, or as, e.g, rodents marked in the series of October catches, are not caught at all in the next series (Fig. 3).

4.3. Estimation of rodent consumption

Consumption of rodents has been estimated using the two following methods.

Method I. Consumption of rodents was calculated out of the product of the number of individual-days and consumption of one individual during one day (Tab. III). Daily consumption of one individual of an average weight was assumed after Drożdż (1968) and Górecki (unpublished data).

Rodents consumption (kcal/ha/year) estimated by 2 methods

Tab. III

Species	1969		1970	
	method I C = number of individual--days × daily consumption of individual (kcal)	method II C = number of individual--days × $(DEB + P + FU)$ (kcal)	method I C = number of individual--days × daily consumption of individual (kcal)	method II C = number of individual--days × $(DEB + P + FU)$ (kcal)
Apodemus agrarius	67,849 ± 5,814	56,260	83,280 ± 7,137	69,056
Microtus sp.	18,878 ± 1,070	23,795	21,637 ± 1,225	27,254
Apodemus flavicollis	7,462 ± 1,486	6,515	1,539 ± 307	1,344
Clethrionomys glareolus	703 ± 69	577	979 ± 97	805
Micromys minutus	–	–	6,752	6,752
Arvicola terrestris	–	–	6,658	6,658
Sum	94,892 ± 8,439	87,147	120,845 ± 8,766	111,869

Comparison of the average weight of individuals of the Strzeleckie Meadows with the average weight of laboratory individuals estimated by Drożdż (1968)

Tab. IV

Species	The average weight of individual (g) (Drożdż 1968)	The average weight of individual on Strzeleckie Meadows (g)	
		1969	1970
Apodemus agrarius	20.6 ± 2.2	19.50	20.04
Microtus sp.	21.8 ± 2.1	24.11	24.95
Apodemus flavicollis	28.8 ± 5.5	23.29	25.43
Clethrionomys glareolus	23.1 ± 2.1	18.80	24.60
Micromys minutus	–	–	8.2
Arvicola terrestris	–	–	52.03

The average weight of individuals on Strzeleckie Meadows differs from the weight of rodents, for which Drożdż (1968) calculated the mean food demand (Tab. IV). For some species these differences are quite considerable, e.g. *Apodemus flavicollis*. Therefore, the mean food demand for these rodent species shall be slightly different (smaller or greater) than the one determined by Drożdż (1968). Thus, the estimation of rodent consumption using this method is not very accurate.

The average weight of individuals from Strzeleckie Meadows was calculated from the period of few series of catches. Such average was weighed proportionally to particular periods of time, during which the individuals had a given weight.

Method II. Consumption of rodents on Strzeleckie Meadows was calculated out of the product of the number of individual-days and the maintenance costs of one individual during one day.

The value of the maintenance costs of one individual during one day was assumed after: Gębczyński (1966), Górecki (1968, 1969), Górecki, Grodziński (1968), Drożdż (1968).

These authors estimated the maintenance costs according to the formula: $C = P + R + FU$, assuming that $R = DEB$, $P = 0$ for animals, which do not change their weight. C – consumption, P – production, R – respiration, F – faeces, U – urine, DEB – daily energy budget. In the experiments on Strzeleckie Meadows it has been assumed also that $P = 0$, and the consumption of rodents of a constant body weight has been calculated. The rodent weight is an average from several series of catches. DEB is calculated on the basis of

ADMR – average daily metabolism rate. In the daily energy budget the heat production for thermoregulation beyond the nest is taken into consideration as well as corrections for group effect and reproduction costs. Daily energy budget (*DEB*) is a product of average body weight of individuals and daily energy budget expressed in kcal/g body/day (Gębczyński 1966, Górecki 1968, 1969, Górecki, Grodziński 1968) (Tab. V). When calculating the costs of maintenance of one individual during a day the energy losses in urine and faeces in relation to the energy intake in food (Drożdż 1968) are taken into consideration.

Daily energy budget (*DEB*) and daily consumption of individual six rodent species

Tab. V

Species	Body weight of individuals on Strzeleckie Meadows (g)	*DEB* Daily energy budget in summer		*C = DEB + P + FU* kcal/ind./day
		kcal/g body/day	kcal/ind./day	
Apodemus flavicollis	24.0	0.47 [1,2]	11.5	12.8 [3]
Microtus arvalis	24.0	0.73 [1]	14.0	18.9 [3]
Apodemus agrarius	20.0	0.63 [4]	12.6	14.0 [3]
Clethrionomys glareolus	24.6	0.56 [5]	13.7	17.5 [3]

[1] Górecki, Grodziński 1968.
[2] Gębczyński 1966.
[3] Drożdż 1968.
[4] Górecki 1969.
[5] Górecki 1968.

Knowing the number of individual-days and the maintenance costs of one individual during a day the consumption of rodents on Strzeleckie Meadows (Tab. III) has been calculated.

For species *Micromys minutus* and *Arvicola terrestris* consumption may be calculated only using method II as we have no data on the consumption value of one individual per day for these rodents.

The consumption value calculated by both these methods is similar (Tab. III); method I provides values 8.2% greater in 1969, and 7.4% greater in 1970.

5. DISCUSSION OF RESULTS

The number of rodents on the given area is a parameter difficult to be precisely determined. The comparison of results obtained on 1, 2, 3, 4 ha areas showed that the 1 ha area determines well the rodent abundance, but only in summer, while in autumn at the natural number increase of rodents this area gives overestimated results (Tab. I).

The value of thus estimated by two methods rodent consumption is similar. The consumption value obtained by method I is slightly higher (about 8%). It is possible that this is due to the greater weight of individuals, for which the daily food demand has been calculated, than to the average weight of individuals on Strzeleckie Meadows.

Method II ($C = DEB + P + FU$) is more accurate. It takes into consideration several parameters (e.g. reproduction costs, heat production for thermoregulation beyond the nest and the like), which are not respected in method I. Thus estimated consumption is surely the most approximate one to the real consumption value on the examined meadows. The consumption estimation by method I is based only on the daily consumption value of one individual of an average weight.

Annual net primary production of the examined meadows was estimated by Traczyk (1971) by the harvesting method as 476 g d.w./m^2.

Assuming that the calorific value of one gramme dry plant weight is about 4.53 kcal/g (Wiegert and Evans 1964) it can be assumed that the net primary production of Strzeleckie Meadows is 2,071 kcal/m^2/year.

In 1969 the rodent consumption was estimated using method I as about 9.5 kcal/m^2/year (0.5% of net primary production of these meadows). Rodent consumption calculated by method I in 1970 was up to 12.1 kcal/m^2/year (0.6% net primary production).

Andrzejewska 1971, Andrzejewska, Wójcik 1971 studied the effect of two dominant groups of phytophagous invertebrates (*Orthoptera* and *Homoptera-Auchenorrhyncha*) on primary production of Strzeleckie Meadows. Consumption of *Orthoptera* (according to the comparative data for the period 1964–1968) is from 9 to 313 kcal/m^2/year at a density ranging from 0.6 to 20 individuals/m^2/year. *Orthoptera* together with *Homoptera* consume from 14.5 to 324.6 kcal/m^2/year (Andrzejewska 1971, Andrzejewska, Wójcik 1971, unpublished data obtained from the Department of Grassland Ecosystems, Institute of Ecology, Polish Academy of Sciences).

The consumption value of phytophagous invertebrates is from 0.7 to 15.5% of net primary production of Strzeleckie Meadows.

Comparing the percentage of primary production losses on the Meadows

due to phytophagous invertebrates and rodents, it can be said that the rodents affect the energy circulation in the examined ecosystem.

Grodziński et. al.(1966) carried out studies on the effect of rodents on primary production of meadows in Western Bieszczady. On the examined area *Pitymys subterraneus* (de Selys-Longch.) populations dominated, and *Microtus agrestis* L. to a lesser extent. Average density of rodents on mountain meadow pastures was estimated as about 15/ha (13 *Pitymys subterraneus*, 2 *Microtus agrestis*). Annual food consumption by rodents was about 76,000 kcal/ha, which is about 1.03% of annual net primary production.

Gębczyńska (1970) in studies on the bioenergy of *Microtus oeconomus* (Pall.) population estimated the consumption value of these rodents in relation to the net primary production of a drainaged peatbog in Augustów Forest: *Microtus oeconomus* was very abundant and ranged from 56 to 131 individuals/ha. The losses in net primary production due to the rodents were 3.1%.

Comparing these literature data with obtained ones it can be said that in all three ecosystems the rodents utilize only a slight percentage of net primary production as having a small influence upon the energy circulation in ecosystems.

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OCENA KONSUMPCJI GRYZONI W EKOSYSTEMIE ŁĄKOWYM NALEŻĄCYM DO ZBIOROWISKA RZĘDU *MOLINIETALIA*

Streszczenie

Oszacowano konsumpcję gryzoni na śródleśnej łące należącej do zbiorowiska rzędu *Molinietalia*.

W ciągu dwuletnich badań (1969 i 1970r.) stwierdzono, że ekosystem ten zamieszkuje 7 gatunków gryzoni, wśród których dominowały *Apodemus agrarius* (Pall.) i *Microtus arvalis* (Pall.). Dziesięciodniowe serie badań przeprowadzono metodą CMR na podstawowej powierzchni próbnej o wielkości 1 ha.

Porównując liczbę gryzoni na powierzchni 1 ha oraz na obszarze 2, 3 i 4 ha, stwierdzono, że powierzchnia jednohektarowa dobrze określa liczebność gryzoni w lecie. Przy jesiennym naturalnym wzroście liczebność gryzoni, powierzchnia 1 ha daje wyniki zawyżone.

Na podstawie liczebności gryzoni w cyklu rocznym na powierzchni 1 ha (tab. I) obliczono konsumpcję.

Konsumpcję gryzoni oszacowano z iloczynu liczby osobnikodni i dziennego zapotrzebowania pokarmowego 1 osobnika (I sposób) oraz z iloczynu liczby osobnikodni i konsumpcji jednego osobnika w ciągu dnia (II sposób, tab. III). Wartość konsumpcji obliczonej dwoma sposobami jest podobna. Sposób I daje wartości większe średnio o 7,8%. Konsumpcja gryzoni wynosiła w pierwszym roku badań 9,5 kcal/m²/rok (0,5% produkcji pierwotnej netto badanych łąk) i w drugim roku 12,1 kcal/m²/rok (0.6% produkcji pierwotnej).

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