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Lucyna WASILEWSKA

Department of Soil Ecology, Institute of Ecology,
Polish Academy of Sciences, Dziekanów Leśny near Warsaw, 05-092 Łomianki, Poland

LONG-TERM CHANGES IN COMMUNITIES OF SOIL NEMATODES ON FEN PEAT MEADOWS DUE TO THE TIME SINCE THEIR DRAINAGE

ABSTRACT: Reaction of nematodes is related to physical and chemical properties of fen peat soils differentiated by peat origin and drainage time from 1 to 100 years. Drainage of peat soils was always accompanied by increasing numbers of nematodes, especially in the group of phytophages. The drainage time was always a significant factor determining the dominance structure, trophic structure and biocenotic indicators in nematode communities. On alder-fen peat the changes in communities of nematodes were greater than on sedge-moss-fen peat and sedge-fen peat depending mainly on superdominance of *Paratylenchus* sp.

KEY WORDS: Bioindicators, community structures, drainage, fens, soil nematodes, succession.

1. INTRODUCTION

A serious problem of drained peats is the gradual reduction of organic matter in soil resulting in the disappearance of peat deposits. This process is accelerated by insufficient moisture in soils poorly retaining water. Organic matter accumulated in peat under anaerobic conditions is after drainage gradually mineralized, affecting thus changes in the soil subsystem. Physical and chemical properties of peat transform it then into moorsh. Simultaneously the succession of plant associations and communities of heterotrophic organisms takes place. Short and long-term ecological results of drainage of fens are presented by K a j a k (1985) on the basis of multi-directional studies in the Biebrza river valley in 1976 – 1980 and some earlier publications. The drained marshes of the Biebrza River valley became mainly meadows and therefore the studies concerned changes in ecosystems of cultivated meadows. The rate of changes in these ecosystems depends on water relations, kind of peat, its chemical composition and kind of management (A n d r z e j e w s k a et al.

1985, Kajak 1985, Kajak et al. 1985, Wasilewska et al. 1985). The rate of these processes depends on the longevity of period since drainage (Walczyna 1973). The initial period of these changes, when mineralization is the fastest, can be distinguished.

Soil microorganisms, both microflora and soil invertebrates, decide about the rate of matter decomposition and the kind of substances produced as its result (Swift et al. 1979, Swift and Heal 1986). The ecological literature frequently presents a view that soil invertebrates favour the retention of elements in the ecosystem and change their cycling course (French 1979, Luxton 1982, Coleman et al. 1983, Sheehan 1984b). Soil organisms react fast to changes in the habitat and therefore should be used for judging the transformations and their directions. For example, in peat-moorsh soils with periodical moisture defficiency the contribution of very small saprophages having high metabolism increases at the expense of biger animals contributing to permanent relations in soil; also abundantly occurring phytophagous animals reduce the plant cover variety (Kajak et al. 1985, Wasilewska et al. 1985 and Wasilewska in press). It remains an open question whether the intensive peat decomposition under aerobic conditions also takes place under the influence of mycorrhiza (Tołpa 1956).

Nematodes are the most numerous group among soil Metazoa, whereas in grasslands they are considered as main consumers (Scott et al. 1979). Recently they have been considered as indicators of a number of soil processes and as bioindicators of contamination and degradation of natural environment (Arpin et al. 1984, Ferris and Ferris 1984/1985, Arpin and Ponge 1986, Wasilewska 1986, Zullini and Peretti 1986). It can be added that freshwater and marine nematodes have been considered for a long time as perfect bioindicators of water pollution (Ferris and Ferris 1979). The recognition of nematodes as indicators of soil processes following the drainage of fen peats can be found in papers by Soloveva (1985) and Wasilewska (in press).

The aim of the present paper is to determine the kind of changes occurring in communities of nematodes with the time from drainage. Composition and numbers of particular genera, dominance and trophic structures have been examined. It is also an attempt to decide whether communities of nematodes can be indicators of succession stages on different kinds of peat.

2. DESCRIPTION OF SITES

Research sites in the north-eastern Poland were situated in the ice-marginal valleys of Biebrza and Narew on peatlands. According to soil processes the following were distinguished: bog soil, moorsh soil and gley soil (Okruszko 1977, Liwski et al. 1984). Research sites on natural fens (not drained) were on peat soils given a symbol Pt. These soils are characterized by organic matter increment due to peat formation. Depending on the swamping the soils are distinguished as slightly swamped (Pt I), moderately swamped (Pt II) and strongly swamped (Pt III) (Table 1).

Table 1. Characteristics of stations examined, number of samples and years of studies on communities of soil nematodes acc. to my data and data obtained by Kajak et al. (1985), Kaczmarek (in press), Gotkiewicz and Szuniewicz 1987a, 1987b Gotkiewicz et al. 1983, Churski and Churska 1980; moisture-soil complexes after Okruszko (1977) and Liwski et al. (1984)

Station symbol*	Geographical name of station	Years after drainage	Moorshing stage	Bulk density of soil ($g \cdot cm^{-3}$)	Total soil porosity (%)	Meso-pores (% of vol.)	Soil moisture (% by weight) IX.82	IX.79	Plant community	Studies on communities of soil nematodes: year	number of sampling
					Sedge-moss-fen peats – moisture-soil complex A						
1 A_0	Dobarz	0**	Pt I cc	0.16	90.1		80.9		Caricetum limoso-diandrae	1981–1983	6
2 A_{1-3}	Toczyłowo	1–3	Mt I aa	0.16	89.8	55.8	80.0		*Festuca rubra, Carex rostrata*	1981–1983	7
3 A_{15-20}	Wizna A	15–20	Mt I aa	0.16	88.5	50.7	79.0	80.6	*Festuca rubra, Carex rostrata*	1978–1983	19
4 A_{100}	Sojczyn Grądowy	100	Mt				77.0		Mixture of meadow grasses	1982–1983	3
					Sedge-fen peats – moisture-soil complex B						
1 B_0	Burzyn I	0**	Pt II bb	0.15			Long stagnation		Caricetum elatiae	1979	1
2 B_0	Burzyn II	0**	Pt II bb	0.38			of water		Phalaridetum arundinaceae	1979	1
3 B_0	Dobarz	0**	Pt II bb	0.35	90.0		74.9		Peucedano-Caricetum paradoxae	1981–1983	6
4 B_0	Dolistowo	0(?)	Mt II cb	0.18			73.7	74.2	Caricetum gracilis	1979	5
5 B_{1-5}	Lipniki	1–5	Mt I bb	0.18		51.5	64.9	66.2	*Festuca rubra, Dactylis glomerata*	1978–1983	19
6 B_{15-20}	Wizna	15–20	Mt II bb	0.26	83.0	39.2	74.9	75.4	*Festuca rubra, Dactylis glomerata*	1978–1983	21
7 B_{25-30}	Kuwasy	25–30	Mt II bc	0.22			62.2		*Agrostis canina, Festuca rubra*	1978–1982	8
8 B_{50}	Toczyłowo	50	Mt II bb	0.22	84.6	41.6	64.0		*Festuca rubra, Dactylis glomerata*	1981–1983	7
9 B_{100}	Modzelówka	100	Mt III c	0.29	84.5		58.6		*Deschampsia caespitosa, Potentilla anserina*	1978–1983	20
10 B_{100}	Modzelówka	100	Mt III cb	0.33			51.6		Mixture of meadow grasses	1979	8
					Alder-fen peats – moisture-soil complex C						
1 C_0	Gugny (alder swamp)	0**	Pt						Carici elongatae-Alnetum	1981	2
2 C_{10}	Kiślaki	10	Mt II cl***	0.19	88.4		75.4		*Poa palustris, Agrostis palustris*, herbs	1982–1983	2
3 C_{15-20}	Wizna	15–20	Mt II cc	0.23	82.5	29.1	54.2	60.8	*Festuca rubra*, herbs, weeds	1978–1983	19
4 C_{30}	Pińczykowo	30	Mt II						Mixture of meadow grasses	1982	1
5 C_{50}	Kuwasy	50	Mt II cc	0.27	82.5		52.3		*Festuca rubra*, herbs, weeds	1979–1983	5
6 C_{50}	Kuwasy (birch forest)	50	Mt II cc	0.20	87.0	34.5			*Betula pubescens* Ehrh.	1979–1983	3
7 C_{50}	Toczyłowo	50	Mt II cc	0.25	84.7	35.7	52.2		*Festuca rubra*, herbs, weeds	1982–1983	2
8 C_{100}	Modzelówka	100	Mt III c	0.39	77.5		53.0		*Festuca rubra*, herbs, weeds	1982–1983	2

*Consists of a consecutive number (Arabic numerals) and the kind of moisture-soil complex (A, B, C), and years after drainage. **Undrained natural fens. ***Soils on shallow peat.

After drainage the peat structure is transformed under the influence of moorsh--forming process. Other stations were situated on areas drained at different time on moorsh soils given a symbol Mt. Depending on the stage of the moorsh-forming process the soils can be classified as: slightly moorshed (Mt I), moderately moorshed (Mt II) and strongly moorshed (Mt III) (Table 1). When characterizing the structures of organic soil formations Polish pedologists (Okruszko 1977, Liwski et al. 1984) take into consideration the degree of decomposition in two peat layers under the moorsh. Slightly decomposed peat soil formations containing up to 30% of decomposed organic matter have a spongy or fibric structure determined by symbol a. Moderately decomposed peats of an amorphic-fibric structure (30–60% of decomposed organic matter) are determined by symbol b. Strongly decomposed organic formations with an amorphic structure (over 60% of decomposed organic matter) are determined by symbol c.

With consideration to potential site conditions, depending on soils having approximate properties, the distinguished kinds of soils were grouped in bigger units determined as prognostic soil moisture complexes: wet (A), moist (B) and arid (C). Soils of complex A are formed from weakly decomposed fibric peats, mostly sedge-moss ones. These are permanently moist soils having a high inflow of ground-water and high capillary ascent. Soils of complex B are formed from moderately decomposed hemic peats, mostly sedge ones and display a high water absorbing capacity and simultaneously good aeration. Soils of complex C are formed from strongly decomposed sapric peats, mostly alder ones having high permeability and aeration. Macroporosity favours the mineralization processes and thus such soil contains plenty of mineral nitrogen. This division of organic soils, presented by Okruszko (1977) and Liwski et al. (1984) is being commonly used by Polish pedologists.

As the drained peat soils are used as cultivated meadows the research stations were located on meadows. Meadows on fens drained at different periods in the last 100 years were chosen in an order differing in time after drainage (Table 1). The factor of peat origin (Wasilewska in press) so significant for nematodes was taken into consideration as the state of soil moisture depends on it. Thus three series of stations represented the three kinds of peat. For the purpose of comparison stations on non-drained-fen peats with natural vegetation were also chosen for each kind of peat. For the series of alder-fen peat the alder swamp was chosen as the non-drained fen and the second non-meadow station was natural birch forest 50 years ago drainaged (Table 1). The latter was chosen as an example of the effect of forest utilization after drainage.

In reclaimed sedge-moss-fen and sedge-fen peats communities of plant associations develop consistently with the trend before land reclamation (i.e., towards the association of Molinio-Arrhenatheretea class). On alder-fen peat this process was disturbed due to susceptibility to overdrying of matrix soil formation (Pacowski 1977). Natural predispositions of site are such that plant associations on sedge-moss and sedge peats, under conditions of adjusted water relations, develop into relatively stable ones, protecting the top layers against excessive mineralization. Plant associations on alder peats lack stability.

In the sequence of stations from sedge-moss-fen peats through sedge-fen peats to alder-fen peats the bulk density of soil increases, whereas soil porosity decreases (especially the per cent of mesopores) as well as soil moisture. With the increasing time from drainage the intensity of the moorsh-forming process increases (from stage Mt I bb to stage Mt III c in sedge-fen peat, from stage Mt II cc or Mt II cl to stage Mt III c in alder-fen peat, and no changes in sedge-moss-fen peat examined), bulk density of soil increases, porosity percentage and soil moisture decrease (Table 1). In the series of stations on sedge-fen peat two stations drained at the same time ($9B_{100}$ and $10B_{100}$) differed considerably. Station $10B_{100}$ had a higher aridity (the lowest soil moisture of all stations) and displayed some degradation of plant cover. In the series of meadow stations on alder-fen peat there were also two forest stations: $1C_0$ (non-drained) and $6C_{50}$ (drained 50 years ago). The latter is discussed separately.

A fuller characteristics of the habitat of stations examined is given by Pałczyński (1975), Okruszko (1976), Pacowski (1977), Kajak et al. (1984, 1985) and Kaczmarek (in press).

3. METHODS

It has been assumed that the chosen sites in the order according to the time after drainage and peat origin (Table 1) should reflect the reaction of nematodes to the change of physico-chemical properties of soil after drainage, and thus their reaction to stress caused by drainage, as well as the long-term stabilization of nematode communities due to stress. In communities of nematodes the studies aimed at finding changes connected with the time after drainage. The following parameters were taken into consideration:

1. Density of specimens in genera, trophic groups and in functional groups
2. Proportions among these groups
3. Number of genera
4. Dominance structure
5. Trophic structure
6. Generic diversity of nematodes
7. Similarity among communities or smaller units
8. Mean weight of an individual in a community (data only for some stations).

Soil samples were taken by steel soil corer (2 cm^2 the opening surface and 50 cm^3 capacity) to the depth of 25 cm. On each station at the time of single sampling the soil from 20 injures taken at random was accumulated. Four portions (25 cm^3 each) of mixed soil were extracted by modified Baermann method (Wasilewska 1979). The efficiency of this extraction method approximated that by Seinhorst flotation method used for the same soil samples. Determinations of the genus (Goodey 1963, broadened) and trophic group (Wasilewska 1979) were made on the basis of three subsamples from each sampling. Many genera had a character of sensu lato, but this form was used for all stations to make the comparison possible. The body weight of nematodes was estimated by A n d r á s s y's (1956) method, measuring about 500 individuals in a sample. Generic similarity of nematode communities was determined using Marczewski and Steinhaus' index presented by R o m a n i s z y n (1972), whereas the generic diversity – by Shannon's index (H') (S h a n n o n and W e a v e r 1949).

Table 1 gives the number of sampling. The investigations were not conducted simultaneously at all stations and not all were examined with equal intensity. Thus a question could be put, whether seasonal variability or differentiation of weather conditions in particular years would not present a barrier in recognizing long-term succession changes caused by the time after drainage, i.e., changes between stations. This would first of all concern alder-fen peats which after drainage show the greatest variability in soil moisture (Fig. 1). To prove this is not so, some parameters characteristic for soil nematode-communities and determined according to 1) samples from several months in one year, taken at the same station, 2) samples for several years taken at the same station, and 3) samples at a certain date from several stations in an order according to the time after drainage. These parameters (broadly analysed further in the paper) were: numbers of *Paratylenchus* sp., percentage of omnivores and predators, ratio of numbers of bacteri- and fungivores to obligatory plant parasites and the generic diversity index. The sampling plan for the 6-years of

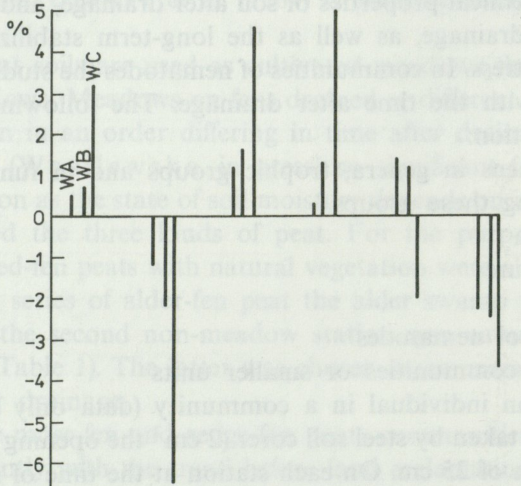


Fig. 1. Deviations from mean soil moisture (in 0 – 10 cm layer) measured in the years 1978 – 1983 on the example of 3 stations differentiated by the origin of peat. Station WA – $3A_{15-20}$, WB – $6B_{15-20}$ and WC – $3C_{15-20}$

Table 2. Sampling distribution between 1978 and 1983 at stations differing in time after drainage of alder-fen peats (Series of sampling dates explained in the text)

Station symbol* \ Months	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2 C_{10}						1982	1983		
3 C_{15-20}	1 1979 2 1980	1978 1979 1980	1979	1978 1979 1980 1981 1983 3	1978 1979	1978 1979 1982	1979 1983	1978	
4 C_{30}						1982			
5 C_{50}		1982		1983	1979		1979 1983 7		
7 C_{50}							1983 6	1982	
8 C_{100}				1983 4		1982 5			

*For explanation see Table 1.

investigations contained suitable series of dates for comparison of these four parameters (Table 2). Friedman's non-parametric test was applied (Siegel 1956). The chosen parameters did not show statistically significant differences in samples taken at the same station in different months of a given year (series $1: p > 0.99$ and series $2: 0.6 < p < 0.9$) and in July for several years at the same station (series $3: 0.5 > p > 0.3$). However, statistically significant differences were observed in parameters of samples taken at different stations (series $4: p = 0.04$, series $5: p = 0.01$, series $6: p < 0.001$ and series $7: p < 0.001$). A higher level of significance of differences for series containing a station nearest to the drainage moment – $2C_{10}$ (series 5, 6 and 7) than for series without this station (series 4) indicates the special position of this station in the succession sequence (see results). Such considerations allowed to analyse the problem of succession changes in nematode communities on the basis of material available.

Table 3. Verification of differences between physical and biotic soil parameters at stations differing by the time after drainage and the origin of peat. Friedman's test (S i e g e l 1956) was used

Station symbol	$2A_{1-3}$ $3A_{15-20}$ $4A_{100}$	$5B_{1-5}$ $6B_{15-20}$ $7B_{25-30}$ $8B_{50}$ $9B_{100}$ $10B_{100}$	$2C_{10}$ $3C_{15-20}$ $5C_{50}$ $8C_{100}$
Physical parameters of soil – degree of peat moorshing – volumetric soil density – soil moisture (as aridity)	$N=3$ $k=3$ $x_r^2=0.66$ $p>0.7$ (NS)	$N=3$ $k=6$ $x_r^2=12.76$ $p<0.05$	$N=3$ $k=4$ $x_r^2=7.9$ $p<0.03$
Biotic parameter – density of specimens in particular genera	$N=66$ $k=3$ $x_r^2=0.57$ $p>0.7$ (NS)	$N=73$ $k=6$ $x_r^2=10.08$ $0.1>p>0.05$	$N=58$ $k=4$ $x_r^2=10.9$ $p<0.01$
Above parameters – total	$N=69$ $k=3$ $x_r^2=0.35$ $p>0.8$ (NS)	$N=76$ $k=6$ $x_r^2=9.58$ $0.1>p>0.05$	$N=61$ $k=4$ $x_r^2=13.73$ $p<0.001$

4. RESULTS

4.1. DOMINANCE STRUCTURE OF NEMATODE COMMUNITIES AND THE DENSITY OF TAXONS

4.1.1. Relation between changes in physical and biotic parameters after drainage

For the majority of stations examined three parameters of physical properties of soil of drained fen peat were known providing information on absorbing capacity and water conductivity of these soils (Table 3). Friedman's (Siegel 1956) nonparametric test showed that among stations drained at different time, situated on sedge-fen and alder-fen peats, the differences between these parameters were statistically significant, whereas within sedge-moss-fen peat stations they were statistically insignificant (Table 3). Differences in density of specimens in genera at the same stations were also significant for sedge-fen peat, and alder-fen peat, and insignificant for sedge-moss-fen peat (Table 3). Here the significance of differences for stations on alder-fen peat was higher than on sedge-fen peat. Joint consideration of physical and biotic parameters (density of specimens in genera) shows that they are not differentiated within stations on sedge-moss-fen peat (insignificant differences) and are significantly differentiated on sedge-fen peat and alder-fen peat. The level of significance of differences on alder-fen peat was higher than on sedge-fen peat. It seems that greater differences in physical properties of soil caused by its drainage resulted in greater differentiation of biotic factor, i.e., density of specimens in particular genera of nematodes.

4.1.2. Dominance classes in communities versus peat genesis and the time after drainage

In order to estimate directional changes in dominance character and the kind of peat influencing them, the participation of dominance classes in nematode communities was observed. Four classes of dominance index were distinguished for genera: superdominants – over 30% of numbers of total community, dominants – 10–30%, subdominants – 2.5–9.9% and accidents – below 2.5%.

The highest degree of dominance (> 30%) was recorded on alder-fen peat up to 30 years after drainage and in non-drained sedge-moss-fen peat (Fig. 2). On alder-fen peat superdominants were 59–34% of total nematodes, whereas superdominants and dominants together were 78–60%. On sedge-fen peat superdominance was not observed, and dominants did not exceed 50% of total nematodes, similarly as on drained sedge-moss-fen peat. Thus sharper dominance structure was connected mainly with alder-fen peat in the first 30 years after drainage.

Changes in dominance connected with the time after drainage were the most

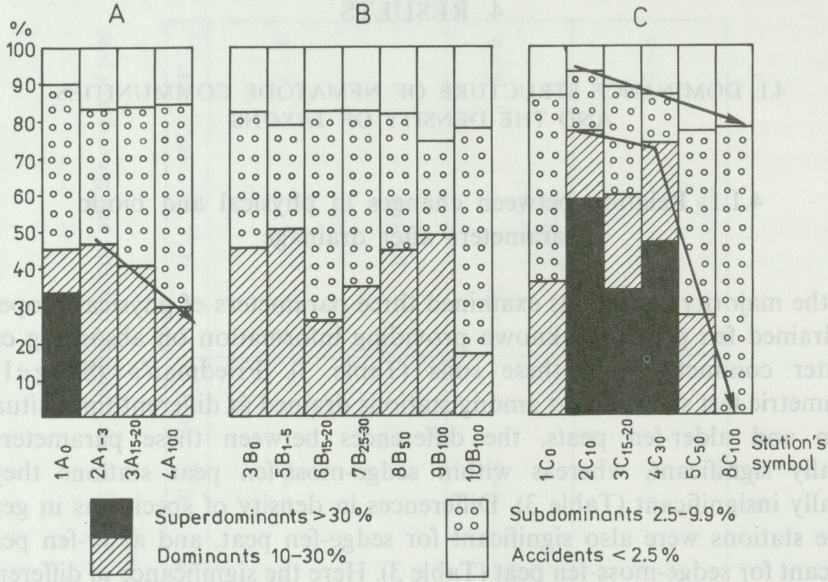


Fig. 2. Dominance structure acc. to numbers in nematode communities at stations differentiated by the time after drainage and the origin of peat
A — Sedge-moss-fen peat, B — Sedge-fen peat, C — Alder-fen peat

distinct in alder-fen peat (Fig. 2). With the increasing time from the drainage participation of superdominants and dominants decreased in favour of subdominants and accidents. The decrease of dominants in favour of subdominants with the increasing time after the drainage was also observed on sedge-moss-fen peat. On sedge-fen peats no distinct directional changes were observed in connection with time after the drainage. And so, drainage of sedge-fen peat resulted in smaller changes in the character of nematode dominance than drainage of alder-fen peat and moss-sedge-fen peat. Only 30 years after the drainage the dominance structure of nematode genera on alder-fen peat changes fundamentally but even after 100 years the dominance does not resemble the natural fen peat.

4.1.3. Dominance of taxonomic units and trophy of taxons

The number of genera forming nematode communities was distinctly lower in the sequence of stations on alder-fen peat (22–41) and higher in the sequence of stations on sedge-fen peat (37–53) and sedge-moss-fen peat (35–49) (Table 4). The greatest differences concerned genera from the class of accidents, the least abundantly represented on alder-fen peat. On natural sedge moss-fen peat ($1A_0$) and alder-fen

Table 4. Number of genera of nematodes in distinguished dominance classes in peat soils drained at a different time

Station symbol / Dominance class (%)	Sedge-moss-fen peats				Sedge-fen peats							Alder-fen peats						
	1 A_0	2 A_{1-3}	3 A_{15-20}	4 A_{100}	3 B_0	5 B_{1-5}	6 B_{15-20}	7 B_{25-30}	8 B_{50}	9 B_{100}	10 B_{100}	1 C_0	2 C_{10}	3 C_{15-20}	4 C_{30}	5 C_{50}	8 C_{100}	6 C_{50}
Superdominants > 30	1												1*	1*	1*			
Dominants 10–30	1	3	3	2	3	4	2*	3	3	3	1*	3	1	2	2	1*		2
Subdominants 2.5–9.9	8	6	9	11*	8	7*	10	9*	7	6*	11	8	4	6	3	11	16*	10*
Accidents < 2.5	25*	38*	37	26	36	39	37	25	31*	44	30	11	17	32	16	27	19	24
Total	35	47	49	39	47	50	49	37	41	53	42	22	23	41	22	39	35	36

*Dominance class in which *Paratylenchus* sp. occurs.

Table 5. Number of genera in dominance classes with a division into trophic groups: B – bacterivores, F – fungivores, FPP – facultative plant parasites, OPP – obligatory plant parasites, O – omnivores, P – predators, A – typical aquatic

Dominance class (%)	Station symbol	Sedge-moss-fen peats				Sedge-fen peats							Alder-fen peats						
		$1A_0$	$2A_{1-3}$	$3A_{15-20}$	$4A_{100}$	$3B_0$	$5B_{1-5}$	$6B_{15-20}$	$7B_{25-30}$	$8B_{50}$	$9B_{100}$	$10B_{100}$	$1C_0$	$2C_{10}$	$3C_{15-20}$	$4C_{30}$	$5C_{50}$	$8C_{100}$	$6C_{50}$
Superdominants > 30	B	1																	
	F																		
	FPP																		
	OPP													1*	1*	1*			
	O																		
	P																		
	A																		
Dominants 10–30	B		2	2	1	2	2	1	1	1	1				1	1			2
	F																		
	FPP	1	1	1	1	1	1		1	1	1		1	1	1				
	OPP						1*	1*	1*	1*	1*	1*				1	1*		
	O												2						
	P																		
	A																		

Subdominants 2.5 – 9.9	B	4	2	5	4	3	4	5	4	4	2	6	5	3	3	1	5	7	4
	F	1	2	1	1	1	1	2	2	2	1	2	1		1	1	2	2	1
	FPP	2			2	2		1				1	2		1	1	1	2	2
	OPP		2*	1*	3*	1*	1	1	3	1	1	1		1	1		3	4*	2*
	O	1		2	1	1	1	1			2	1						1	1
	P																		
	A																		
Accidents < 2.5	B	11	19	15	14	15	13	16	13	9	17	11	5	6	14	9	12	7	14
	F	2	1	2	1	3	3	3	2	1	4	1		3	4	1		2	2
	FPP	1	4	4	3	4	6	4	4	4	4	3	1	3	3		5	3	3
	OPP	4*	7	5	3	4	8	6	2	7	8	6	2*	3	5	4	3	1	2
	O	3	5	5	3	5	5	5	3	6	7	5	1	1	4	1	5	6	2
	P	2	2	4	2	3	4	3	1	3	3	4	2	1	2	1	2		1
	A	2		2		2				1	1								

*Asterisks represent obligatory plant parasites found in the dominance class highest at a given station.

Table 6. Numbers of nematode genera ($N \cdot 10^3 \cdot m^{-2}$), standard error and dominance structure at stations on sedge-moss-fen peats drained at different times, (B – bacterivores, F – fungivores, FPP – facultative plant parasites, OPP – obligatory plant parasites, O – omnivores, P – predators, A – typical aquatic)

Station symbol	1 A_0		2 A_{1-3}		3 A_{15-20}		4 A_{100}	
Number of sampling	6		7		19		3	
Genus	mean	SE	mean	SE	mean	SE	mean	SE
1. *Rhabditis* – B	1315***	1297	527*	165	635**	290	210*	105
2. *Tylenchus* – FPP	473**	190	1354**	588	529**	129	817**	392
3. *Plectus* – B	353*	164	240*	133	281*	77	320*	80
4. *Aphelenchoides* – F	330*	256	606*	306	250*	83	383*	44
5. *Acrobeloides* – B	283*	184	886**	406	207*	41	1017**	283
6. *Prismatolaimus* – B	237*	154	1	1	1	0.7	397*	173
7. *Eudorylaimus* – O	140*	95	96	45	115*	35	233*	66
8. *Aglenchus* – FPP	138*	78	80	42	52	23	457*	228
9. *Rhabdolaimus* – B	132*	61	4	3	205*	99	513*	243
10. *Ditylenchus* – FPP	127*	96	50	26	66	32	300*	152
11. *Teratocephalus* – B	73	30	1	1	49	21	113	13
12. *Cervidellus* – B	67	67	1	1	1	0.6		
13. *Tylenchorhynchus* – OPP	57	32	330*	163	28	13		
14. *Panagrolaimus* – B	42	27	744*	307	503*	173	73	63
15. *Monhystera* – B	30	22	20	13	64	43	3	3
16. *Coslenchus* – FPP	27	18	57	57	5	5	67	67
17. *Mesodorylaimus* – O	22	16	37	15	56	14	50	50
18. *Aphanolaimus* – B	18	13					47	29
19. *Hemicycliophora* – OPP	12	5	17	14	24	5		
20. *Tobrilus* – B	10	6	1	1	3	2		
21. *Aporcelaimellus* – O	7	7	3	3	5	5	33	33
22. *Actinolaimus* – P	7	5					3	3
23. *Cylindrolaimus* – B	5	5	1	1	2	1		
24. *Heterocephalobus* – B	5	3	16	10	6	5	13	13
25. *Chronogaster* – B	5	3	3	3	8	5		
26. *Alaimus* – B	3	3	17	13	2	1	7	7
27. *Aphelenchus* – F	3	3	317*	156	59	16		
28. *Hirschmaniella* – OPP	3	2	3	1	4	2	40	40
29. *Dorylaimida* others – O	3	2			0.5	0.5	33	33
30. *Wilsonema* – B	2	2	7	5	29	26	7	7
31. *Nothotylenchus* – F	2	2						
32. *Paratylenchus* – OPP	2	2	1	1			177*	161
33. *Ethmolaimus* – A	2	2						
34. *Mononchus* – P	2	2	4	3	18	11	3	3
35. *Prodesmodora* – A	2	2						
36. *Helicotylenchus* – OPP			314*	159	310*	109	120	120
37. *Cephalobus* – B			110	83	103*	34	7	7
38. *Chiloplacus* – B			100	100				
39. *Eucephalobus* – B			90	40	136*	32	53	29
40. *Rotylenchus* – OPP			77	40	39	26		
41. *Pratylenchus* – OPP			57	57	21	9		
42. *Tylencholaimus* – O			46	42	158*	93		
43. *Deladenus* – F			30	28				
44. *Zeldia* – B			29	29				

Table 6, continued

Station symbol	$1\ A_0$		$2\ A_{1-3}$		$3\ A_{15-20}$		$4\ A_{100}$	
Number of sampling	6		7		19		3	
Genus	mean	SE	mean	SE	mean	SE	mean	SE
45. *Psilenchus* – FPP			23	14	0.5	0.5	3	3
46. *Meloidogyne* juv. – OPP			17	14			223*	189
47. *Seinura* – P			16	14	5	5		
48. *Prodorylaimus* – O			14	14	2	2		
49. *Anaplectus* – B			13	11	33	15		
50. *Heterodera* juv. – OPP			10	10			200*	200
51. *Panagrolaimidae* „I" – B			3	3	1	1		
52. *Cephalobidae* others – B			1	1				
53. *Diplogaster* – B			1	1	4	3		
54. *Paraphelenchus* – F					20	10		
55. *Diploscapter* – B					8	8		
56. *Euteratocephalus* – B					7	5	3	3
57. *Ironus* – P					6	5		
58. *Chromadoridae* – A					5	5		
59. *Tripyla* – P					1	0.7		
60. *Anonchus* – A					0.5	0.5		
61. *Pungentus* – O					0.3	0.3		
62. *Bastiania* – B							133	133
63. *Pratylenchinae* others – OPP							67	67
64. *Aulolaimus* – B							33	33
65. *Basiria* – FPP							30	30
66. *Acrobeles* – B							3	3
67. *Mesorhabditis* – B							7	7
68. *Neotylenchus* – F							10	10
Total:	3939	2464	6375	2224	4067.8	963	6208	756

***Superdominants >30% in a community. **Dominants: 10–30%. *Subdominants: 2.5–9.9%. – Accidents: < 2.5%.

peat ($1C_0$) there was less genera than at drained stations. Drainage thus favoured the increase in number of genera on these two types of peat. On sedge-fen peat this relation was not observed (Table 4). However, other sedge fluvial fen (mentioned in Table 4) flooded by river for several months in a year also had a small number of genera (18 genera on $1B_0$ and 28 genera on $2B_0$).

The only superdominant on natural sedge-moss-fen ($1A_0$) (Table 5) was a genus from the bacterivorous group *Rhabditis sl.* spp. (Table 6). On sedge-fen peat representants of this dominance class were not found (Tables 5, 7). On alder-fen peat the superdominant was one genus of the group of obligatory plant parasites (Table 5) – *Paratylenchus* sp. (Table 8). Dominants of drained sedge-moss-fen peat were bacterivores and facultative plant parasites such as *Tylenchus, Acrobeloides, Rhabditis* and *Panagrolaimus* (Table 6), and on sedge- and alder-fen peats they are joined by such obligatory plant parasites as *Helicotylenchus, Paratylenchus* and *Tylen-*

Table 7. Numbers of nematode genera ($N \cdot 10^3 \cdot m^{-2}$), standard error and dominance structure at stations on sedge-fen peats drained at a different time
For explanations see Table 6

Station symbol	3 B_0		5 B_{1-5}		6 B_{15-20}		7 B_{25-30}		8 B_{50}		9 B_{100}		10 B_{100}	
Number of smaplings	6		19		21		8		7		20		8	
Genus	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
1. *Tylenchus* – FPP	215**	77	949**	237	307*	271	2248**	511	2241**	872	1100**	193	455*	336
2. *Prismatolaimus* – B	167**	85	93	36	41	12	178	51	19	14	7	5	39	15
3. *Plectus* – B	107**	57	212*	51	193*	60	555*	151	186	77	286*	50	295*	115
4. *Acrobeloides* – B	93*	47	891**	267	364*	88	1489**	382	939*	293	144	68	480*	201
5. *Eudorylaimus* – O	60*	30	248*	54	67	15	180	52	211	80	162	38	233*	38
6. *Aphelenchoides* – F	57*	18	226*	71	262*	83	808*	276	524*	153	397*	156	270*	151
7. *Aglenchus* – FPP	40*	26	82	30	74	34	165	79	260	111	84	30	95	42
8. *Rhabdolaimus* – B	35*	16	135	39	127*	42	175	123	56	27	129	24	266*	120
9. *Ditylenchus* – FPP	32*	14	110	49	29	17	250	94	197	84	119	43	44	36
10. *Tetylenchus* – OPP	32*	16	0.5	0.5										
11. *Monhystera* – B	28*	8	61	31	25	11	223	143	57	57	54	12	45	16
12. *Rhabditis* – B	24	11	241*	55	360*	149	1240*	428	1444**	1129	1494**	872	118	48
13. *Ethmolaimus* – A	17	13												
14. *Teratocephalus* – B	16	3	53	19	31	14	133	55	57	36	26	11	131	60
15. *Tylenchorhynchus* – OPP	12	9	131	54	54	15	1271**	330	450*	161	160	37	465*	109
16. *Dorylaimida* others – O	12	6	6	5	0.9	0.9			14	14			1.3	1.3
17. *Tylenchus* „l" – FPP	10	6												
18. *Heterocephalobus* – B	9	3	26	20	4	2	1.3	1.3	47	42	14	10		
19. *Panagrolaimus* – B	8	4	727**	410	584**	193	968*	199	979*	424	349*	148	201*	68
20. *Meloidogyne* juv. – OPP	8	8	41	18			121	91	49	34	182	62	26	16
21. *Mesodorylaimus* – O	8	3	48	12	47	19	70	31	64	56	204*	73	44	36
22. *Nothotylenchus* – F	8	8			1	1					0.3	0.2		
23. *Nygolaimus* – P	7	7											13	13
24. *Wilsonema* – B	5	3	194*	102	23	8	54	32	33	17	37	21	219*	80
25. *Eucephalobus* – B	5	5	99	37	87	25	490*	135	300*	126	69	22	121	44
26. *Tobrilus* – B	5	3									9	9		

27. *Chronogaster* – B	3	2	28	20	6	5	1.3	1.3	19	13	1.5	1	1.3	1.3
28. *Fanagrolaimidae* „l” – B	3	3	4	4	5	5								
29. *Coslenchus* – FPP	3	2	11	11	2.5	2								
30. *Hirschmaniella* – OPP	3	3	2	1	2	1			6	4				
31. *Prodorylaimus* – O	3	3	9	5	0.5	0.5					58	25		
32. *Prodesmodora* – A	3	2							1.4	1.4				
33. *Anaplectus* – B	3	3	29	19	2	1	25	16			10	5	6	4
34. *Malenchus* – FPP	3	3	4	4			13	13						
35. *Cervidellus* – B	2	2	0.5	0.5	0.7	0.5	50	50						
36. *Cephalobus* – B	2	2	508*	212	148*	79	260	82	369*	109	88	17	156*	75
37. *Neotylenchus* – F	2	2	22	18			25	25			5	4		
38. *Psilenchus* – FPP	2	2	15	11	1.2	0.7	25	16	1.4	1.4	2	1	1.3	1.3
39. *Hemicycliophora* – OPP	2	2	69	26	60	14			1.4	1.4	2	2		
40. *Calolaimus* – O	2	2												
41. *Aporcelaimellus* – O	2	2			0.5	0.5			29	29			65	26
42. *Tripyla* – P	2	2	1	0.7	0.5	0.5					4	3	1.3	1.3
43. *Alaimus* – B	0.8	0.8	14	5	13	9					37	16	60	30
44. *Axonolaimidae* „l” – B	0.8	0.8												
45. *Euteratocephalus* – B	0.8	0.8			1	1					10	9		
46. *Aphelenchus* – F	0.8	0.8	166	63	186*	83	518*	157	450*	148	116	62	261*	140
47. *Actinolaimus* – P	0.8	0.8												
48. *Helicotylenchus* – OPP			1081**	332	330*	84	1215*	399	1160**	471	1301**	366	130	76
49. *Paratylenchus* – OPP			395*	289	531**	239	481*	172	243	169	213*	63	873**	446
50. *Rotylenchus* – OPP			52	34	82	17	300	152	69	44	195	54	1.3	1.3
51. *Diphtherophora* – O			46	14							0.5	0.5	1.3	1.3
52. *Tylencholaimus* – O			31	15	108*	58	41	37	1.4	1.4	601*	131	39	15
53. *Pratylenchus* – OPP			25	15	5	4	416*	147	79	45	165	44	129	50
54. *Mononchus* – P			22	9	1.2	0.7	25	25	19	13	12	6	15	12
55. *Paraphelenchus* – F			18	12	27	13	13	13	67	26	22	19	4	4
56. *Acrobeles* – B			11	11	10	6	26	26					26	16
57. *Trichodorus* – OPP			11	11										
58. *Seinura* – P			11	11	3	1			3	1.8	0.5	0.5		

Table 7, continued

Station symbol	3 B_0		5 B_{1-5}		6 B_{15-20}		7 B_{25-30}		8 B_{50}		9 B_{100}		10 B_{100}	
Number of samplings	6		19		21		8		7		20		8	
Genus	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
59. *Ironus* – P			1	0.7					1.4	1.4				
60. *Basiria* – FPP			0.5	0.5					9	9	1.5	1		
61. *Drilocephalobus* – B			0.5	0.5										
62. *Deladenus* – F					10	10								
63. *Cylindrolaimus* – B					4	2			3	3	16	10		
64. *Zeldia* – B					1.5	1.5	5	5					1.3	1.3
65. *Gracilacus* – OPP					1.5	1					0.5	0.5	13	13
66. *Diplogaster* – B					0.5	0.4					0.5	0.5		
67. *Chiloplacus* – B							13	13			1.5	1	13	13
68. *Eudorylaimus* „I" – O									59	56				
69. *Criconemoides* – OPP									29	29				
70. *Dorylaimellus* – O											60	59		
71. *Heterodera* juv. – OPP											17	10		
72. *Chromadora* – A											10	5		
73. *Longidorus* – OPP											5	5	6	4
74. *Enchodelus* – O											3	2		
75. *Pungentus* – O											0.5	0.5		
76. *Dorylaimoides* – O											1	0.6		
77. *Aporcelaimus* – P													1.3	1.3
Total	1064	436	7161	1474	4224.5	945	14071.6	2533	10747	3712	7986.3	1835	5366.4	1827

Table 8. Numbers of nematode genera ($N \cdot 10^3 \cdot m^{-2}$), standard error and dominance structure at stations on alder-fen peats drained at different time. For explanations see Table 6

Station symbol	1 C_0	2 C_{10}	3 C_{15-20}		4 C_{30}	5 C_{50}		8 C_{100}
Number of samplings	2	2	19		1	5		2
Genus	mean	mean	mean	SE	mean	mean	SE	mean
1. *Mesodorylaimus* — O	35**		19	11		92	32	150
2. *Eudorylaimus* — O	33**	50	42	17	200	352	264	400*
3. *Malenchus* — FPP	25**	100						
4. *Prismatolaimus* — B	24*		179	103	100	192	107	200
5. *Acrobeloides* — B	24*	1125*	1504**	265	1500*	808*	255	150
6. *Monhystera* — B	22*		106	50	100	212	62	150
7. *Tylenchus* — FPP	22*	6475**	2282**	453	1300*	760*	196	850*
8. *Aglenchus* — FPP	12*	150	574*	187		180	111	150
9. *Rhabdolaimus* — B	8*		77	25	100	732*	385	400*
10. *Aphelenchoides* — F	7*	600	649*	181	900*	788*	284	650*
11. *Plectus* — B	7*	100	210	67		1068*	550	350*
12. *Tobrilus* — B	5							
13. *Pratylenchus* — OPP	5	200			300	780*	412	300*
14. *Tripyla* — P	5					80	80	
15. *Monhystrella* — B	4							
16. *Hirschmaniella* — OPP	4							
17. *Rhabditis* — B	1.5	1350*	559*	215	400	252	106	1000*
18. *Heterocephalobus* — B	1.5		29	20				
19. *Ditylenchus* — FPP	1.5	100	39	15		40	40	300*
20. *Seinura* — P	1.5	225	16	11	200			
21. *Desmolaimus* — B	1.5							
22. *Dorylaimida others* — O	1.5							100
23. *Paratylenchus* — OPP		20000***	4901***	1094	13400***	4800**	2336	
24. *Panagrolaimus* — B		1550*	1447*	314	4700**	1412*	531	800*
25. *Helicotylenchus* — OPP		1350*	623*	191	2900**	320	135	700*
26. *Hemicycliophora* — OPP		125	3	2	100			
27. *Wilsonema* — B		100	458*	156	300	712*	384	300*
28. *Aphelenchus* — F		100	60	27	700	520*	233	400*
29. *Tylenchorynchus* — OPP		100	225	90	100	772*	442	550*
30. *Cephalobus* — B		75	30	15	400	212	89	350*
31. *Alaimus* — B		75	6	5	100	260	140	100
32. *Teratocephalus* — B		75	193	45	300	432	154	
33. *Nothotylenchus* — F		75	10	10				
34. *Eucephalobus* — B		50	13	1		232	96	350*
35. *Rotylenchus* — OPP			92	33	200	20	20	150
36. *Paraphelenchus* — F			62	35				150
37. *Gracilacus* — OPP			42	42				400*
38. *Anaplectus* — B			26	26				
39. *Euteratocephalus* — B			21	14		360	271	150
40. *Deladenus* — F			21	21				
41. *Acrobeles* — B			10	10	100	240	240	
42. *Diphtherophora* — O			10	10				50
43. *Psilenchus* — FPP			8	6		40	40	
44. *Cervidellus* — B			7	5		40	40	

Table 8, continued

Station symbol	$1\ C_0$	$2\ C_{10}$	$3\ C_{15-20}$		$4\ C_{30}$	$5\ C_{50}$		$8\ C_{100}$
Number of samplings	2	2	19		1	5		2
Genus	mean	mean	mean	SE	mean	mean	SE	mean
45. *Coslenchus* – FPP			5	5		80	48	250
46. *Mononchus* – P			1	0.7		40	40	
47. *Longidorus* – OPP			0.5	0.5				
48. *Tylencholaimus* – O			0.5	0.5		60	60	200
49. *Zeldia* – B			0.5	0.5				
50. *Meloidogyne* juv. – OPP						780*	380	
51. *Aporcelaimellus* O						160	116	
52. *Cylindrolaimus* – B						120	80	
53. *Chiloplacus* – B						40	40	
54. *Heterodera* juv. – OPP						40	40	
55. *Dorylaimellus* – O						40	40	
56. *Basiria* – FPP						12	12	
57. *Pungentus* – O								100
58. *Diplogaster* – B								50
59. *Neotylenchus* – F								50
60. *Ditylenchus* „l" – FPP								50
61. *Enchodelus* – O								50
62. *Amphidelus* – B								50
Total	251	34150	14560.5	2365	28400	18080	3332	10400

chorhynchus (Table 7, 8). Apart from *Tylenchus* the dominants of natural fen peats are other genera than dominants of drained peat: *Prismatolaimus, Plectus, Mesodorylaimus, Eudorylaimus* and *Malenchus.* It is characteristic that on drained peatlands omnivores never dominated as in alder swamp (Table 8). The class of subdominants was formed by genera from the group of bacterivores, fungivores, facultative plant parasites and obligatory plant parasites and omnivores (on alder-fen peat the subdominant omnivore occurred only at the station drained 100 years ago) (Table 5). Among accidents there are representatives of all trophic groups, including typical aquatic species. Among the latter on natural peatlands the following occur *Calolaimus ditlevseni* (Micoletzky 1922, Tim 1964), *Ethmolaimus pratensis* de Man 1980, *Hirschmaniella loofi* Sher 1968, *Actinolaimus* sp., *Desmolaimus* sp., *Ironus* sp., and *Prodesmodora* sp.

There are known examples of considerable increase in numbers of obligatory plant parasites in simplified biocenoses as a result of human impact on the environment (Wasilewska 1989a, 1989b). Therefore the dominance of this group was analysed more thoroughly. On natural peatlands the presence of obligatory plant parasites was recorded only in the class of accidents ($1A_0$ and $1C_0$) or in the class of accidents and subdominants ($3B_0$) (Table 5). On sedge-moss-fen peat ($1A_0$) there were four genera: *Tylenchorhynchus, Hemicycliophora, Hirschmaniella* and *Paratylenchus* (Table 6), on sedge-fen peat: *Tetylenchus, Tylenchorhynchus, Meloidogyne* juv., *Hirschmaniella* and *Hemicycliophora* (Table 7) and on alder-fen peat:

Pratylenchus and *Hirschmaniella* (Table 8). Obligatory plant parasites on drained peat occur not only in the class of accidents but also in higher ones: in sedge-moss-fen peat in the class of subdominants ($2A_{1-3}$ – *Tylenchorhynchus* and *Helicotylenchus*, $3A_{15-20}$ – *Helicotylenchus*, $4A_{100}$ – *Meloidogyne*, *Heterodera* and *Pratylenchus*); in sedge-fen peat – also in the class of dominants (*Helicotylenchus*, *Paratylenchus* or *Tylenchorhynchus*) and in alder-fen peat – also in the class of superdominants (*Paratylenchus*) (Tables 5–8). These observations indicate that alder-fen peat is the most susceptible for being colonized by nematodes – obligatory plant parasites whereas sedge-fen peat is more susceptible than sedge-moss-fen peat. It proves the unfavourable for man transformation of environment as a result of peat drainage.

4.1.4. Changes in the tendency of genus dominance after drainage

The position in dominance structure of particular genera at all stations of drained peatlands was compared for natural (non drained) peat, sedge-moss peat (Table 9), sedge peat (Table 10) and alder peat (Table 11). With consideration to the most frequent reaction to drainage (decrease, increase, maintenance of the position in a given dominance class) by particular genera of nematodes recorded in natural and drained peatlands, three groups were distinguished (Environment denotations: M – sedge-moss-fen peat, S – sedge-fen peat and A – alder-fen peat):

lower position in dominance structure	higher position in dominance structure	the same position in dominance structure
Prismatolaimus – MSA	*Acrobeloides* – MS(↑↓) A(↑↓)	*Aphelenchoides* – MSA
Aglenchus – MSA	*Panagrolaimus* – MS	*Tylenchus* – MS
Rhabdolaimus – SA	*Rhabditis* – SA	*Plectus* – M
Eudorylaimus – SA	*Cephalobus* – S	
Ditylenchus – MS	*Aphelenchus* – S	
Plectus – SA		
Monhystera – SA		
Rhabditis – M		
Mesodorylaimus – A		
Malenchus – A		
Tetylenchus – S		

The two first genera descending in the dominance structure behave similarly on all kinds of peat, whereas the remaining ones – only on two or one. The subdominant *Acrobeloides* has a varying position in dominance structure on sedge-fen and alder-fen peats – increasing up to 30 years after drainage afterwards stable and finally a decline in dominance.

The genera found only at drained peat stations and belonging to a higher class than accidents at one station at least are as follows: *Paratylenchus*, *Helicotylenchus*, *Gracilacus* and *Tylencholaimus*.

Table 9. Changes in dominance of genera in drained sedge-moss-fen peats in relation to natural fen

1 A_0	2 A_{1-3}	3 A_{15-20}	4 A_{100}
Superdominants			
Rhabditis	$\underset{\cdot\cdot}{\leftarrow}$	$\underset{\cdot}{\leftarrow}$	$\underset{\cdot\cdot}{\leftarrow}$
Dominants			
Tylenchus	—	—	—
Subdominants			
Plectus	—	—	—
Aphelenchoides	—	—	—
Acrobeloides	$\underset{\cdot}{\rightarrow}$	—	$\underset{\cdot}{\rightarrow}$
Prismatolaimus	$\underset{\cdot}{\leftarrow}$	$\underset{\cdot}{\leftarrow}$	—
Eudorylaimus	$\underset{\cdot}{\leftarrow}$	—	—
Aglenchus	$\underset{\cdot}{\leftarrow}$	$\underset{\cdot}{\leftarrow}$	—
Rhabdolaimus	$\underset{\cdot}{\leftarrow}$	—	—
Ditylenchus	$\underset{\cdot}{\leftarrow}$	$\underset{\cdot}{\leftarrow}$	—
Accidents			
Teratocephalus	—	—	—
Cervidellus	—	—	
Tylenchorhynchus	$\underset{\cdot}{\rightarrow}$	—	
Panagrolaimus	$\underset{\cdot\cdot}{\rightarrow}$	$\underset{\cdot\cdot}{\rightarrow}$	—
Monhystera	—	—	—
Coslenchus	—	—	—
Mesodorylaimus	—	—	—
Aphanolaimus			—
Hemicycliophora	—	—	
Tobrilus	—	—	
Aporcelaimellus	—	—	—
Actinolaimus			—
Cylindrolaimus	—	—	
Heterocephalobus	—	—	—
Chronogaster	—	—	
Alaimus	—	—	—
Aphelenchus	$\underset{\cdot}{\rightarrow}$	—	—
Hirschmaniella	—	—	—
Dorylaimida others		—	—
Wilsonema	—	—	—
Nothotylenchus			
Paratylenchus	—		$\underset{\cdot}{\rightarrow}$
Ethmolaimus			
Mononchus	—	—	—
Prodesmodora			

$\underset{\cdot}{\leftarrow}$ Decrease by one dominance class. $\underset{\cdot\cdot}{\leftarrow}$ Decrease by two dominance classes. $\underset{\cdot}{\rightarrow}$ Increase by one dominance class. $\underset{\cdot\cdot}{\rightarrow}$ Increase by two dominance classes. – Remaining in the same dominance class. No graphical sign – total lack.

Table 10. Changes in dominance of genera in drained sedge-fen peats in relation to natural fen. For explanation see Table 9

3 B_0	5 B_{1-5}	6 B_{15-20}	7 B_{25-30}	8 B_{50}	9 B_{100}	10 B_{100}
Dominants						
Tylenchus	—	←	—	—	—	←
Prismatolaimus	←	←	←	←	←	←
Plectus	←	←	←	←	←	←
Subdominants						
Acrobeloides	→	—	→	—	←	—
Eudorylaimus	—	←	←	←	←	—
Aphelenchoides	—	—	—	—	—	—
Aglenchus	←	←	←	←	←	←
Rhabdolaimus	←	—	←	←	←	—
Ditylenchus	←	←	←	←	←	←
Tetylenchus	←					
Monhystera	←	←	←	←	←	←
Accidents						
Rhabditis	→	→	→	→	→	—
Ethmolaimus						
Teratocephalus	—	—	—	—	—	—
Tylenchorhynchus	—	—	→	→	—	→
Dorylaimida others	—	—		—		—
Tylenchus „l”						
Heterocephalobus	—	—	—	—	—	
Panagrolaimus	→	→	→	→	→	→
Meloidogyne	—			—	—	—
Mesodorylaimus	—	—	—	—	→	—
Nonthotylenchus		—			—	
Nygolaimus						—
Wilsonema	→	—	—	—	—	→
Eucephalobus	—	—	→	→	—	—
Tobrilus					—	
Chronogaster	—	—	—	—	—	—
Panagrolaimidae „l”	—	—				
Coslenchus	—	—				
Hirschamniella	—	—		—		
Prodorylaimus	—	—			—	
Prodesmodora				—		
Anaplectus	—	—	—		—	—
Malenchus	—		—			
Cervidellus	—		—			
Cephalobus	→	→	—	→	—	→
Neotylenchus	—		—		—	—
Psilenchus	—	—	—	—	—	—
Hemicycliophora	—	—		—	—	
Calolaimus						
Aporcelaimellus		—		—		—
Tripyla	—	—			—	—
Alaimus	—	—			—	—
Axonolaimidae „l”						
Euteratocephalus		—			—	
Aphelenchus	—	→	→	→	—	→
Actinolaimus						

Table 11. Changes in dominance of genera in drained alder-fen peats in relation to natural fen. For explanations see Table 9

1 C_0	2 C_{10}	3 C_{15-20}	4 C_{30}	5 C_{50}	8 C_{100}	6 C_{50}
Dominants						
Mesodorylaimus		←		←	←	←
Eudorylaimus	←	←	←	←	←	←
Malenchus	←					
Subdominants						
Prismatolaimus		←	←	←	←	←
Acrobeloides	—	→	—	—	←	—
Monhystera		←	←	←	←	←
Tylenchus	→	→	—	—	—	—
Aglenchus	←	—		←	←	←
Rhabdolaimus		←	←	—	—	←
Aphelenchoides	←	—	—	—	—	—
Plectus	←	←		—	—	—
Accidents						
Tobrilus						
Pratylenchus	—		—	→	→	
Tripyla				—		
Monhystrella						
Hirschmaniella						
Rhabditis	→	→	—	—	→	→
Heterocephalobus		—				
Ditylenchus	—	—		—	→	→
Seinura	—	—	—			
Desmolaimus						
Dorylaimida others					—	

4.1.5. Position of *Paratylenchus* sp. in dominance structure

Because of the indicatory role of *Paratylenchus* (Wasilewska in press) its position is determined in dominance structure of analysed sequence of stations (Table 4). It is an accident taxon in sedge-moss-fen peat, whereas it does not occur in natural peatland and freshly drained and even 20 years after the drainage ($3A_{15-20}$). At a station drained 100 years ago it becomes a subdominant. On sedge-fen peat it is a subdominant or dominant (in $8B_{50}$ it is the most numerous accident). It is worth pointing out that at two stations drained 100 years ago is has the higher position of only dominant on degraded peat ($10B_{100}$). On alder-fen peat it is a superdominant at a station drained 10 years earlier and maintained this position many years later. At a station drained 50 years ago it becomes a dominant, whereas on that drained 100 years ago it is only an accident (at station $8C_{100}$ it is *Gracilacus* – systematically close and isolated from the genus *Paratylenchus*). The position of Paratylenchus in the dominance structure seems distinctly connected with fen peat transformation (moorshing) and degradation, but indicates that these processes are slow in

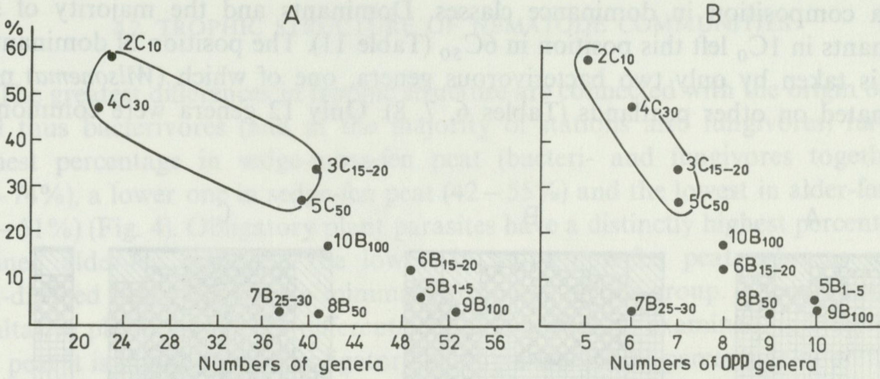


Fig. 3. Number of genera in a nematode community – A and number of genera from the group of obligatory plant parasites (OPP) – B and the dominance of *Paratylenchus* (alder-fen peats encircled)

sedge-moss-fen peat, violent in alder-fen peat shorly after drainage (with a recession tendency after 30 years), and intermediate in sedge-fen peat.

Together with increasing dominance (percentage) of *Paratylenchus* sp. a decrease in the number of genera forming the community is observed as well as of those forming the group of obligatory plant parasites (Fig. 3). Stations on alder-fen peat form the group with the smallest number of genera and the highest dominance of *Paratylenchus*.

4.1.6. Dominance structure of nematodes in birch forest on drained fen as the most degraded habitat

Among the variously utilized alder peatlands (meadow, field and forest) the forest soil was the most overdried especially in dry years (Gotkiewicz and Szuniewicz 1987a). In moorsh-peat soil under birch forest there is usually excesive aeration and such habitat has a distinct degradation character mainly because of the great amount of mineralized nitrogen (467 kg N/ha acc. to Gotkiewicz in press). In the forest undergrowth there is usually one species of nitrophilous plant (nettle) and the forest stand of little use is easily infected by pathogenic fungi and dies (Dudek 1983, 1987). The birch forest on alder fen peat from the area of Kuwasy drained 50 years ago ($6C_{50}$) was analysed. Comparison of natural alder swamp ($1C_0$) and birch forest on drained alder peat ($6C_{50}$) shows the following differences in colonization by nematodes: (a) after drainage the number of genera increased, especially accidental genera (Table 4); (b) significant increase of genera grouping bacterivorous species (from 10 in $1C_0$ to 20 in $6C_{50}$) (Table 5); (c) basical change in genera composition in dominance classes. Dominants and the majority of subdominants in $1C_0$ left this position in $6C_{50}$ (Table 11). The position of dominants in $6C_{50}$ is taken by only two bacterivorous genera, one of which (*Wilsonema*) never dominated on other peatlands (Tables 6, 7, 8). Only 12 genera were common for

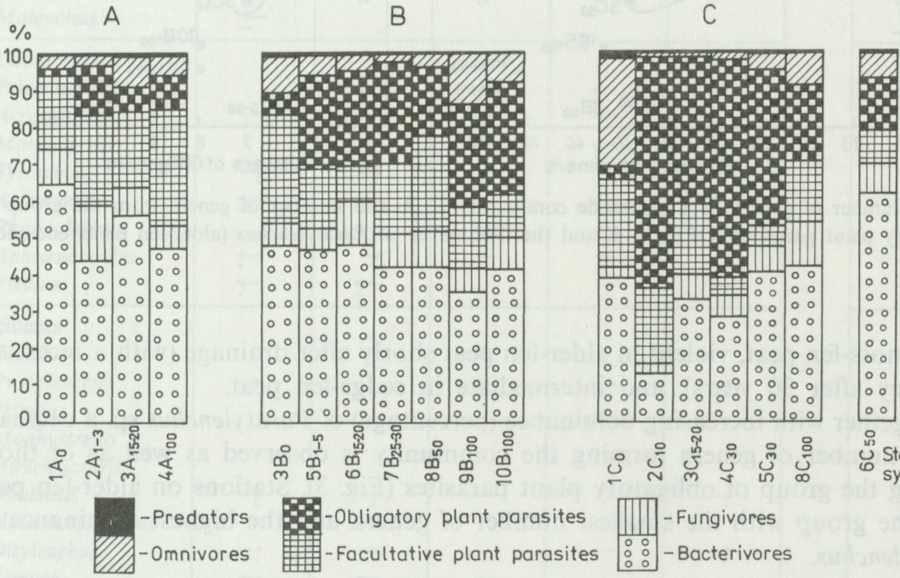


Fig. 4. Trophic structure in nematode communities at stations differentiated by the time after drainage and the origin of peat

A – Sedge-moss-fen peat, B – Sedge-fen peat, C – Alder-fen peat

both stations, whereas 24 genera found in $6C_{50}$ were not recorded in alder swamp – $1C_0$; (d) *Bunonema* sp. (I have found it for the first time in Poland) occurred in connection with decomposition of litter and wood; (e) in $6C_{50}$ the percentage of bacterivores and obligatory plant parasites was higher than in $1C_0$, whereas that of predators and facultative plant parasites was lower (Fig. 4); (f) at station $6C_{50}$ among obligatory plant parasites the most abundant were *Paratylenchus* and *Gracilacus* (systematically and functionally resembling the former); jointly treated they enter the group of dominants. Similarly as on alder peatlands used as meadows nematodes of the family Paratylenchidae dominate. In $6C_{50}$ the numbers of *Paratylenchus* + *Gracilacus* was on the average $1.8 \cdot 10^6 \cdot m^{-2}$ (range $0.7 - 3.8 \cdot 10^6 \cdot m^{-2}$). In forest ecosystems phytophages usually do not attain so high numbers as in meadow ecosystems (Wasilewska 1979). Thus this group should be estimated separately. It would be worthwhile to observe in alder peatlands only the changes connected with the time after drainage.

4.2. TROPHIC STRUCTURE OF NEMATODE COMMUNITIES

The greatest differences in trophic structure are connected with the origin of peat. And thus bacterivores (and at the majority of stations also fungivores) have the highest percentage in sedge-moss-fen peat (bacteri- and fungivores together — 54—74%), a lower one in sedge-fen peat (42—55%) and the lowest in alder-fen peat (15—51%) (Fig. 4). Obligatory plant parasites have a distinctly highest percentage in drained alder-fen peat and the lowest in sedge-moss-fen peat, whereas natural non-drained peatlands have a minimal percentage of this group. The percentage of facultative plant parasites is differentiated within stations examined; in sedge-moss--fen peat it is higher than of obligatory plant parasites. The percentage of omnivores and predators is higher in drained sedge-moss-fen peat and sedge-fen peat than in alder-fen peat.

Even a 100 years period after drainage did not obliterate the differences in trophic structure of drained and natural peatlands of each kind of peat. Within the course of years proportions of trophic groups change and this can be most distinctly observed in the case of alder peatlands. Here the percentage of bacterivores increases and of obligatory plant parasites decreases; such distinct changes in proportions are not observed in other kinds of peat (Fig. 4). Thus the obligatory plant parasites accompany the fast mineralization, but their role decreases together with the slowing down of this process in alder-fen peat. In sedge-fen peat if estimating its mineralization according to obligatory plant parasites, they indicate only small changes 100 years after drainage.

4.3. SIMILARITY OF NEMATODE COMMUNITIES

The degree of similarity of nematode communities in the course of time from drainage and the modification of this phenomenon by the kind of peat were analysed.

Marczewski and Steinhaus index of similarity was higher than the lowest value in sedge-moss-fen peat by 17.3% (index range 31.8—49.1%), in sedge-fen peat by 38.9% (range 26.6—65.5%) and in alder-fen peat by 44.5% (range 9.3—65.5%) (Fig. 5). Thus in the sequence of stations nematode communities were the most similar in sedge-moss-fen peat, and the most different in alder-fen peat. Communities in natural peatlands and in meadows on drained fens were the most similar in sedge-moss-fen peats (index range: 31.8—43.5%), averagely in sedge-fen peats (24.6—33.9%) and the least — in alder-fen peats (9.3—18.5%) (Fig. 5). This proves that the greatest changes in nematode communities took place after drainage in alder-fen peats, smaller on sedge-fen peats, and the smallest in sedge-moss-fen peats. In sedge-fen peats the similarity is the greatest in the group of stations drained 1—50 years ago, whereas in alder-fen peats — in the group of stations drained 10—30 years ago (Fig. 5). In alder-fen peats the station drained the longest time ago is the least similar to other stations. In sedge-fen peats it is very much the same, although the similarity to other stations is greater. Sedge-moss-fen peats do not show such differentiation.

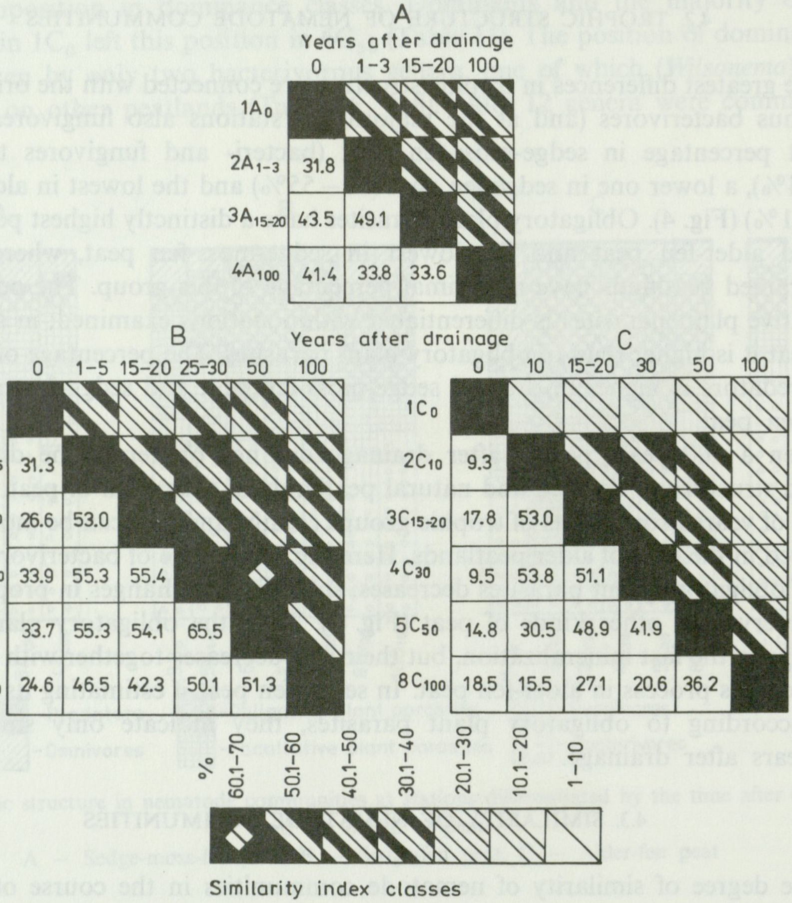


Fig. 5. Diagram of similarity of nematode communities differentiated by the time after drainage and the origin of peat on the basis of Marczewski and Steinhaus' similarity index
A — Sedge-moss-fen peat, B — Sedge-fen peat, C — Alder-fen peat

Similarity of stations examined was analysed with consideration to only one trophic group, namely obligatory plant parasites (OPP), because superdominance was observed in this trophic group after drainage of peats. The range of similarity index of this group was 3.4 – 44.0% for stations in sedge-moss-fen peats, 4.3 – 69.1% for stations in sedge-fen peats, and 0.0 – 83.4% for stations in alder-fen peats (Fig. 6). The difference between the highest and lowest value of similarity index in OPP group was twice bigger than for whole nematode communities. This proves that OPP group underwent greater changes than the whole nematode community. Similarity index of OPP group between natural not drained fen and meadows on drained peats was, similarly as in the case of whole nematode communities, the highest in sedge-moss-fen peats (3.4 – 27.0%), medium in sedge-fen peats

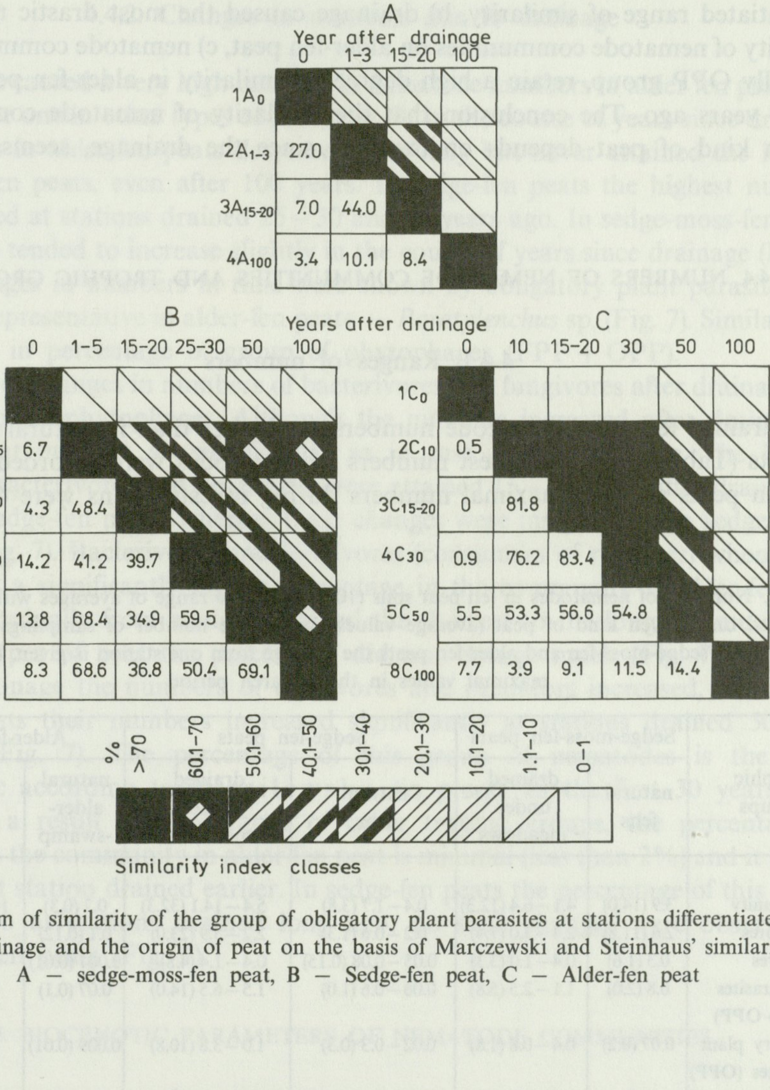


Fig. 6. Diagram of similarity of the group of obligatory plant parasites at stations differentiated by the time after drainage and the origin of peat on the basis of Marczewski and Steinhaus' similarity index A — sedge-moss-fen peat, B — Sedge-fen peat, C — Alder-fen peat

(4.3 – 14.2%) and the lowest in alder-fen peat (0.0 – 7.7%) (Fig. 6). It also proves that the greatest changes after drainage took place in alder-fen peats. But lower similarity index for OPP group than for the whole nematode community shows that obligatory plant parasites underwent stronger changes after drainage than the whole nematode community. In alder-fen peats the similarity of OPP group in stations drained 10 – 30 years ago is the highest (76.2 – 83.4%). The station drained 50 years ago still has a quite high similarity to this group of stations (53.3 – 56.6%), whereas the station drained 100 years ago shows very small similarity to other stations. In sedge-fen peats the station drained 100 years ago does not differ to such an extent from stations drained later (Fig. 6).

Reassuming it can be said: a) nematodes in alder-fen peat have the most differentiated range of similarity, b) drainage caused the most drastic reduction of similarity of nematode communities on alder-fen peat, c) nematode communities, and especially OPP group, retain a high degree of similarity in alder-fen peats drained 10–30 years ago. The conclusion that the similarity of nematode community on a given kind of peat depends on the time since the drainage, seems justified.

4.4. NUMBERS OF NEMATODE COMMUNITIES AND TROPHIC GROUPS

4.4.1. Ranges of numbers

In drained fen peats nematode numbers are higher than in natural (undrained) fen peats (Table 12). The highest numbers of nematodes were recorded in drained alder-fen peats and the maximal numbers during investigations were $45 \cdot 10^6 \cdot m^{-2}$.

Table 12. Numbers of nematodes in fen peat soils ($10^6 \cdot m^{-2}$). The range of averages within all stations examined on a given kind of peat (average values acc. to the number of samplings in Table 1) For undrained sedge-moss-fen and alder-fen peats the average from one station is given. In brackets are maximal values in the research period

Trophic groups	Sedge-moss-fen peats		Sedge-fen peats		Alder-fen peats	
	natural fens	drained under meadows	natural fens	drained under meadows	natural alder-swamp	drained under meadows
Whole community	3.9 (14.0)	4.1–6.4 (12.3)	0.4–1.7 (3.8)	5.4–14.1 (32.3)	0.2 (0.3)	10.4–34.1 (45.2)
Bacterivores	2.6 (11.8)	2.4–3.0 (7.4)	0.2–0.6 (1.3)	2.2–5.9 (23.0)	0.1 (0.12)	4.4–8.1 (11.0)
Fungivores	0.3 (1.6)	0.4–1.0 (3.3)	0.05–0.08 (0.15)	0.4–1.4 (4.8)	0.007 (0.01)	0.8–1.6 (3.6)
Plant parasites (FPP+OPP)	0.8 (2.0)	1.1–2.5 (5.8)	0.06–0.6 (1.0)	1.5–6.5 (14.0)	0.07 (0.1)	3.7–28.6 (39.0)
Obligatory plant parasites (OPP)	0.07 (0.2)	0.4–0.8 (1.8)	0.02–0.3 (0.3)	1.0–3.8 (10.8)	0.009 (0.01)	2.1–21.8 (31.2)
Paratylenchus sp.	0	0–0.2 (0.5)	0–0.01 (0.01)	0.2–0.9 (5.4)	0	0.4–20.0 (30.0)
Omnivores and predators	0.2 (0.6)	0.2–0.4 (0.6)	0.05–0.1 (0.3)	0.2–1.1 (3.4)	0.007 (0.01)	0.1–1.2 (2.6)

Nematodes from the group of bacterivores, fungivores, and especially obligatory plant parasites (and genus *Paratylenchus*) attained the highest numbers in alder-fen peats. The range of numbers of the two least numerous groups: fungivores and omnivores with predators did not show significant differences depending on the origin of peat.

4.4.2. Changes in numbers due to drainage

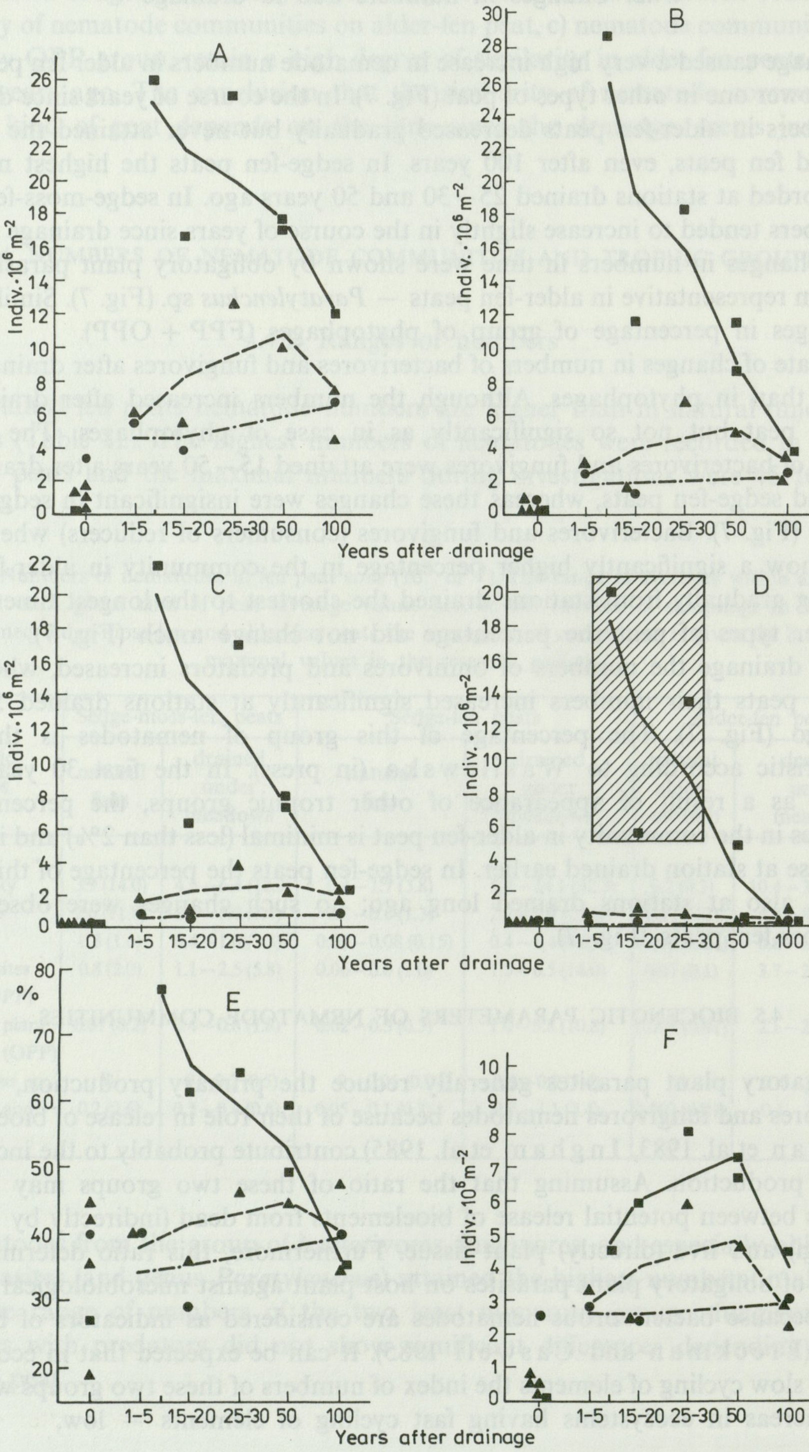
Drainage caused a very high increase in nematode numbers in alder fen peats and a much lower one in other types of peat (Fig. 7). In the course of years since drainage the numbers in alder-fen peats decreased gradually but never attained the level in undrained fen peats, even after 100 years. In sedge-fen peats the highest numbers were recorded at stations drained 25–30 and 50 years ago. In sedge-moss-fen peats the numbers tended to increase slightly in the course of years since drainage (Fig. 7). Similar changes in numbers in time were shown by obligatory plant parasites and their main representative in alder-fen peats – *Paratylenchus* sp. (Fig. 7). Similar were the changes in percentage of group of phytophages (FPP + OPP).

The rate of changes in numbers of bacterivores and fungivores after drainage was different than in phytophages. Although the numbers increased after drainage in alder-fen peat but not so significantly as in case of phytophages. The highest numbers of bacterivores and fungivores were attained 15–50 years after drainage in alder- and sedge-fen peats, whereas these changes were insignificant in sedge-moss--fen peat (Fig. 7). Bacterivores and fungivores (consumers of reducers) when taken jointly show a significantly higher percentage in the community in alder-fen peat increasing gradually from stations drained the shortest to the longest time ago; in two other types of peat the percentage did not change much (Fig. 7).

After drainage the numbers of omnivores and predators increased, whereas in alder-fen peats their numbers increased significantly at stations drained 50–100 years ago (Fig. 7). The percentage of this group of nematodes is the most characteristic according to Wasilewska (in press). In the first 30 years after drainage as a result of appearance of other trophic groups, the percentage of omnivores in the community in alder-fen peat is minimal (less than 2%) and it begins to increase at station drained earlier. In sedge-fen peats the percentage of this group increases also at stations drained long ago; no such changes were observed in sedge-moss-fen peats (Fig. 7).

4.5. BIOCENOTIC PARAMETERS OF NEMATODE COMMUNITIES

Obligatory plant parasites generally reduce the primary production, whereas bacterivores and fungivores nematodes because of their role in release of bioelements (Coleman et al. 1983, Ingham et al. 1985) contribute probably to the increase of primary production. Assuming that the ratio of these two groups may indicate reactions between potential release of bioelements from dead (indirectly by bacteria and fungi) and live (directly) plant tissue. Furthermore, this ratio determines the pressure of obligatory plant parasites on host plant against microbiological activity in soil, because bacterivorous nematodes are considered as indicators of bacterial activity (Freckman and Caswell 1985). It can be expected that in ecosystems having a slow cycling of elements the index of numbers of these two groups would be high, whereas in ecosystems having fast cycling of elements – low.


A
B
C
D
E
F
Indiv.·10⁶ m²
Indiv.·10⁶ m⁻²
%
0
1–5
15–20
25–30
50
100
Years after drainage
Years after drainage
Years after drainage

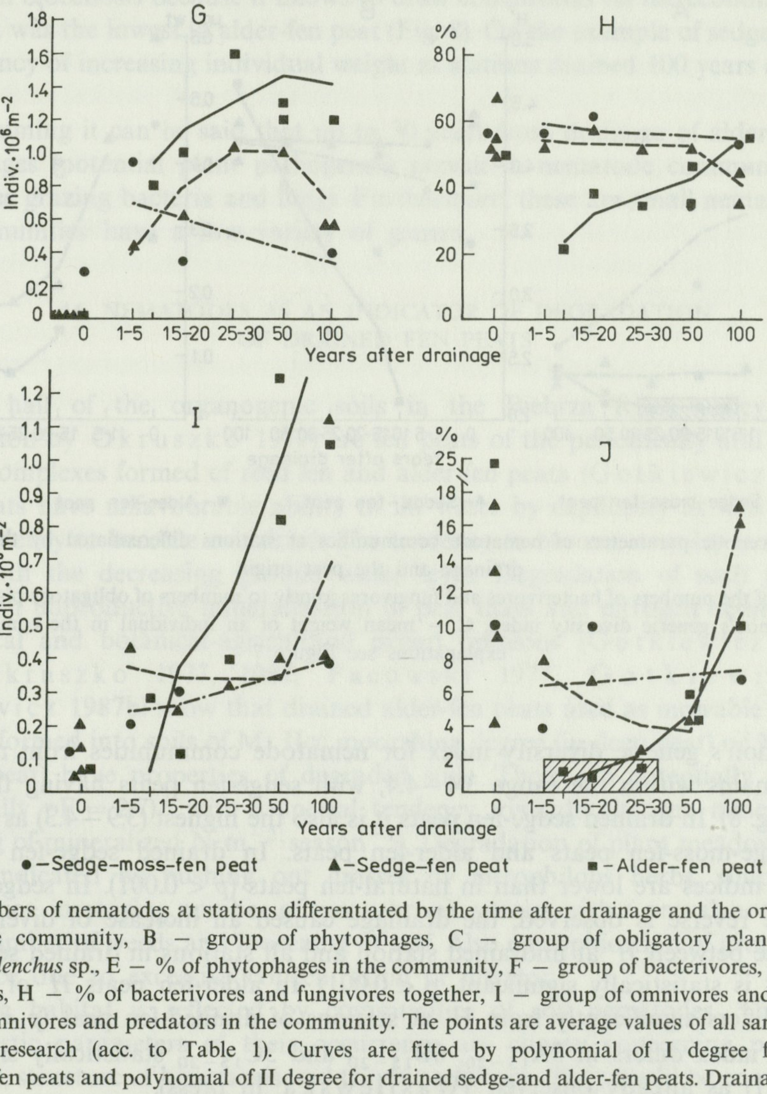


Fig. 7. Numbers of nematodes at stations differentiated by the time after drainage and the origin of peat A — whole community, B — group of phytophages, C — group of obligatory plant parasites, D — *Paratylenchus* sp., E — % of phytophages in the community, F — group of bacterivores, G — group of fungivores, H — % of bacterivores and fungivores together, I — group of omnivores and predators, J — % of omnivores and predators in the community. The points are average values of all samples taken during the research (acc. to Table 1). Curves are fitted by polynomial of I degree for drained sedge-moss-fen peats and polynomial of II degree for drained sedge-and alder-fen peats. Drainage time 0 is for natural-fen peats (undrained)

In natural-fen peats the ratio of numbers of bacteri- and fungivores to numbers of obligatory plant parasites is very high, exceeding several times this ratio for drained fen peats. In drained sedge-moss-fen peats it is 4.2 – 15.8, in sedge-fen peats – 2.0 – 3.6, and in alder-fen peats 0.57 – 3.18 (Fig. 8). In alder-fen peats drained 10 to 30 years ago this ratio is 0.57 – 1.10, and it should be remembered that in alder-fen peat the numbers of bacterivores and fungivores were the highest as compared with other types of peat (Fig. 7). Thus the increase in numbers of both functional groups of nematodes (phytophages and bacteri- and fungivores) is uneven after drainage — the numbers of phytophages increase faster.

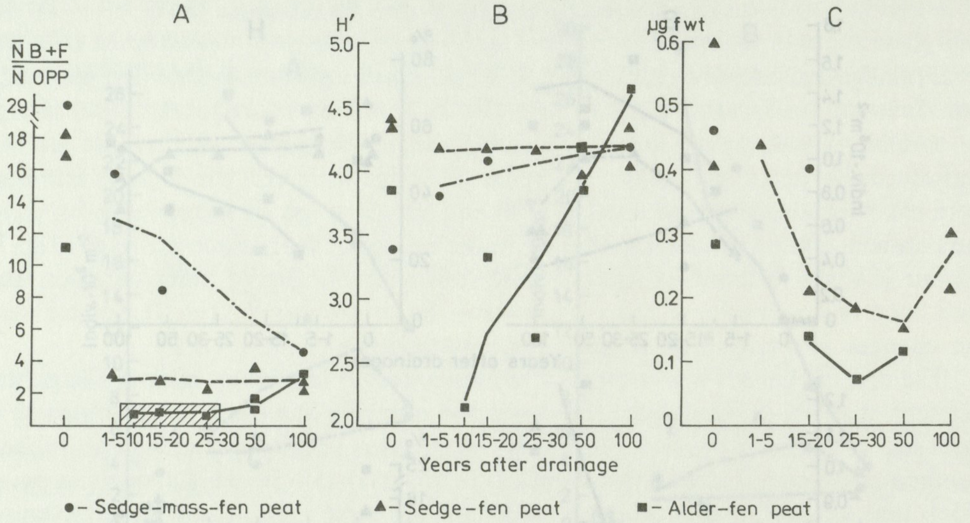


Fig. 8. Biocenotic parameters of nematode communities at stations differentiated by the time after drainage and the peat origin

A — ratio of the numbers of bacterivores and fungivores jointly to numbers of obligatory plant parasites, B — Shannon's generic diversity index, C — mean weight of an individual in the community. For explanations see Figure 7

Shannon's generic diversity index for nematode communities from natural-fen peats remains within the range 3.4 – 4.4, with sedge-fen peats having the highest value (Fig. 8). In drained sedge-fen peats it is also the highest (3.9 – 4.3) as compared with sedge-moss-fen peats and alder-fen peats. In drained sedge-fen peats the diversity indices are lower than in natural-fen peats ($p < 0.001$). In sedge-moss-fen peats the reverse is observed, the drainage caused an increase of diversity index (difference between *H'* at undrained station and all stations in drained sedge-moss--fen peat is statistically significant, $p < 0.001$). In alder-fen peats *H'* of undrained station differs significantly from H' at stations of drained-fen peat ($p < 0.001$). *H'* diversity index differs in $3A_{15-20}$, $6B_{15-20}$ and $3C_{15-20}$ statistically significantly ($p < 0.001$) as already observed (Wasilewska in press).

Thus drainage increased the diversity of genera in sedge-moss-fen peats and decreased the diversity in sedge-fen and alder-fen peats. In alder-fen peats this was a drastic reduction up to 30 years after drainage, whereas in sedge-fen peats *H'* did not vary much in the sequence of stations drained at a different time. This confirms the already observed fact that nematode communities in sedge-fen peats seem to be the most stable (Wasilewska in press). In alder-fen peats there was a drastic reduction of *H'* up to 30 years after drainage in comparison both to natural alder-fen peat and to drained sedge-moss-fen and sedge-fen peats. During that period *H'* was 2.1 – 3.3 (Fig. 8). In peats drained 50 and 100 years ago the diversity index distinctly increased (*H'* = 4.2 – 4.7).

Mean weight of an individual in a community is a very significant indicator of changes in biocenosis because it allows to draw conclusions on the economics of the system. It was the lowest in alder-fen peat (Fig. 8). On the example of sedge-fen peats the tendency of increasing individual weight at stations drained 100 years ago seems probable.

Reassuming it can be said that up to 30 years from drainage of alder-fen peats phytophages (potential plant pathogenes) prevail in nematode communities over nematodes grazing bacteria and fungi. Furthermore, these are small nematodes and the communities have a low variety of genera.

4.6. NEMATODES AS AN INDICATOR OF DEGRADATION OF DRAINED FEN PEATS

Over half of the organogenic soils in the Biebrza River valley (acc. to classification by Okruszko 1977) are fen peats of the periodically arid (BC) and arid (C) complexes formed of reed fen and alder-fen peats (Gotkiewicz in press). These peats have unfavourable ability to lift water by capillarity as well retention and a tendency to become overdried. The tendency to become overdry is noticeable in soil with the decreasing ground water level. Degradation of such peat soils depends on unproductive mineralization of peat mass and nitrogen denitrification. Pedological and botanical-agricultural expert opinions (Gotkiewicz 1977, in press, Okruszko 1977, 1987, Pacowski 1977, Gotkiewicz and Szuniewicz 1987b) show that drained alder-fen peats used as mowable meadows and transformed into soils of Mt IIcc moorshing degree (in deep peat) or Mt IIcl (in shallow peat) have properties of degraded soils. These are potentially arid soils (periodically pF = 2.7)[1] with a special tendency towards nitrogen mineralization (over 30 g of mineralized $N \cdot m^{-2} \cdot season^{-1}$). Degradation of plant meadow associations is indicated by pushing out grasses by nitrophilous herbs, simpler plant communities, increasing number of synanthropic species with a prevalence of herbs, greater number of weeds and loosening of turf. Also eutrophication of ground water takes place due to excessive concentration of nitrates.

Such a habitat is reflected by communities of soil nematodes. Three most characteristic parameters of their occurrence are chosen concerning population characters, structure of biocenosis and trophic relations. They could be considered as indicators of the above described state of the habitat:

1. Numbers of *Paratylenchus* sp. – over $5 \cdot 10^6 \cdot m^{-2}$ (Fig. 7D).
2. Percentage of omnivores and predators in the community – less than 2% (Fig. 7J).
3. Ratio of numbers of bacteri- and fungivores to numbers of obligatory plant parasites $\frac{\bar{N}\ B+F}{\bar{N}\ OPP}$ – below 2 (Fig. 8A).

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[1] Soil moisture ranges within the period of investigations were in $3C_{15-20}$ – 52–73% by weight (after Chmielewski, oral information) and in $2C_{10}$ – 40–80% by volume (after Churski, oral information).

These chosen indices of degradation of drained alder-fen peats "act" within 10 or less – (30–50) years after drainage. They were selected on the basis of a 6-year period of investigations conducted both intensively and extensively. As a biological index it may provide other information than estimations of physical and chemical soil parameters as well as botanical.

Bioindication by means of chosen indices provides information on structural and functional changes within one of the most abundant taxons among soil invertebrates. This provides grounds for judging about processes in soil and first of all about the prevalence of mineralization at the expense of live plant tissue. Up to now I have managed to "test" the index in other areas than the Biebrza River valley, namely in the Liwiec River valley near Trojanów (alder-fen peats at a moorshing degree Mt II, drained 25 years ago). Single sampling on November 4, 1986 showed: *Paratylenchus* sp. – $8.6 \cdot 10^6 \cdot m^{-2}$; omnivores and predators – 1.2% in the community and $\frac{\bar{N}B + F}{\bar{N}OPP} = 0.25$.

5. DISCUSSION

Changes in physical and chemical properties of soil after drainage produced permanent changes in nematode communities. They are connected with moorsh-forming process and mineralization of peat mass and depend on the kind of peat.

Drainage of peat soils was a stress (acc. to definition of Dodd and Lauenroth 1979) for ecosystems examined and the extent of perturbations depended on the origin of peat. Sheehan (1984a, 1984b) suggests an analysis of natural forms of stress as well as those caused by toxic pollutants by means of the same, mainly structural parameters of the community.

Such parameters as abundance, species variety, community composition, species dominance, diversity of taxons and similarity index allowed to determine that nematode communities in drained alder-fen peats were under the greatest stress as proved by:

1. The numbers of the whole community, including bacterivores, fungivores and phytophages which increased, changed the most.

Small numbers of nematodes in swamp soils and natural peat – lands (Peterson 1982) increased several times after drainage exceeding considerably the numbers of nematodes in mineral soils (Wasilewska et al. 1985). An increase in the numbers of bacterivores proves the higher activity of bacteria (Bååth et al. 1981) and perhaps also Actinomycetes [2] (Freckman and Caswell 1985). But the

[2] Very abundant only in alder-fen peats. There is an opinion that Actinomycetes reduce hyphae (Ingham et al. 1986a). Tołpa (1956) assumes that mycorrhiza is of great significance in nitrogen mineralization in peats degraded by drainage. Although there exists an opinion that ectomycorrhizal fungi may participate in mineralization of elements (Coleman et al. 1983) but this phenomenon has not been fully investigated. Interactions between fungi, parasitic nematodes and plants are not well known yet, although there are no doubts as to their existence (Webster 1985).

increase in numbers of root phytophages related with higher nitrogen content in the habitat as confirmed by investigations of Sohlenius and Boström (1986). The release of mineral nitrogen in soil of station $3C_{15-20}$ was 346 kg $N \cdot m^{-2}$, of station $5C_{50}$ – 303 kg $N \cdot m^{-2}$ (Gotkiewicz in press), whereas numbers of phytophages were respectively $11.6 \pm 3.5 \cdot 10^6 \cdot m^{-2}$ and $8.22 \pm 2.4 \cdot 10^6 \cdot m^{-2}$, and thus there is a positive correlation.

2. Decreasing significance in nematode community of omnivores and predators considered as stabilizers of the community (Wasilewska 1985, 1987, Ingham et al. 1986b). Sheehan (1984a) describes this stress index for the community as the withdrawal of groups of species having a "unique role" (e.g., pollinating) or "key" species controlling the functioning of the ecosystem. In nematode communities omnivores and predators (dorylaimids) which are more abundant in ecosystems very little transformed by man (Wasilewska 1974), are according to the author such a group. This group reacts first to a chemical stress as e.g., lead contamination (Zullini and Peretti 1986).

3. The sharpest dominance of genera as proved by superdominance and smaller number of genera in particular dominance classes.

4. Superdominance of the phytophage *Paratylenchus* sp. These nematodes have a small body size, can migrate (migratory ectoparasites), are non-specific in the choice of hosts (or a smaller one than specialized parasites), great specific abundance of host plants, non-specific pathogenic symptoms, ability to produce numerous populations, easily rebuild the population, can fall into an inactive state (anhydrobiosis). Species which manage to survive the severe stress in the ecosystem grow and reproduce fast according to Odum (after Sheehan 1984a). Distinct dominance of species in a community under conditions of strong chemical stress is known among other soil invertebrates, e.g., *Acari Oribatei* (Bielska 1986). It is also known that *Paratylenchus projectus* increased in numbers (and death of other nematode species) due to application of nematocide (Leijdens and Hofmeester 1986) or nitrogen fertilizer (Kozłowska and Domurat 1977). Nematodes react to drying by passing into an inactive stage (anhydrobiosis) for the duration of stress (Freckman 1986, Freckman et al. 1987). This ability is shown by *Paratylenchus* in larval stage-4 (L_4). High ability to survive under rather extreme conditions has been observed in *Paratylenchus microdorus* which was a main dominant at the mountain top (greater temperature and moisture fluctuations) and died out at its foot (Norton and Oard 1981).

Anhydrobiosis in connection with high reproduction and fast growth in summer was considered as a mechanism of survival of desert nematode species (Moorhead et al. 1987), ascribing such species rather a K-selective type of development (Freckman and Mankau 1986). Since the classic differentiation of r- and K-selective species (Pianka 1970) the development strategy of parasites and pathogenes, including nematodes, has been considered. The doubts concerned the proper distinction of species of a small body size and high reproductive potential, which develop under stable environmental conditions (Norton 1978). Simultaneous directing of plant pathogenes towards r- and K-strategies is not at all abnormal (Andrews and Rouse 1982). Yeates (1986) suggests that parthenogenesis in nematodes from the group of migratory ectoparasites (including *Paratylenchus*) is a result of speciation by polyploids and not by means of r-selection. Even if it is too early to analyze fully the life strategy of many nematode species (Yeates 1987) the dominance of *Paratylenchus* sp. in specific natural conditions discussed here speaks for itself and has consequences for the biocenosis. Specific character of these conditions are the physical properties of soil (plenty of micropores, disappearance of mezopores) and chemical (mineral nitrogen in excess), high seasonal and periodical fluctuations of soil moisture (causing periodical release of bioelements). These characters indicate the instability of habitat and the period of disturbances can not be predicted but it is an attribute of habitat of drained alder-fen peats. Thus the percentage of small, resistant to drought, surviving critical and variable environmental conditions species increases. Whether the ability of *Paratylenchus* sp. to dominate in such habitat is a result of its competetive abilities or whether it is only a physiological adapatation, we shall learn in the future.

The dominance of phytophage-nematode having high maintenance costs (small body size), consuming about 20% of annual root production (probably in the period close to the drainage more than that) in the first 30 years after the drainage is probably not the only one. It can be assumed that in degraded alder-fen peats there is a well developed chain of grazing live plant tissue by grazing on plants, e.g., by numerous Elateridae larvae (Andrzejewska et al. 1985) and by active extraction by sucking phytophages, aphids (Andrzejewska et al. 1985), phytophage-nematodes (present paper) and probably mycorrhizal fungi (Tołpa 1956). The activity of sucking phytophages is acc. to Odum and Biever (1984) the quickest form of energy flow from the autotroph to heterotroph level. The drained alder-fen peats are a perfect example of ecosystem with the quickest form of mineralization by live plant tissue. The detritus chain is short here (Kajak et al. 1985, Wasilewska et al. 1985) and so the energy is dispersed quickly. Thus the suggested here bioindication method by *Paratylenchus* contains information on functional changes of the whole ecosystem under the drainage stress.

5. The lowest values of index $\frac{\bar{N}B + F}{\bar{N}OPP}$ suggested by the author (Wasilewska in press).

The index indicates only to a small extent the prevalence of mineralization of dead or live plant tissue as it is generally for only one group of soil invertebrates. However, its relative character when comparing ecosystems is not worse for that. It would be better to present this ratio in better to compare parameters such as e.g., productivity parameters instead of numbers.

6. The lowest index of generic diversity of nematodes up to 30 years after drainage.

7. The smallest body size.

Communities dominated by smaller organisms convert energy and bioelements much quicker (Peters 1983).

8. Similarity of communities in undrained and drained peats is the lowest in alder-fen peats.

All this proves that reaction of ecosystem to the drainage stress, although diminished lasts during the period of 100 years.

6. CONCLUSIONS

Changes in structure of soil nematode communities connected with the time since drainage (1 – 100 years) of natural fen peats and utilizing them as meadows can be characterized as follows:

– All changes connected with the time since drainage depend on the origin of peat.

– Drainage of sedge-fen peats caused smaller changes in nematode dominance than that of alder-fen and sedge-moss-fen peats. Sharper dominance structure (superdominance) occurred only in alder-fen peats in the first 30 years after drainage. In the following years dominance structure changed basically, but even after 100 years it did not resemble the natural fen.

– Number of genera forming nematode communities was the lowest in alder-fen peats as compared with other kinds.

– Drained alder-fen peats were the most easily colonized by obligatory plant parasitic nematodes, whereas sedge-fen peats were easier to colonize than sedge--moss-fen peats.

– The dominant group of nematodes in drained peats consisted of 7 nematode genera; at one station 1 – 4 genera.

– The position of *Paratylenchus* in dominance structure seems to be distinctly connected with peat transformation (moorshing) and peat degradation, indicating that these processes are very slow in sedge-moss-fen peats, violent in alder-fen peats with a reverse tendency after 30 years, and intermediate in sedge-fen peats. The stronger is the dominance of *Paratylenchus* sp. the less genera in a community.

– In the soil of birch forest drained 50 years ago *Paratylenchus* sp. and *Gracilacus* sp. became dominants.

– In the course of years after drainage proportions of trophic groups changed, the greatest in alder-fen peats. Percentage of bacterivores increased, whereas of obligatory plant parasites – decreased. But even after 100 years there was no return to the initial state.

– Similarity of nematode communities in a given peat type is due to the time after the drainage. In alder-fen peats after drainage the similarity of communities was the lowest. Nematode communities, and especially the group of obligatory plant parasites showed high similarity in alder-fen peats drained 10 – 30 years ago.

– Drainage caused a great increase in numbers of nematodes. It was the highest in alder-fen peats (maximal numbers of individuals – $45 \cdot 10^6 \cdot m^{-2}$), whereas in other kinds of peat it was not so high. Numbers of phytophages increased faster than of bacteri- and fungivores. In the course of years the numbers of several trophic groups and of the genus *Paratylenchus* decreased. The numbers of omnivores and predators also increased after drainage, but their percentage did not exceed 2% in the first 30 years after drainage of alder-fen peats.

– In the first 30 years after drainage of alder-fen peats in nematode communities, phytophages (potential plant pathogenes) prevailed over nematodes grazing bacteria and fungi. These were small nematodes having low generic diversity.

– Nematodal indices of degradation of drained alder-fen peats "acting" within 10 or less – 30(50) years after drainage were chosen: a) numbers of *Paratylenchus* sp. – over $5 \cdot 10^6 \cdot m^{-2}$; b) percentage of omnivores and predators in a group – less than 2% and c) ratio of numbers of bacteri- and fungivores to numbers of obligatory plant parasites $\frac{\bar{N}B+F}{\bar{N}OPP}$ below 2.

These indices prove the structural and functional changes in the ecosystem of drained alder-fen peats used as meadows and transformed into soils of a Mt IIcc and Mt IIcl degree of moorshing. Bioindices probably correlate with the amount of nitrogen mineralized in soil which is then greater than $30\ g \cdot m^{-2} \cdot season^{-1}$.

7. SUMMARY

Communities of soil nematodes occurring in drained fen peat soils utilized as meadows and for the purpose of comparison those in natural-fen peats, were examined. Research stations differed by the time after drainage (1–100 years) and origin of fen peat (sedge-moss, sedge and alder). Studies were conducted in the Biebrza River and Narew River valleys, using the results of many years of investigations conducted on these areas – pedological, phytosociological, botanical and agricultural. As the degree of moorshing-process increased from sedge-moss-fen peats to alder-fen peats the bulk density increased, soil porosity (especially % of mesopores) and soil moisture decreased (Table 1). At 22 research stations soil samples for nematodes were taken 1–21 times (depending on the station) during the investigations between 1978 and 1983 (Table 1). Changes in communities due to the time after drainage were found on the basis of following parameters: density of particular genera and trophic groups, number of genera, dominance structure, trophic structure, generic diversity, indices of similarity of communities and mean weight of an individual in a community. The following were found:

1. All changes due to the time after drainage depend on the origin of peat.

2. Drainage of sedge-fen peats caused smaller changes in nematode dominance than drainage of alder- and sedge-moss-fen peats (Tables 9, 10, 11). Sharper dominance structure (superdominance) occurred only in alder-fen peats in the first 30 years after drainage. In the next years the dominance structure changed basically, but even after 100 years it does not resemble the natural-fen peat (Tables 4, 5, 6, 7, 8, Fig. 2).

3. The number of genera forming nematode communities was the lowest in alder-fen peats as compared with other kinds of peat (Table 4).

4. Drained alder-fen peats were the easiest to colonize by obligatory plant parasitic nematodes, whereas sedge-fen peats were more easily colonized than moss-sedge-fen peats (Table 5).

5. The dominant group of nematodes in drained peats consisted of 7 genera of nematodes: 1–4 genera at one station (Table 4).

6. The position of *Paratylenchus* in dominance structure seems distinctly connected with peat transformation (moorshing) and degradation, indicating that these processes are very slow in sedge-moss--fen peats, violent in alder-fen peats with a reverse tendency 30 years after drainage and intermediate in

sedge-fen peats (Table 4). The stronger the dominance of *Paratylenchus* sp. the less genera form the community (Fig. 3).

7. In the soil of birch forest on alder-fen peat drained 50 years ago *Paratylenchus* sp.and *Gracilacus* sp. become dominants (Tables 4, 5, 11, Fig. 4).

8. In the course of years after drainage proportions among trophic groups changed the most in alder-fen peats. Percentage of bacterivores increased and of obligatory plant parasites decreased (Fig. 4). But even 100 years after the drainage did not cause a return to the initial state.

9. Similarity of communities in a given kind of peat is due to the reaction of nematodes to time after the drainage. The similarity of stations was reduced most drastically as a result of drainage in alder-fen peats. Nematode communities and especially the group of obligatory plant parasites maintained a high degree of similarity in alder-fen peats drained 10–30 years ago (Figs. 5, 6).

10. Drainage caused a strong increase in numbers of nematodes (maximal numbers of individuals – $45 \cdot 10^6 \cdot m^{-2}$) in alder-fen peats and a much weaker one in other kinds of peat. The numbers of phytophages increased faster than of bacteri- and fungivores (Table 12). In the course of years the numbers of several trophic groups and of the genus *Paratylenchus* decreased. Omnivores and predators also reacted to drainage by an increase in numbers, but their percentage in the first 30 years after drainage did not exceed 2% (Fig. 7).

11. In the first 30 years after drainage of alder-fen peat phytophages (potential plant pathogenes) prevailed in nematode communities over nematodes grazing bacteria and fungi. These were small nematodes and the communities had a low generic diversity (Fig. 8).

12. Nematodal indices of degradation of drained alder-fen peats "acting" within 10 or less – 30(50) years after drainage were chosen. They concern population characters, structure of biocenosis and trophic relations. These are: (a) numbers of *Paratylenchus* sp. – over $5 \cdot 10^6 \cdot m^{-2}$; (b) percentage of omnivores and predators in a community – less than 2% and (c) ratio of numbers of bacteri- and fungivores to numbers of obligatory plant parasites $\frac{\bar{N} B+F}{\bar{N} OPP}$ – below 2. These indices prove structural and functional changes in the ecosystem of drained alder-fen peats used as meadows and transformed into soil of a Mt IIcc and Mt IIcl moorshing degree. Bioindices probably are correlated with the amount of nitrogen mineralized in soil which exceeds then 30 $g \cdot m^{-2} \cdot season^{-1}$.

8. POLISH SUMMARY

Badano zespoły nicieni glebowych zasiedlające osuszone gleby torfowe zagospodarowane jako łąki oraz, dla porównania, zasiedlające torfowiska naturalne. Stanowiska badawcze różniły się czasem, który upłynął od odwodnienia (od 1 do 100 lat) i genezą torfu (mechowiskowy, turzycowiskowy i olesowy). Badania prowadzono w dolinie rzeki Biebrzy i Narwi, przy czym wykorzystano wyniki wieloletnich badań gleboznawczych, fitosocjologicznych, botanicznych i rolniczych prowadzonych na tych terenach. Wraz ze wzrostem stopnia zmurszenia od torfów mechowiskowych do olesowych wzrastał ciężar objętościowy i zmniejszała się porowatość gleby (szczególnie % mezoporów) oraz wilgotność gleby (tab. 1). Na 22 stanowiskach badawczych pobrano próby gleby na nicienie w ilości od 1 razu do 21 razy (zależnie od stanowiska) w okresie badawczym 1978–1983 (tab. 1). Zmian w zespołach związanych z upływem lat do odwodnienia poszukiwano w oparciu o następujące parametry: liczebność rodzajów i grup troficznych, liczba rodzajów, struktura dominacji, struktura troficzna, różnorodność rodzajowa, wskaźniki podobieństwa zespołów i przeciętny ciężar osobnika w zgrupowaniu. Stwierdzono:

1. Wszelkie zmiany związane z czasem od odwodnienia uzależnione są od genezy torfu.

2. Odwodnienie torfów turzycowiskowych wywołało mniejsze zmiany w charakterze dominacji nicieni niż odwodnienie torfów olesowych i mechowiskowych (tab. 9, 10, 11). Zaostrzona struktura dominacji (superdominacja) wystąpiła tylko na torfach olesowych w pierwszym trzydziestoleciu po odwodnieniu.

W następnych latach struktura dominacyjna ulega zasadniczej zmianie, jednak nawet po 100 latach nie upodabnia się do torfowiska naturalnego (tab. 4, 5, 6, 7, 8, rys. 2).

3. Liczba rodzajów tworzących zespoły nicieni była najniższa na torfach olesowych w porównaniu z pozostałymi typami torfów (tab. 4).

4. Odwodnione torfy olesowe wykazały najwyższą podatność na zasiedlenie przez nicienie – fitofagi obligatoryczne, a torfy turzycowiskowe wyższą niż torfy mechowiskowe (tab. 5).

5. W skład dominującej grupy nicieni na odwodnionych torfach wchodzi 7 rodzajów nicieni; na jednym stanowisku od 1 do 4 rodzajów (tab. 4).

6. Pozycja *Paratylenchus* w strukturze dominacji wydaje się najwyraźniej sprzężona z procesami przemiany torfu (proces murszenia) jak i z degradacją torfu, wskazując, iż procesy te są bardzo powolne na torfach mechowiskowych, niezmiernie gwałtowne na torfach olesowych z tendencją odwrotu po 30 latach i pośrednie na torfach turzycowiskowych (tab. 4). Im silniejsza dominacja *Paratylenchus* sp. tym mniej rodzajów tworzących zespół (rys. 3).

7. W glebie olsu brzozowego, 50 lat po odwodnieniu, do pozycji dominanta dochodzi *Paratylenchus* sp. i *Gracilacus* sp. (tab. 4, 5, 11, rys. 4).

8. W miarę upływu lat od odwodnienia ulegają zmianie proporcje między grupami troficznymi najsilniej na torfach olesowych. Występuje wzrost udziału bakteriofagów i spadek udziału fitofagów obligatorycznych (rys. 4). Jednakże nawet 100-letni okres po odwodnieniu nie spowodował powrotu do stanu pierwotnego.

9. Podobieństwo zespołów na danym typie torfu wynika z reakcji nicieni na czas upływający od odwodnienia. Odwodnienie obniżyło podobieństwo stanowisk najdrastyczniej na torfach olesowych. Zespoły nicieni, a szczególnie grupa fitofagów obligatorycznych zachowała wysoki stopień podobieństwa na torfach olesowych odwodnionych od 10 do 30 lat wcześniej (rys. 5, 6).

10. Odwodnienie spowodowało bardzo silny wzrost liczebności nicieni. Na torfach olesowych był on najsilniejszy (maksymalna stwierdzona liczebność osobników – $45 \cdot 10^6 \cdot m^{-2}$) i znacznie słabszy wzrost po osuszeniu wystąpił na pozostałych typach torfów. Wzrost liczebności fitofagów zachodził szybciej niż bakterio- i mykofagów (tab. 12). W miarę upływu lat następował spadek liczebności kilku grup troficznych i spadek liczebności rodzaju *Paratylenchus*. Pantofagi i drapieżce też zareagowały na odwodnienie wzrostem liczebności, ale ich udział w pierwszych 30 latach po odwodnieniu torfów olesowych nie przekraczał 2% (rys. 7).

11. W pierwszych 30 latach po odwodnieniu torfów olesowych w zespołach nicieni przeważały fitofagi (potencjalne patogeny roślin) nad nicieniami spasającymi bakterie i grzyby. Były to ponadto nicienie drobne a same zespoły charakteryzowały się niską różnorodnością rodzajową (rys. 8).

12. Wytypowano nicieniowe wskaźniki degradacji osuszonych torfów olesowych „działające" w zakresie od 10 lub mniej do 30–50 lat po odwodnieniu. Zestaw tych wskaźników dotyczy cech populacyjnych, struktury biocenozy i zależności troficznych. Są to: a) liczebność *Paratylenchus* sp. – powyżej $5 \cdot 10^6 \cdot m^{-2}$; b) udział pantofagów i drapieżców w zgrupowaniu – poniżej 2% i c) stosunek liczebności bakterio- i mykofagów do liczebności fitofagów obligatorycznych $\frac{\bar{N}B+F}{\bar{N}OPP}$ – poniżej 2.

Powyższe wskaźniki dowodzą zmian strukturalnych i funkcjonalnych w ekosystemie odwodnionych torfów olesowych użytkowanych łąkowo i przekształconych w gleby o stopniu zmurszenia Mt IIcc i Mt IIcl. Biowskaźniki korelują prawdopodobnie także z ilością mineralizowanego azotu w glebie, która jest wtedy większa niż 30 $g \cdot m^{-2} \cdot sezon^{-1}$.

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