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ANALYSIS OF A SHEEP PASTURE ECOSYSTEM IN THE PIENINY MOUNTAINS (THE CARPATHIANS)

XIII. QUANTITATIVE DISTRIBUTION, RESPIRATORY METABOLISM AND SOME SUGGESTION ON PRODUCTION OF NEMATODES*

ABSTRACT: It was found that the numbers of nematodes ranged from 3 to 4 millions per m^2, and biomass from about 1.5 to 3 g. Their cumulative respiratory metabolism was 41–65 kcal/m^2/year, and consumption ranged from 100 to 200 kcal/m^2/year. The highest values of these parameters were recorded for the unutilized pasture plot. The numbers of microbivorous and fungivorous groups tended to increase, while those of omnivorous group tended to decrease with increasing input of sheep manure.

Contents

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1. INTRODUCTION

In relation to the authors study on the role of nematodes in different ecosystems, some papers have already been published on the nematodes of afforested dunes (W a s i l e w s k a 1970, 1971a), potato and rye crops (W a s i l e w s k a 1974a), and a mountain pasture in Bulgaria (W a s i l e w s k a 1974b). The present paper represents a continuation of the same kind of studies. They were conducted in a mountain pasture located in the Male Pieniny mountains, near village the Jaworki, southern Poland. The Department of Biocenology, Institute of Ecology, Polish Academy of Sciences has made an attempt to estimate the total energy flow through a mountain pasture ecosystem. The objective of the author's work was to characterize the role of nematodes in that ecosystem. The management of the pasture was typical for that region: some parts of the pasture were used as grazing lands, other, small parts, were enclosed and used as sheep folds. There were differences in the rate of fertilizing with sheep manure between these two parts differently utilized. Due to these differences it was possible to determine the effect of the intensity of fertilizing on some biological and chemical processes occurring within the mountain pasture ecosystems. In this regard, the numbers and respiratory metabolism of different nematode trophic groups were also analysed, and energy flow through the whole nematode community was estimated.

2. STUDY AREA

The study area was covered with *Lolio-Cynosuretum* R. Tx. 1937 association (T r a c z y k an K o c h e v 1974). This originally uniform plant association has been differentiated as a result of the differences in the way of its utilization. Three plots were selected accordingly:

1. An ordinary used part of the pasture grazed by sheep throughout the growing season. Therefore, the sheep manure input was uniformly distributed in time. This plot is called "the pasture" in this paper.
2. An enclosed, inaccessible for sheep part of the pasture, thus neither fertilized nor grazed, nor treated in any other way (mown, for instance). This plot is called "the unutilized pasture".
3. A similarly enclosed part of the pasture used as a sheep-fold. Sheep stayed in the fold for 2–3 successive nights and during milking. This was of utilization resulted in covering the ground with an uniform layer of manure, and in the total destruction of the vegetation, which was followed by its luxurious growth. The manure input was limited to a short period of time but it was very intensive and amounted to about 500 g of dry weight/m^2 per folding period. Such areas were used as grazing lands several months later. This system of fertilizing is comparatively little diversified and results in an

excess of nitrogen and potassium in the soil, accompanied by a defficiency in the phosphorus content (Czerwiński and Tatur 1974b). As a result of putting sheep in the fold there was an increase in the content of available mineral compounds in soil, a rise in plant production and in the numbers of bacteria (Czerwiński et al. 1974).

The pasture under study was situated on brown soils containing about 4–5% of organic matter to a depth of 10 cm (Czerwiński and Tatur 1974a).

The three study plots have been arranged according to the increasing rate of fertilizing with sheep manure:

Unutilized pasture — Pasture — Sheep-fold →

The rate of fertilizing with sheep manure

3. METHODS

The studies were carried out from May, 1970 to April, 1971 except in January and February. The samples of soil were taken once a month or occasionally every two months with a core (the volume of the container was 50 cm^3) to a depth of 25 cm. In each of the three plots 20 cores were taken at random. From the mixed soil of the original cores 4 subsamples of 25 ml each were taken to extract nematodes. Nematodes were extracted by means of the modified Baermann method described in the preceding papers (Wasilewska 1970, 1971a and 1974a).

The numbers and biomass of nematodes were estimated in each subsample (two of them were analysed as a whole, and from two others several smaller subsamples were taken using the dilution method). Information on the reliability of the results for this method of data processing is presented in another paper (Wasilewska 1974a). The average annual estimated of numbers and biomass are based on 24–32 soil subsamples for each of the three plots.

The extracted individuals were identified to genus and only in some cases to species, mainly basing on the classification by Goodey (1963). Adults and juveniles were distinguished. The principle of distinguishing the trophic groups was presented elsewhere (Wasilewska 1971a and 1971b).

The body weight of an in individual was found by Andrássy method (1956), and the community biomass was calculated as a sum of the body weight of all individuals in a representative sample.

Respiratory metabolism of the community was calculated as a sum of the respiration of individuals in the sample. To estimate respiratory rate, a regression formula was used as reported by Klekowski, Wasilewska and Paplińska (1972). This regression concerns the relation of adult nematode body weight to respiratory rate at 20°C (R = 1,40 W where R is the amount of oxygen consumed by an individual per time unit and W is the body weight). Another paper of these authors indicates that the respiratory rate of juveniles is higher than that of adults (Klekowski, Wasilewska and Paplińska 1974). They have found that the metabolic rate (R/W ratio) of the youngest juveniles of *Panagrolaimus rigidus* is even more than 300% higher than that of adults. The increase in the metabolic rate of juveniles ranged from 140 to 317% of that of adults. It has been assumed that the relation found for *P. rigidus* is the same for all investigated nematode species. Successive juvenile stages were not distinguished, therefore it was assumed that the metabolic rate of juveniles was twice as high as that of adults. In this regard a correction was introduced into the calculation of the community metabolism. Namely, the values of oxygen consumption by juveniles, calculated according to the above formula, was firstly doubled and then added to the values of oxygen consumption of the adults. This correction was not considered in preceding papers where the cost of maintenance (respiratory metabolism) of the nematode group was calculated (W a s i l e w s k a 1971 and 1974a).

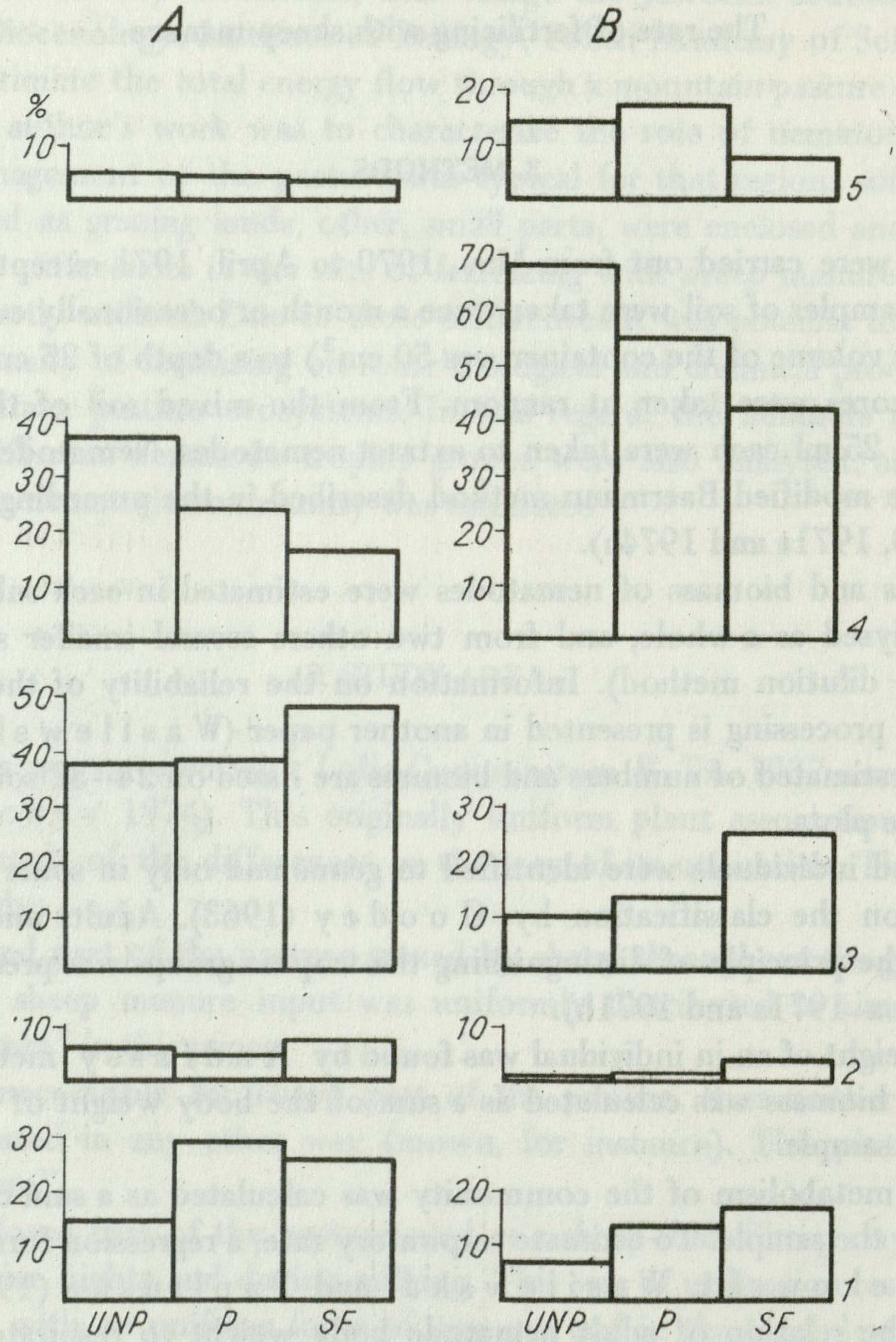

Fig. 1. Percentage contribution of particular trophic groups of nematodes to the total nematode community on the basis of *A* – mean annual numbers of individuals, *B* – mean annual biomass.

UNP – unutilized pasture, *P* – pasture, *SF* – sheep fold, 1 – microbivorous, 2 – fungivorous, 3 – parasites of higher plants, 4 – omnivorous, 5 – predators

To calculate the oxygen consumption at the actual soil temperatures, the normal curve of Krogh recalculated by W i n b e r g (1968) was used. The average monthly soil temperatures measured to a depth of 5 cm were (in °C): May 1970 – 10, June 15, July 17, August 17, September 12, October 7, November 5, December 1.

The respiratory metabolism of the trophic group is presented in Tables I, II, III, IV and V. It is calculated in energy units, assuming that 1 l 0_2 is an equivalent to 4.6 kcal.

4. RESULTS

Numbers, biomass and respiratory metabolism are presented for each of the considered nematode trophic groups inhabiting the three study plots. The most numerous were either plant parasite and microbivorous groups or microbivorous and omnivorous groups (Fig. 1*A*). Different results are obtained when the proportions among biomass are considered (Fig. 1*B*).

4.1. M i c r o b i v o r o u s g r o u p

The following genera of this group were found in the plots: *Diplogaster* s.l., *Rhabditis* s.l., *Panagrolaimus, Cephalobus, Eucephalobus, Heterocephalobus, Acrobeloides, Chiloplacus, Prismatolaimus, Monhystera, Tripyla* and *Alaimus.*

The estimates of numbers, biomass and respiratory metabolism of this nematode group throughout the year are indicated in Table I. It is characteristic that the average annual numbers, biomass and cumulative respiratory metabolism are higher in the plots fertilized with sheep manure than in the unutilized pasture plot (Tab. I). The most probable explanation is that these parameters depend on fertilizing. Fertilizing has indirect effect, namely, through the development of bacterial flora. The recorded numbers of bacteria in the sheep-fold plot was almost twice as high as in the pasture plot; it was also higher in the pasture plot than in the unutilized pasture plot (J a k u b c z y k 1974). According to the data of G o u r and P r a s a d (1970), application of farmyard manure also resulted in an increase of the saprozoic nematodes. The relation of the numbers of the microbivorous nematodes to the humus content (thus probably to the development of microbial flora and fungi associated with humus) was also observed in the dunes of the Kampinos Forest (W a s i l e w s k a 1971a). In both the cases (either manure or humus) the substrate for bacterial flora development is concerned, upon which the microbivorous group is dependent.

4.2. F u n g i v o r o u s g r o u p

This group consisted of four genera: *Aphelenchoides, Aphelenchus, Paraphelenchus* and *Nothotylenchus.* It was scarce as compared with other groups. Its respiratory metabolism tended to increase with increasing rate of fertilizing by sheep (Tab. II).

Tab. I. Numbers, biomass and respiratory metabolism of the microbivorous nematode group in the plots

Months 1970/1971	Unutilized pasture			Pasture			Sheep-fold		
	numbers	biomass	respiratory metabolism	numbers	biomass	respiratory metabolism	numbers	biomass	respiratory metabolism
	$10^3/m^3$	mg/m^2	$cal/m^2/hr$	$10^3/m^2$	mg/m^2	$cal/m^2/hr$	$10^3/m^2$	mg/m^2	$cal/m^2/hr$
V	250*	146*	0.285*	800	253	1.044	800	217	1.007
VI	300	76	0.446	500	73	0.676	900	224	1.909
VII	650*	121*	0.718*	400	104	0.934	200	58	0.741
VIII	650*	121	0.718 *	600*	196*	1.104*	1 100*	446*	2.093*
IX	000	165	0.984	800	288	1.274	2 000	834	3.441
X	500	137	0.354	700	108	0.478	100	19	0.097
XI	400	522	0.175	1 300	233	0.676	450*	57*	0.147*
XII	600*	354*	0.220*	1 200*	215*	0.502*	450*	57*	0.147*
III	800	186	0.271	1 100	207	0.322	800	94	0.198
IV	200	216	0.124	2 600	1 316	2.571	1 200	271	0.961
Average annual	535±173***	204±92	0.429±0.194	1 000±432	298±247	0.960±0.435	800±378	228±170	1.074±0.747
Cumulative respiratory metabolism	$kcal/m^2/year$? 3.2**			$kcal/m^2 year$ = 7.1			$kcal/m^2/year$ = 7.9		

*interpolated values.
**without the values for January and February 1971.
***with 95% confidence limits.

Tab. II. Numbers, biomass and respiratory metabolism of the fungivorous nematode group in the plots

Months 1970/1971	Unutilized pasture			Pasture			Sheep-fold		
	numbers	biomass	respiratory metabolism	numbers	biomass	respiratory metabolism	numbers	biomass	respiratory metabolism
	$10^3/m^2$	mg/m^2	$cal/m^2/hr$	$10^3/m^2$	mg/m^2	$cal/m^2/hr$	$10^3/m^2$	mg/m^2	$cal/m^2/hr$
V	100*	7*	0.184*	200	9	0.101	200	46	0.161
VI	200	14	0.253	300	29	0.317	400	33	0.465
VII	200*	11*	0.179*	200	42	0.584	200	37	0.363
VIII	200*	11*	0.179*	150*	29*	0.331*	150*	24*	0.212*
IX	200	8	0.106	100	15	0.078	100	10	0.055
X	100	4	0.032	0	0	0	400	101	0.368
XI	300	47	0.097	100	26	0.046	250*	65*	0.216*
XII	400*	58*	0.101*	150*	23*	0.051*	250*	65*	0.216*
III	500	69	0.110	200	20	0.055	100	30	0.064
IV	0	0	0	100	12	0.069	200	98	0.193
Average annual	220±100	23±17	0.124±0.051	150±55	21±7	0.163±0.127	225±72	51±21	0.231±0.090
Cumulative respiratory metabolism	$kcal/m^2/year = 0.9$			$kcal/m^2/year = 1.2$			$kcal/m^2/year = 1.7$		

Explanation as in Table I.

Tab. III. Numbers, biomass and respiratory metabolism of the nematodes of the group of the parasites of higher plants

Months 1970/1971	Unutilized pasture			Pasture			Sheep-fold		
	numbers	biomass	respiratory metabolism	numbars	biomass	respiratory metabolism	numbers	biomass	respiratory metabolism
	$10^3/m^2$	mg/m^2	$cal/m^2/hr$	$10^3/m^2$	mg/m^2	$cal/m^2/hr$	$10^3/m^2$	mg/m^2	$cal/m^2/hr$
V	500*	123*	0.768*	1 800	289	1.463	1 100	185	1.053
VI	900	225	1.486	2 000	425	2.935	2 300	534	4.743
VII	1 750*	369*	2.286*	800	248	1.955	1 300	195	1.794
VIII	1 750*	369*	2.286*	1 200*	386*	2.110	1 350*	330*	2.038
IX	2 600	512	3.087	1 600	523	2.263	1 400	464	2.282
X	2 000	302	1.104	1 200	267	0.915	1 400	390	1.182
XI	1 700	414	1.178	1 100	176	0.506	1 550*	322*	0.823*
XII	1 450*	326*	0.823*	1 500*	212*	0.460*	1 550*	322*	0.823*
III	1 200	238	0.465	1 900	249	0.419	1 700	253	0.465
IV	100	20	0.051	400	137	0.409	1 600	349	1.247
Average annual	1 395±502	290±0.639	1 350±345	1 350±345	291±81	1.344±0.629	1 525±218	334±75	1.645±0.835
Cumulative respiratory metabolism	$kcal/m^2/year$ = 9.9			$kcal/m^2/year$ = 9.9			$kcal/m^2/year$ = 12.1		

Explanation as in Table I.

4.3. Group of the parasites of higher plants

In the study plots 24 nematodes species belonging to 12 genera were recorded: *Tylenchus davainei* (Bastian, 1865) Filipev, 1934, *T. discrepans* Andrássy, 1964, *T. ditissimus* Brzeski, 1963, *T. leptosoma* de Man, 1880, *T. orbus* Andrássy, 1954, *T. vulgaris* Brzeski, 1963, *Aglenchus costatus* (de Man, 1921) Meyl, 1960, *Basiria duplexa* (Hagemeyer, Allen, 1952) Geraert, 1968, *B. tumida* (Colbran, 1960) Geraert, 1968, *Tylenchorhynchus dubius* (Buetschli, 1973) Filipev, 1936, *Ditylenchus intermedius* (de Man, 1880) Filipev, 1936, *D. valveus* Malek, 1968, *Heterodera* sp., *Meloidogyne* sp., *Rotylenchus fallorobustus* Sher, 1965, *Helicotylenchus pseudorobustus* (Steiner, 1914) Golden, 1956, *H. canadensis* Waseem, 1961, *Pratylenchus crenatus* Loof, 1960, *P. alleni* Ferris, 1961, *Paratylenchus aciculus* Brown, 1959, *P. elachistus* Steiner, 1949, *P. besoekianus* sensu Geraert, 1968, *P. microdorus* Andraassy, 1959, *Boleodorus thylactus* Thorne, 1941. *D. valveus* and *P. alleni* are new to the Polish fauna.

When the role of the group of plant parasites is estimated, orientation is needed whether these are facultative or obligatory parasites; hence the necessity of identification to species. The effect of this nematode group on primary production may be much greater than their actual consumption (Wasilewska 1972). The most abundant among the species presented above were migratory root parasites of the genera *Helicotylenchus*, *Rotylenchus* and *Paratylenchus*, while obligatory parasites, such as *Heterodera* sp. and *Meloidogyne* sp. were scarce. In this paper only the amount of food consumed by the nematodes of this group is analysed. Two species have been shown to be new to the Polish faune.

The average annual numbers, biomass and cumulative respiratory metaobilsm of the parasites of higher plants did not exhibit any significant differences among the three plots (Tab. III) although the percentage contribution of the number and biomass of this group increased with increasing intensity of fertilizing by sheep (Figs. 1*A* and 1*B*). This suggests that either there is no any influence of fertilizing on this group of nematodes or that the method used to find the direct or indirect through plants influence was not reliable. There are some indications, however, that nitrogen added in various forms to the soil, also in the form ammonium compounds, significantly reduced the number of *Pratylenchus penetrans* (Walker 1971).

4.4. Omnivorous group

This group was mainly composed of *Mesodorylaimus*, *Eudorylaimus*, *Pungentus*, *Tylencholoaimus*, *Enchodelus*, *Dorylaimellus*, *Dorylaimoides*, *Tylencholoaimellus* and *Diptherophora*. Because the body size of the individuals of this group is generally large, then even small numbers of them results in large biomass of the group (like for the predator group). The response of the nematodes of this group to fertilizing with sheep manure was the most pronounced (Tab. IV). Average annual numbers, biomass and cumulative respiratory metabolism were significantly lower in the plots where sheep were present (in the pasture and sheep-fold) than in the unutilized pasture. The values for the pasture were intermediate. There was a consequent decrease in the values of these parameters with

Tab. IV. Numbers, biomass and respiratory metabolism of the omnivorous nematode group in the plots

Months 1970/1971	Unutilized pasture			Pasture			Sheep-fold		
	numbers	biomass	respiratory metabolism	numbers	biomass	respiratory metabolism	numbers	biomass	respiratory metabolism
	$10^3/m^2$	mg/m^2	$cal/m^2/hr$	$10^3/m^2$	mg/m^2	$cal/m^2/hr$	$10^3/m^2$	mg/m^2	$cal/m^2/hr$
V	800*	2 170*	5.897*	700	1 101	2.732	500	565	2.383
VI	900	2 477	9.444	1 000	1 676	7.958	700	573	4.545
VII	2 100*	2 488*	10.166*	700	1 059	4.655	600	317	2.443
VIII	2 100*	2 488*	10.166*	550*	993*	3.376*	750*	1 055*	3.984*
IX	3 300	2 500	100.88	400	926	2.098	900	1 794	5.520
X	1 400	980	2.995	900	1 497	2.355	200	119	0.308
XI	800	2 082	1.904	1 300	943	1.348	250*	230*	2.285*
XII	800*	1 744*	1.504*	1 100*	794*	1.095*	250*	230*	0.285*
III	800	1 405	1.104	900	646	0.837	300	342	0.262
IV	700	1 862	2.346	900	2 430	4.122	800	1 622	2.332
Average annual	1 370±588	2 020±354	5.640±2.795	845±189	1 207±358	3.059±1.447	525±177	685±408	2.235±1.328
Cumulative respiratory metabolism	$kcal/m^2/year$ = 41.4			$kcal/m^2/year$ = 22.5			$kcal/m^2/year$ = 16.4		

Explanation as in Table I.

Tab. V. Numbers, biomass and respiratory metabolism of the predator nematode group in the plots

Months 1970/1971	Unutilized pasture			Pasture			Sheep-fold		
	numbers	biomass	respiratory metabolism	numbers	biomass	respiratory metabolism	numbers	biomass	respiratory metabolism
	$10^3/m^2$	mg/m^2	$cal/m^2/hr$	$10^3/m^2$	mg/m^2	$cal/m^2/hr$	$10^3/m^2$	mg/m^2	$cal/m^2/hr$
V	50*	232*	1.237*	200	836	2.700	100	106	0.501
VI	100	464	2.475	200	505	2.907	100	100	0.819
VII	250*	466*	2.502*	300	892	3.223	50*	55*	0.469*
VIII	250*	466*	2.502*	150*	446*	1.927*	50*	55*	0.469*
IX	400	467	2.530	0	0	0	100	10	0.115
X	100	53	0.207	0	0	0	100	72	0.258
XI	100	467	0.754	300	257	0.626	150*	167*	0.285*
XII	200*	702*	0.741*	200*	254*	0.460*	150*	167*	0.285*
III	300	937	0.722	100	251	0.294	200	262	0.308
IV	0	0	0	100	367	0.409	100	63	0.230
Average annual	175±85	425±190	1.367±0.699	155±72	381±205	1.255±0.875	110±31	105±51	0.374±0.134
Cumulative respiratory metabolism	$kcal/m^2/year$ = 10.0			$kcal/m^2/year$ = 9.2			$kcal/m^2/year$ = 2.7		

Explanations as in Table I.

increasing rate of fertilizing. The highest numbers, biomass and cumulative respiratory metabolism of this group were observed in the less disturbed by sheep environment, i.e., in the unutilize pasture. Intensive fertilizing with sheep manure had as the result an almost threefold decrease in numbers of this group. K i m p i ń s k i and W e l c h (1971) have found that the number of dorylaims (the main representatives of the omnivorous group) decreased with the increasing content of nitrogen in soil. In addition, it seems that the omnivorous group prefers more natural habitats and it is markedly reduced, for instance, in agrocoenoses where its number is low (S a n d n e r and W a s i l e w s k a 1970, W a s i l e w s k a 1974a).

The omnivorous group in natural or approaching to natural habitats become a dominant group, which is illustrated by the situation in the pasture under study (Fig. 1, Tab. IV). Abundance and the contribution of this group to the total nematode community seem to indicate that it can be regarded as an index of an outside impact on natural environment. This needs further investigations, however, the more as the only suggestion indicating that dorylaims were more sensitive to habitat changes than other nematodes is reported by J o h n s o n and F e r r i s (1971).

4.5. P r e d a t o r g r o u p

This group consisted of two genera, *Mononchus* and *Seinura.* The contribution of predators to the total community of soil nematodes is generally low. Some representatives of this group reach large body size, which can be of importance when its total biomass is estimated. The number of this group was very low in the sheep-fold plot (Tab. V).

4.6. T h e r o l e o f n e m a t o d e s i n e n e r g y f l o w t h r o u g h t h e p a s t u r e

The role of nematodes should be considered in the energy flow through the mountain pasture where their average annual numbers ranged from 3 to nearly 4 millions and biomass from about 1.5 to 3 g/m^2, depending on the way of the pasture utilization (Tab. VI). It should be noted here that according to other authors the numbers of nematodes in meadows or pastures are significantly higher (N i e l s e n 1949 and V a s i l 'e v a 1972).

To obtain the value of net production, the formula of E n g e l m a n n (1966) was used: $\log R = 0.62 + 0.86 \log P$ (where R is the respiration of the population in kcal/m^2/year and P is net production in kcal/m^2/year). This formula was calculated from the regression between the net production of invertebrate poikilotherms and their respiratory metabolism. The values of both these parameters were taken from the data of other authors.

The formula of Engelmann was used to calculate the net production of all nematode groups jointly. It was not used to calculate the net production of particular trophic groups as it only gives an approximate value. The results, including the calculated values of assimilation, are presented in Table VI. These approximate values of production and assimilation indicate, however, the order of magnitude for the energy that can be transferred to the next trophic level. Nematodes transfer nearly two times more energy in the unutilized pasture plot (ungrazed and not used as a sheep-fold, thus not fertilized) than in the sheep-fold plot (fertilized with sheep manure at a high rate). Even the grazed pasture plot (with uniform and permanent manure input) has lower values of energy that can be transferred to the next trophic level as compared with unutilized pasture. The latter was not supplied with organic matter in the form of sheep manure but also there was no organic matter losses in the form of consumed grass or as a result of treading.

Assimilation coefficient is certainly differentiated within nematodes according to the trophic group. To calculate consumption, it was accepted after Kitazawa (1967) that the defecation/ingestion ratio is 0.5 and therefore A/C is 50%, because there is no detailed information on this subject. The obtained values of consumption (Tab. VI) are averages for all nematodes and it is known that trophic diversification is very large (Fig. 1, Tabs. I-V). Nevertheless, it gives an approximate value of energy taken by the nematodes in the pasture.

Tab. VI. Annual energy flow through the nematodes in the unutilized pasture, pasture and sheep-fold

Station	Numbers	Wet biomass	Cumulative respiratory metabolism	Net production	Assimilation	Consumption
	$10^3/m^2$	g	kcal/m^2/year	kcal/m^2/year	kcal/m^2/year	kcal/m^2/year
Unutilized pasture	3 695	3.0	65	25	91	182
Pasture	3 500	2.2	50	18	68	136
Sheep-fold	3 185	1.4	41	14	55	110

5. APPENDIX

To give a general characteristics of soil nematodes inhabiting the mountain sheep pastures of the Male Pieniny mountains, the number of individuals was estimated in the soils of different types and the genera occurring there were identified. The samples of soil were taken from 18 plots on August 25, 1971. The geobotanical characteristics of the plots has been presented by Czerwinski, Kotowska and Tatur (1974). These authors has classified the soils of the plots under study as follows (the same symbols are used as in the paper cited above; type 1b is not included because nematodes were not analysed there):

1a – redzina of the initial stage of development,

1c – brown-earth redzina formed on various limestones – two plots,

1d – typical brown redzina derived from deluvial weathering of various limestones – one plot,
1e – brown nonuniform pseudogley leached soil developed from deluvial weathering of limestones – two plots,
1f – brown leached pseudogley soil formed from deluvial weathering of limestones – one plot,
2a – brown acid pseudogley soil derived form sandstones – one plot,
2b – brown leached pseudogley soil derived from sandstones – one plot,
2c – brown leached pseudogley soil derived from mudstones – four plots,
2d – brown leached nonuniform pseudogley soil derived from mudstones and sandstones – one plot,
3a – typical brown soil developed from globotruncate marls – two plots,
3b – brown leached soil developed from globotruncate marls – two plots.

From each plot 10 soil cores 25 cm deep were taken. Each sample was extracted by the modified Baermann method. The number of nematodes in different types of soil is given in Figure 2. There were great differences in nematode numbers. It seems that the parent rock (*I* and *II* – limestones, *III* and *IV* – sandstones, *V* and *VI* – marls) is not responsible for these differences because both high and low nematode numbers were found in each group. The differences were very high for both redzina and brown soils

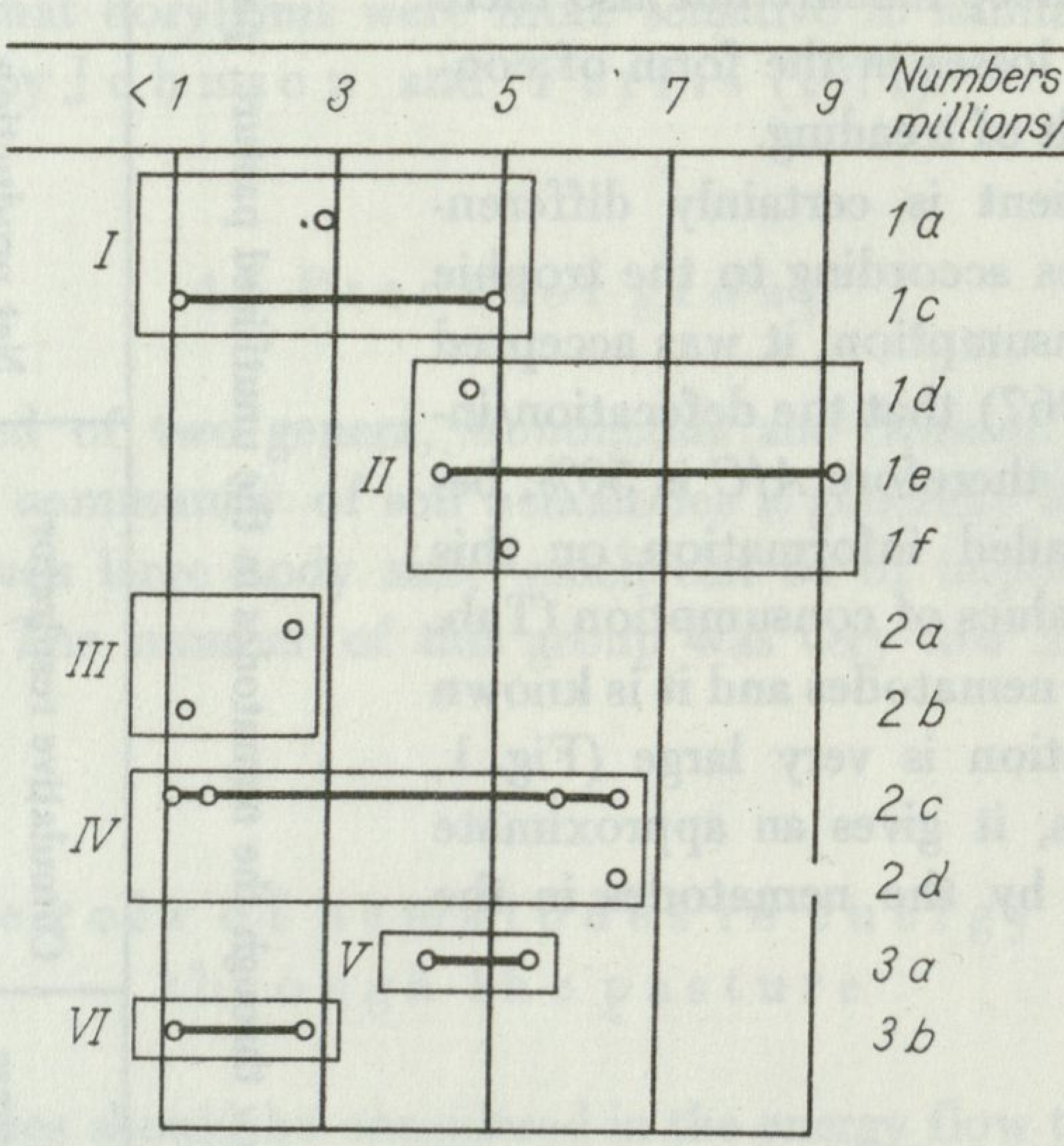

Fig. 2. The number of nematodes in the mountain pastures classified according to the type of soil

For the explanations of the types of soil see the text

The effect of both the pH values and the content of carbon in soil on the number of nematodes is given in Figure 3 (the pH values and percentage of C are taken from C z e r w i ń s k i, K o t o w s k a and T a t u r 1974). The nematode numbers were the highest in the plots with the highest pH values. The highest numbers were observed in the brown nonuniform leached soil developed from deluvial weathering of limestones with pH 4.7 to 5.1. There is no simple correlation between the content of carbon and the nematode numbers. It is readily visible that in highly alkaline soil of the ranker type with a high content of humus, the number of nematodes was low. At other levels of humus content the range of differences in numbers was very great.

The nematodes of all trophic groups were found in the plots in question. They belong to 40 genera. The numbers of the genera occurring in the majority of soil types were very high in some plots. Only two genera, *Neotylenchus* (one species) and *Meloidogyne* (one species) reached high numbers in only one type of soil.

The contribution of particular groups of nematodes to the total number of nematodes in the

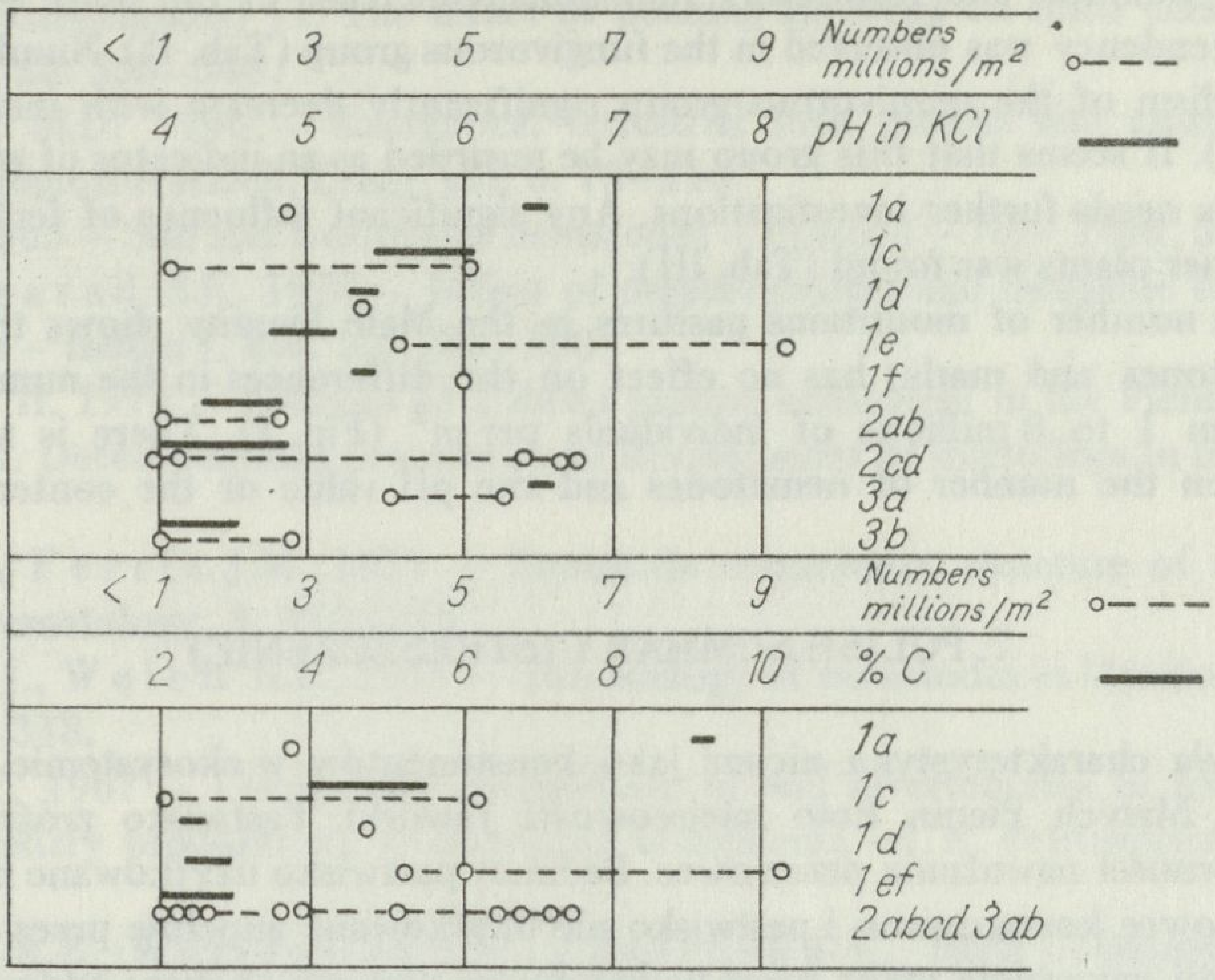

Fig. 3. The number of nematodes in the mountain pastures in relation to the pH value and the content of carbon in soil

For the explanations of the types of soil see the text

majority of the plots was as follows: microbivorous group 25%, fungivorous group 14%, parasites of higher plants 37%, omnivorous group 22% and predators 2%. Therefore, the group of the parasites of higher plants predominated. The presence of predators and a relatively high contribution of omnivorous group were characteristic of all the pasture habitat under study. If the percentage contributions of particular trophic groups are calculated on the basis of biomass or metabolism, the omnivorous group and even predators have a higher position because of a larger size of individuals. The study of the distribution and production of nematodes was carried out only in the soil types 2c, 2d and 3a.

I am grateful to Dr. H. Rudzka for organizing the sampling of soil nematodes on the occasion of taking the samples for soil mites. I also wish to thank E. Paplińska, M. Sc. for the laboratory assistance.

6. SUMMARY

The objective of the study was to characterize nematodes as consumers in one of the mountain pastures of the Male Pieniny mountains, near the village Jaworki. They were differences in the rate of manuring by sheep between particular parts of the pasture. The studies were carried out in a grazed part of the pasture, in an enclosed part of the pasture where sheep were penned-up and in an unutilized part of the pasture. The effect of the intensity of manuring by sheep on the numbers and respiratory metabolism of different nematode trophic groups was analysed and the net production of the total nematode community was estimated. It has been found that:

1. The number of nematodes in the mountain pasture under study ranged from 3 to 4 millions per m^2 and their biomass was about 1.5–3 g. The cumulative respiratory metabolism ranged from 41 to 65 kcal/m^2/year. The net production, assimilation and consumption estimated indicate that nematodes represent a rather important component of the comprehensive studies on energy flow through the ecosystem. The approximate estimate of the consumption is about 100–200 kcal/m^2/year and assimilation is 50–100 kcal/m^2/year (Tab. IV).

2. The highest numbers, respiratory metabolism and production of nematodes were recorded in the unutilized pasture, and that lowest ones in the sheep-fold. So, if all nematodes are analysed as a group, these parameters are inversely correlated with the intensity of fertilizing with sheep manure (Tabs. I-VI).

3. The microbivorous groups seems to be markedly dependent on fertilizing with sheep manure

(Tab. I). Both their numbers and respiratory metabolism increase in the plots fertilized with sheep manure. A similar tendency was observed in the fungivorous group (Tab. II). Numbers and cumulative respiratory metabolism of the omnivorous group significantly decrease with increasing intensity of fertilizing (Tab. IV). It seems that this group may be regarded as an indicator of an outside impact on biocoenosis but this needs further investigations. Any significant influence of fertilizing by sheep on the parasites of higher plants was found (Tab. III).

4. Analysis of a number of mountains pastures in the Male Pieniny shows that the parent rock (limestones, sandstones and marls) has no effect on the differences in the numbers of nematodes, which ranged from 1 to 8 millions of individuals per m^2 (Fig. 2). There is no any pronounced relationship between the number of nematodes and the pH value or the content of carbon in soil (Fig. 3).

7. POLISH SUMMARY (STRESZCZENIE)

Celem pracy była charakterystyka nicieni jako konsumentów w ekosystemie jednego z pastwisk górskich w paśmie Małych Pienin koło miejscowości Jaworki. Pastwisko zróżnicowane było pod względem intensywności nawożenia przez owce. Badano: pastwisko użytkowane na wypas, pastwisko odgrodzone, gdzie owce koszarowano i pastwisko nie użytkowane zupełnie przez owce. Analizowano wpływ intensywności nawożenia przez owce na liczebność oraz metabolizm oddechowy różnych grup troficznych nicieni. Dokonano też określenia szacunkowej wartości czystej produkcji całego zgrupowania nicieni na trzech stanowiskach. Stwierdzono, iż:

1. Na badanym pastwisku górskim wystąpiło od 3 do 4 milionów nicieni na 1 m^2 o biomasie od około 1,5 do 3 g. Metabolizm oddechowy ich wynosił od 41 do 65 kcal/m^2/rok. Oszacowana czysta produkcja, asymilacja i konsumpcja wskazują, iż w całościowych badaniach nad przepływem energii w ekosystemie nicienie stanowią dość ważny element. Oszacowana z grubsza konsumpcja wynosi około 100–200 kcal/m^2/rok i asymilacja około 50–100 kcal/m^2/rok (tab. VI).

2. Największą liczebność, metabolizm i produkcję nicieni stwierdzono na pastwisku nie użytkowanym, najmniejszą – na stanowisku gdzie owce koszarowano. Zatem jeśli analizować całą grupę nicieni łącznie, to parametry te były ujemnie skorelowane ze wzrostem intensywności nawożenia przez owce (tab. I IV).

3. Grupa bakterofagów wydaje się znacznie uzależniona od nawożenia przez owce (tab. I). Liczebność jej i metabolizm oddechowy zwiększał się na stanowiskach nawożonych przez owce. Podobną tendencję obserwowano w grupie mikofagów (tab. II). Liczebność i metabolizm oddechowy grupy wszystkożerców zdecydowanie maleje w miarę wzrostu intensywności nawożenia (tab. IV). Wydaje się, iż można by grupę tę traktować jako indykator wszelkich zakłóceń trwałej biocenozy, co jednak wymaga dalszego potwierdzenia. Nie stwierdzono wyraźnego wpływu nawożenia przez owce na grupę pasożytów roślin wyższych (tab. III).

4. Z analizy całego szeregu pastwisk górskich w Małych Pieninach wynika, iż skała macierzysta (wapienie, piaskowce i margle) nie różnicowała liczebności nicieni, wahającej się na danym terenie od około 1 do 8 milionów osobników/m^2 (fig. 2). Nie udało się stwierdzić wyraźnej zależności liczebności nicieni od pH i zawartości węgla w glebie (fig. 3).

8. REFERENCES

1. A n d r á s s y I. 1956 – Die Rauminhalts und Gewichtbestimmung der Fadenwürmen (Nematoden) – Acta zool. Acad. Sci. Hung. 11: 1–15.
2. C z e r w i ń s k i Z., J a k u b c z y k H., T a t u r A., T r a c z y k T. 1974 – Analysis of a sheep pasture ecosystem in the Pieniny mountains (the Carpathians). VII. The effect of penning-up sheep on soil, microflora and vegetation – Ekol. pol. 22: 547–558.
3. C z e r w i ń s k i Z., K o t o w s k a J., T a t u r A. 1974 – Analysis of a sheep pasture ecosystem in the Pieniny mountains (the Carpathians). I. Short geobotanical characteristics – Ekol. pol. 22: 475–486.
4. C z e r w i ń s k i Z., T a t u r A. 1974a – Analysis of a sheep pasture ecosystem in the Pieniny mountains (the Carpathians). II. The soil-geological conditions – Ekol. pol. 22: 487–504.
5. C z e r w i ń s k i Z., T a t u r A. 1974b – Analysis of a sheep pasture ecosystem in the Pieniny

mountains (the Carpathians) VI. The effect of penning-up sheep on some chemical properties of soil – Ekol. pol. 22: 535–546.

6. Engelmann M.D. 1966 – Energetics, terrestrial field studies and animal productivity – Advances in ecological research, Cragg, vol. 3: 73–115.
7. Goodey T. 1963 – Soil and freshwater nematodes – London – New York, 544 pp.
8. Gour A.C., Prasad S.K. 1970 – Effect of organic matter and inorganic fertilizer on soil and plant nematodes – Indian J. Ent. 32: 186–188.
9. Jakubczyk H. 1974 – Analysis of a sheep pasture ecosystem in the Pieniny mountains (the Carpathians). IX. Decomposition processes and development of microflora in the soil – Ekol. pol. 22: 569–588.
10. Jonson S.R., Ferris J.M. 1971 – Nematode community structure of selected deciduous woodlots – J. Nematology, 3: 315–316.
11. Kimpiński J., Welch H.E. 1971 – The ecology of nematodes in Manitoba soils – Nematologica, 17: 308–318.
12. Kitazawa Y. 1967 – Community metabolism of soil invertebrates in forest ecosystems of Japan (In: Secondary productivity of terrestrial ecosystems, ed. K. Petrusewicz) – Warszawa-Kraków, 649–661.
13. Klekowski R.Z., Wasilewska L., Paplińska E., 1972 – Oxygen consumption by soil-inhabiting nematodes – Nematologica, 18: 391–403.
14. Klekowski R.Z., Wasilewska L., Paplińska E. 1974 – Oxygen consumption in developmental stages of *Panagrolaimus rigidus* – Nematologica, 20: 61–68.
15. Nielson C. Overgaard, 1949 – Studies on the soil microfauna. II. The soil inhabiting nematodes – Natura jutl. 2: 1–132.
16. Sandner H., Wasilewska L. 1970 – The role of the habitat in forming communities of soil nematodes – Zesz. probl. Post. Nauk roln. 92: 391-408.
17. Traczyk T., Kochev Kh. 1974 – Analysis of a sheep pasture ecosystem in the Pieniny mountains (the Carpathians). III. Primary production of *Lolio-Cynosuretum* association – Ekol. pol. 22: 505–516.
18. Vasil'eva I.N. 1972 – Chislennost i vertikalnye raspredelene nematod v lugovoj pochve – Zool. Zhurn. 51: 1563–1565.
19. Walker J.T. 1971 – Populations of *Pratylenchus penetrans* relative to decomposing nitrogenous soil amendments – J. Nematology, 3: 43–49.
20. Wasilewska L. 1970 – Nematodes of the sand dunes in the Kampinos Forest. I. Species structure – Ekol. pol. 18: 429–443.
21. Wasilewska L. 1971a – Nematodes of the sand dunes in the Kampinos Forest. II Community structure based on numbers of individuals, state of biomass and respiratory metabolism – Ekol. pol. 19: 651–688.
22. Wasilewska L. 1971b – Klasyfikacja troficzna nicieni glebowych i roślinnych – Wiad. ekol. 17: 379–388.
23. Wasilewska L. 1972 – Nicienie jako pasożyty roślin wyższych – Kosmos A, 118: 475–489.
24. Wasilewska L. 1974a – Number, biomass and metabolic activity of nematodes of two cultivated fields in Turew. – Zesz. probl. Post. Nauk roln. 154: 419–442.
25. Wasilewska L. 1974b – Evaluation of quantitative distribution of soil nematodes of a pasture in the vicinity of Sofia – Zesz. probl. Post. Nauk roln. 154: 213–225.
26. Winberg G. G. 1968 – Metody opredelenie produkcji vodnykh zhivotnykh – Minsk, 247 pp.

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