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The nematode fauna of the northern Adriatic offshore sediments: community structure and biodiversity

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In order to provide a comparative source of data for local (Adriatic Sea) and regional (Mediterranean) biodiversity, as well as for future environmental quality assessments, the pattern of nematode fauna community structure at silty-sand offshore sediment was investigated. The qualitative and quantitative composition of nematofauna was studied at three northern Adriatic offshore sites associated with circalittoral zone and detritic bottom communities. The study involved the main population parameters (density, dominance, constancy) and community attributes (taxonomic composition, abundance, species richness, evenness, diversity, faunistic affinity). From 57 samples collected over a period of two years 12 350 Nematoda specimens were retrieved and subjected to spatial analysis. The results of multivariate analyses indicate high faunistic similarity, both from the qualitative (QS=68-76%) and quantitative aspects (QS=48-56%). The mutual intersection of k-dominance curves suggested the same trend of distribution of individuals per species at all sites investigated. In all, 168 free-living nematode species, comprising 101 genera and 29 families, were recorded. The area investigated is distinguished by considerable taxonomic diversity and respectable species richness (60% of total nematofauna species) in comparison to other Adriatic regions.

Key words: Nematoda, northern Adriatic, silty-sand sediment, community structure, biodiversity

INTRODUCTION

Free-living marine nematodes are the most diverse, abundant and widespread metazoans in the benthic subsystem. The number of species presented in any one habitat is usually an order of magnitude greater than for any other major taxon (PLATT, 1980; HEIP *et al.*, 1985). A lot of species are cosmopolitan and their distribution is influenced by granulometric composition of sediment rather than the latitudinal position of habitat (HEIP *et al.*, 1982). At shallow depths, communities are controlled by the unpredictable nature of physical variables such as waves, tide, current action, grain-size properties, pore-water content, temperature and salinity (GRAY, 1974). Deeper, in the subtidal zone, due to decreasing variability of most abiotic factors, nematode populations appear to be much more stable (HEIP *et al.*, 1982, 1985). Nematode fauna is distributed independently within 2-3 cm patches and variability on a larger, e.g. km, scale seems to be less important except when an environmental gradient exists or where disturbance is common (HEIP *et al.*, 1985). In such circumstances, due to an array of comparative advantages, nematodes may be used as very suitable indicators of environmental quality assessment (HEIP *et al*., 1982, 1985; GRAY, 1971; BONGERS *et al*., 1991). In stable conditions, rather high nematode diversity can be attained within a relatively small area and rather close faunistic composition may be expected in comparable habitats, even in quite distant regions. In such cases, nematofauna could be an appropriate focus for comparative ecological and biogeographical studies and very suitable tool for biodiversity assessment.

Regardless of ultimate purpose, the essential prerequisite for objective evaluation and interpretation of data is a proper knowledge of actual and comparable community structure. In that sense, significant differences were found between assemblages from physically unstable and comparatively stable environments (e.g. shallow near-shore area *vs.* deeper parts of the subtidal zone) and those that occur in different types of habitat, e.g. muddy *vs.* sandy bottoms (WIESER, 1960; WARWICK & BUCHANAN, 1970; LORENZEN, 1974; HEIP *et al*., 1982, 1983). Unfortunately, to date, insight into different coenological aspects (e.g. regional, depth-wise, sedimentological and temporal) indicates a disproportion between the importance of this issue and the actual state of knowledge. The majority of publications deal with meio- and nematode fauna communities, considering assemblages either from a narrow near-shore belt (sandy beaches, estuaries and bays) or, more rarely, those inhabiting offshore muddy bottoms. Weak sampling coverage of offshore silty-sand habitats may be considered as a global trend, as is the case for the Adriatic Sea. The present paper aims to redress this underestimation and to give a comparative basis for further investigation.

MATERIALS AND METHODS

Study area

The sampling sites SJ 005 (φ 45°18.4'N, λ 13°08.0'E), SJ 007 (φ 45°17.0'N, λ 13°16.0'E) and SJ 107 (φ 45°02.8'N, λ 13° 19.0'E,) are located in the eastern part of the northern Adriatic Sea (Fig. 1) and they belong to the circalittoral zone. According ZAVODNIK *et al.* (1994) these sites are associated with biocoenosis of muddy detritic bottoms - DE (SJ005), biocoenosis of transitional detritic bottoms - DL (SJ007) and biocoenosis of coastal detritic bottoms - DC (SJ107), and are characterized by similar environmental features including depths of 31-37 m, silty-sand type of sediment, contemporary occurrence of acute oxygen deficiency and similar macrobenthic composition. At all sites sediment was classified as poorly sorted silty-sand and was distinguished by a high participation of sand dominated by fine and very fine fractions (Table 1).

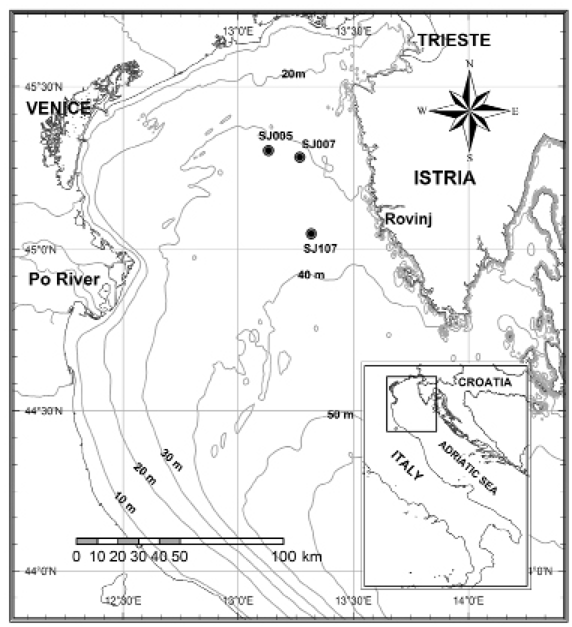

Fig. 1. The study area with sampling sites

Sampling methods and data analysis

Sampling was carried out from November 1989 to February 1991 at monthly intervals, and then seasonally in April, July, September and December 1991. Undisturbed sediment samples (10 cm^2 surface, 10 cm depth) were collected by SCUBA divers, using plastic hand corers. The material was treated according to standard laboratory procedures including: 1) fixation and staining (4% neutralized formalin with addition of Rose Bengal), 2) elutriation, 3) sieving (100 and 50 μm mesh sizes), 4) counting and

Table 1. Grain size analysis of sediment at three sampling sites in the northern Adriatic offshore area, following methods described by FOLK (1974) and classification of sediment types after SHEPPARD (1954) (12, 13). Granulometric parameters are in µm and Φ units (Φ = -log$_2$d, d= diameter in mm

Fraction	Site	SJ 005		SJ 007		SJ 107	
	Grain size (µm)	%	cumul. %	%	cumul. %	%	cumul. %
Gravel	> 4000	3,15	5,42	1,00	2,15	1,21	3,68
	2000-4000	2,27		1,15		2,56	
Sand	1000-2000	2,04	57,03	1,62	69,27	3,70	61,91
	500-1000	3,17		2,34		4,06	
	250-500	3,99		4,19		4,72	
	125-250	27,17		30,75		10,98	
	63-125	20,66		30,37		38,45	
Silt	32-63	9,29	22,11	7,97	18,98	16,99	26,57
	16-32	1,94		1,00		0,76	
	8-16	5,09		4,04		3,69	
	4-8	5,79		5,97		5,13	
Clay	2-4	9,80	15,44	6,96	9,60	5,37	7,84
	< 2	5,64		2,64		2,47	
Total		100,00	100,00	100,00	100,00	100,09	100,00
Mean size	Mz (µm)	101		107		84	
Median	Md (Φ)	3,30		3,20		3,70	
Sorting	Sk (Φ)	2,38		2,39		3,05	
Sorting class		very poorly sorted		very poorly sorted		very poorly sorted	
Sediment type		silty sand		silty sand		silty sand	

classification of the main meiofaunal taxa (this paper concerns only nematodes), 5) separation, mounting and determination (250 ind./sample) of Nematoda species (UHLIG *et al.*, 1973; PLAT & WARWICK, 1983). In total 12 350 Nematoda specimens were retrieved and classified.

Data regarding population parameters, i.e. dominance and constancy, were sorted and analysed according standard coenological classifications (PALLISA *et al.*, 1979; SELVIN & VACCA, 2004). The pooled data (nineteen triplicate samples per site) were subjected to multivariate (Bray-Curtis similarity coefficients), univariate (diversity indices) and distributional analyses (k-dominance curves) (PLATT & LAMBSHEAD, 1985; CLARKE & WARWICK, 1990).

RESULTS AND DISCUSSION

Taxonomical structure of nematode fauna assemblages

In all, 168 free-living nematode species, comprising 101 genera and 29 families, were noted (Table 2). A considerable part of the nematode fauna comprised of members of the families Chromadoridae, Comesomatidae, Cyatholaimidae and Linhomoeidae. These families, combined in different portions, cumulatively comprised 62-70% of all individuals present at particular sites. Some other families, belonging to subclasses Chromadoria (Selachinematidae, Xyalidae, Sphaerolaimidae, Axonolaimidae, Ethmolaimidae and Desmodoridae) and Enoplia (Oncholaimidae, Rhabdodemanidae and Oxystominidae) were also present in notable abundance. Within particular families, the number of subordinated taxa varied from 1 to 10 genera and from 1 to 17 species. Most of the genera contained only one (66 genera) or two species (14 genera) and a maximal number of 5-6 species were distributed within genera *Halalaimus, Sabatieria, Sphaerolaimus, Viscosia,* and *Theristus*. Eight of the species (*Enoploides brunetti, Cylicolaimus magnus, Richtersia staresensis, Sabatieria granifer, Spirinia hamata, Desmodora deconinki, Leptolaimus pumicosus* and *Paralinhomoeus caxinus*) were noted for the first time in Adriatic sediments (TRAVIZI & VIDAKOVIĆ, 1997). In terms of abundance and dominance, the nematofauna assemblages described in this study are fully comparable with assemblages occurring world-wide in silty-sand habitats.

Table 2. Taxonomic composition of free- living nematodes. Total number of genera(G), species (Sp) and specimens (Sm) per site

FAMILY	SITE SJ 005			SITE SJ 007			SITE SJ 107		
	G	Sp	Sm	G	Sp	Sm	G	Sp	Sm
ENOPLIA									
Thoracostomopsidae	2	2	9	2	3	33	2	2	35
Phanodermatidae	1	1	2	2	2	10	1	1	9
Anoplostomatidae	-	-	-	1	1	1	-	-	-
Anticomidae	1	1	7	1	1	47	1	1	10
Ironidae	2	2	13	1	1	2	1	1	6
Leptosomatidae	-	-	-	-	-	-	1	1	1
Oxystominidae	4	8	114	5	13	161	5	11	145
Oncholaimidae	4	7	258	3	9	136	5	11	151
Trypiloididae	-	-	-	1	1	1	-	-	-
Enchelidiidae	1	1	4	4	4	5	4	4	17
Rhabdodemaniidae	1	1	179	1	1	135	1	1	212
Trefusiidae	-	-	-	-	-	-	1	1	1
Σ	16	23	586	21	36	531	22	34	587
CHROMADORIA									
Chromadoridae	7	9	898	8	12	788	9	13	365
Ethmolaimidae	1	2	50	1	4	98	1	3	61
Selachinematidae	4	8	149	4	5	100	4	8	206
Cyatholaimidae	4	6	392	5	8	641	5	10	583
Comesomatidae	8	10	902	7	11	630	6	7	819
Desmodoridae	2	4	101	2	4	56	5	7	34
Leptolaimidae	4	4	15	3	4	67	2	2	38
Aegialolaimidae	-	-	-	-	-	-	1	1	6
Haliplectidae	-	-	-	1	1	1	-	-	-
Ceramonematidae	1	1	3	1	1	4	2	3	30
Desmoscolecidae	2	2	16	1	1	3	2	2	4
Xyalidae	3	7	245	3	7	130	3	8	148
Sphaerolaimidae	1	4	72	1	5	86	1	5	169
Siphonolaimidae	2	2	16	2	2	24	1	1	4
Linhomoeidae	9	15	521	6	17	883	6	12	757
Axonolaimidae	1	1	181	2	4	102	2	3	199
Diplopeltidae	1	1	3	3	3	6	4	4	40
Σ	50	76	3564	50	89	3619	54	89	3463
TOTAL	66	99	4150	71	126	4150	76	123	4050

A dominance pattern characterized by the conspicuous co-dominance of several nematode species was expected due to the prevalence of coarser sediment fractions. Unlike “silty communities” where one species dominated, in “sandy communities” usually three or four equally dominant species were noted (HEIP *et al.*, 1985). Such a distinction was usually explained by increasing habitat heterogeneity caused by increasing sediment grains, decreasing of silty-clay content and improvement of sorting efficiency (WIESER, 1960; HOPPER & MEYERS, 1967; GRAY, 1974; HEIP *et al.*, 1985). Although large numbers of species were found to be common for mud and silty-sand, many of them are muddy- or sandy- preferring, and occur with different dominance in either sediment type. At our stations, enhanced participation of some families (Comesomatidae, Linhomoeidae, Sphaerolaimidae), genera (*Sabatieria, Dorylaimopsis, Sphaerolaimus, Terschellingia, Axonolaimus, Daptonema*) and species (*Sabatieria granulosa, Dorylaimopsis mediterranea, Sphaerolaimus dispar, Terschellingia longicaudata*) typically found to be dominant or very abundant in muddy sediments (BOUCHER, 1972; VITIELLO, 1974) indicated a slight disturbance in nematofauna community structure. It could be linked with the incomplete recovery of nematofauna after acute oxygen deficiency affected this community in the late 80’s (TRAVIZI, 1996, 1998, 2000).

Dominance and constancy patterns

The obvious supremacy of the 5-6 most abundant species (cumulatively dominated by 42-45%), and a similar proportion of the majority that comprised more than 90% of the total species number, were noted at all sites investigated (Fig. 2). Due to a relative abundance of less than 1%, most of the species (76 sp. at site SJ 005, 101 sp. at site SJ 107 and 103 sp. at site SJ 007) should be ranked in the lowermost category of dominance. From a total of 168 species recorded, only 38 species (22 at site SJ 107 and 23 at sites SJ 005 and SJ 007) were distributed

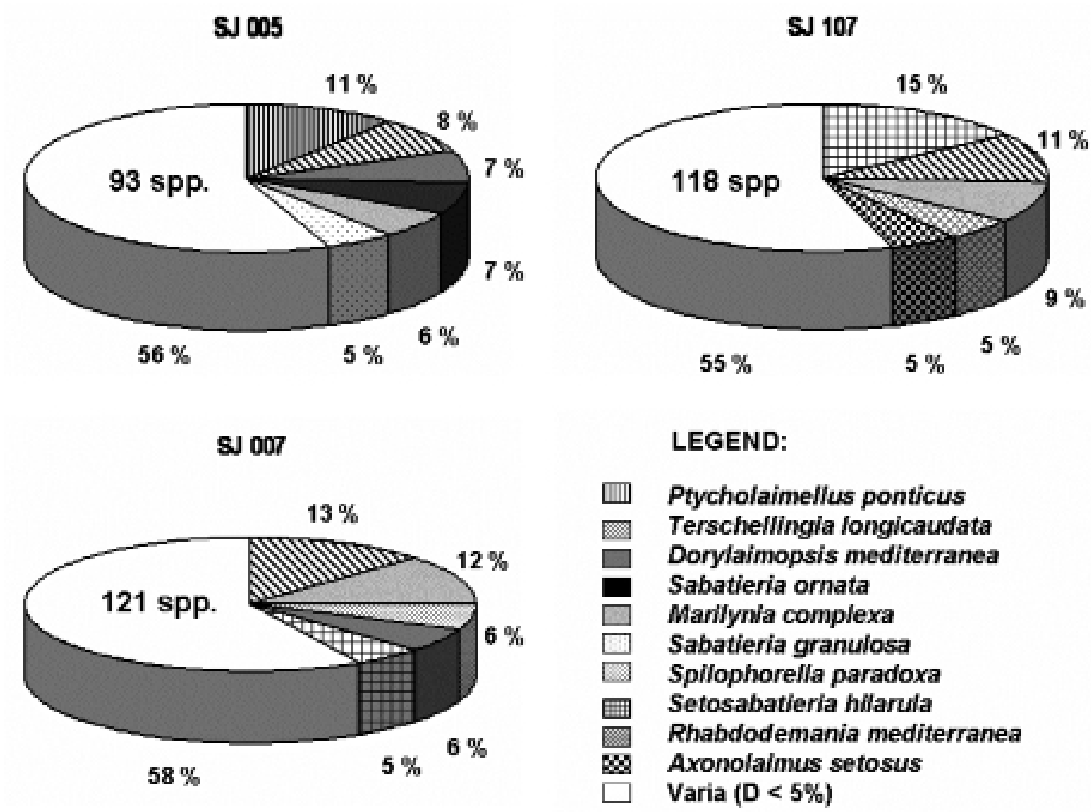

Fig. 2. Species composition and relative abundance of dominant (D >5%) Nematoda species of the northern Adriatic offshore sediment

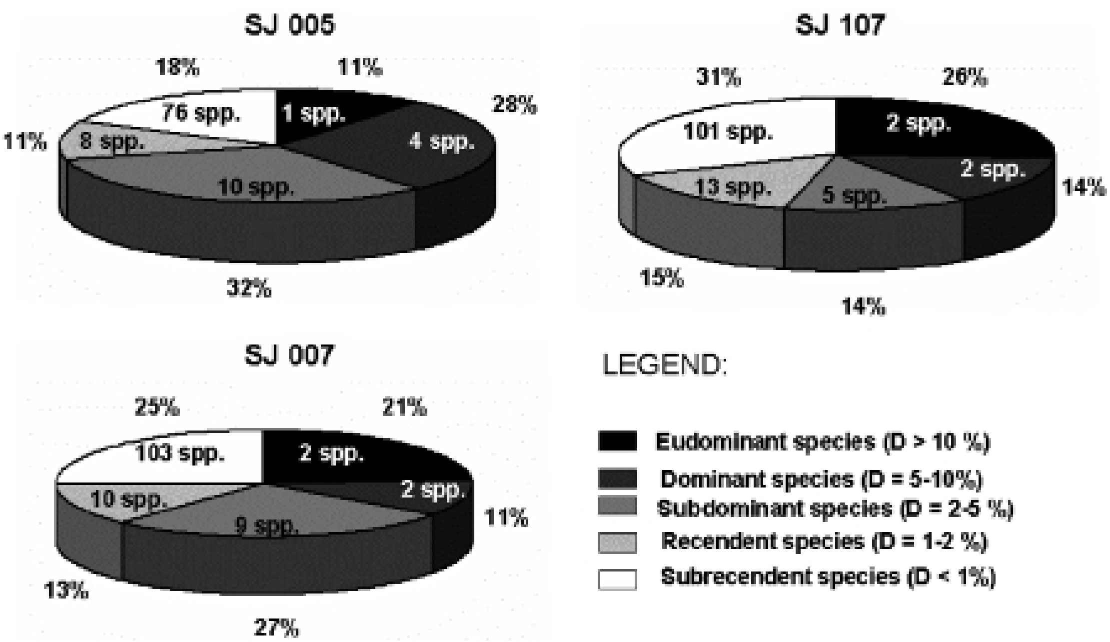

Fig. 3. Cumulative participation of Nematoda species ranked by dominance (D)

among all other dominance categories (Table 3) and that number decreased with increasing rank of dominance (Fig. 3). Very close trends were observed with regard to species constancy, although due to somewhat smoother distribution, a decreasing number of species with increasing rank of constancy achieved a more gradual distribution pattern (Fig. 4). The species distinguished by high population densities were often characterized by a high frequency of occurrence and can be ranked as highly constant species (TIETJEN, 1984). Such species to a

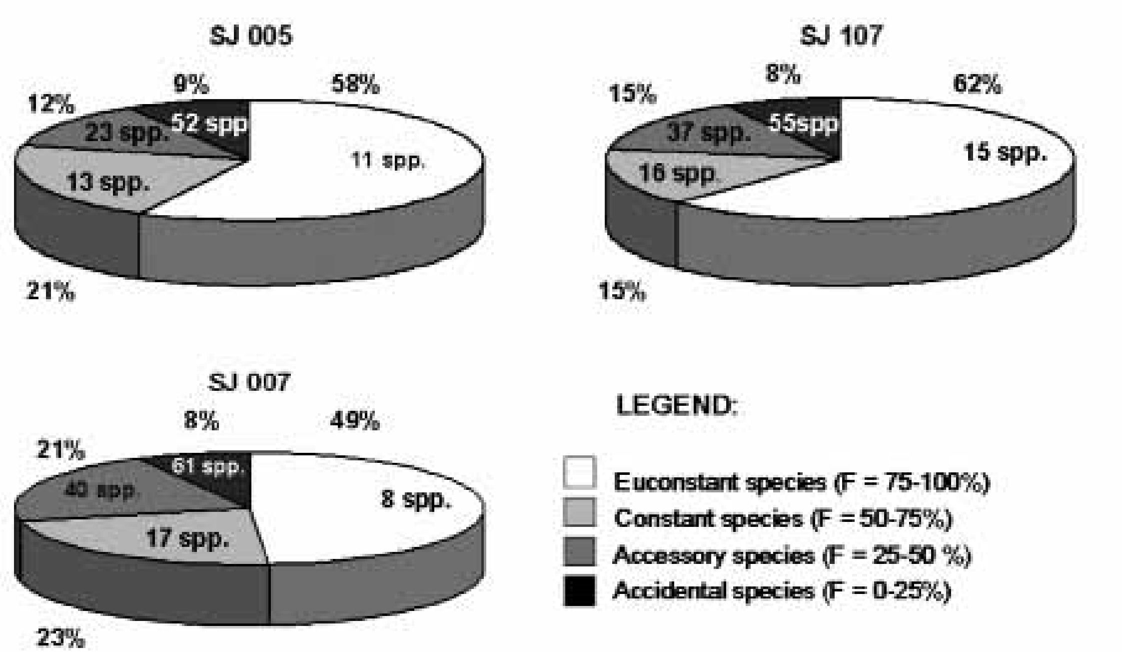

Fig. 4. Cumulative participation of Nematoda species ranked by frequency of occurrence (F) at investigated sites

Table 3. Total number of specimens found during biennial investigations (57 samples per site) with dominance and constancy of species contributing to total nematofauna composition with relative abundance ≥ 1%

SPECIES / SITE	Abundance			Dominance (%)			Constancy (%)		
	SJ 005	SJ 007	SJ 107	SJ 005	SJ 007	SJ 107	SJ 005	SJ 007	SJ 107
Anticoma acuminata	7	41	10	< 1	1,13	< 1	26	63	37
Nuada sp.2	0	28	41	-	< 1	1,01	-	53	79
Metoncholaimus sp.1	86	51	11	2,07	1,23	< 1	53	47	26
Prooncholaimus megastoma	76	0	6	1,83	-	< 1	26	-	16
Viscosia sp.1	55	18	13	1,33	< 1	< 1	47	32	47
Rhabdodemania mediterranea	179	135	212	4,31	3,25	5,23	100	100	100
Actinonema sp.	5	10	113	< 1	< 1	2,79	21	37	84
Chromadora nudicapitata	112	15	21	2,70	< 1	< 1	16	11	26
Prochromadorella sp.1	84	0	27	2,02	-	< 1	53	-	37
Prochromadorella sp.3	0	132	39	-	3,18	< 1	-	63	42
Ptycholaimellus ponticus	459	111	23	11,06	2,67	< 1	100	79	26
Ptycholaimellus sp.	0	127	0	-	3,06	-	-	42	-
Spilophorella euxina	68	113	69	1,64	2,72	1,70	90	68	68
Spilophorella paradoxa	155	232	47	3,73	5,59	1,16	84	84	58
Neotonchus pseudocorcundus	39	58	17	< 1	1,40	< 1	58	74	37
Halichoanolaimus lanceolatus	47	66	71	1,13	1,59	1,75	42	63	68
Richtersia staresensis	59	19	70	1,42	< 1	1,73	58	47	84
Marilynia bellula	96	74	2	2,31	1,78	< 1	74	32	11
Marilynia complexa	260	478	354	6,27	11,52	8,74	79	90	90
Metacyatholaimus adriaticus	20	15	88	< 1	< 1	2,17	47	42	90
Actarjania lepida	33	52	77	< 1	1,25	1,90	26	63	68
Dorylaimopsis mediterranea	298	232	84	7,18	5,59	2,07	100	100	84
Hopperia massiliensis	43	11	0	1,04	< 1	-	42	26	-
Sabatieria granulosa	203	45	0	4,89	1,08	-	90	37	-
Sabatieria granifer	19	0	41	< 1	-	1,01	47	-	47
Sabatieria ornata	281	44	22	6,77	1,06	< 1	100	63	53
Setosabatieria hilarula	13	206	590	< 1	4,96	14,57	21	100	100
Desmodora deconincki	67	8	9	1,61	< 1	< 1	58	16	21
Molgolaimus sp.	16	42	5	< 1	1,01	< 1	11	42	11
Daptonema conicum	104	11	45	2,51	< 1	1,11	74	37	74
Theristus sp.3	114	90	48	2,75	2,17	1,19	84	53	58
Sphaerolaimus dispar	47	39	80	1,13	< 1	1,98	90	58	84
Sphaerolaimus ostreae	9	30	48	< 1	< 1	1,19	37	74	79
Metalinhomoeus sp.5	0	62	0	-	1,49	-	-	37	-
Paralinhomoeus brevibucca	41	18	90	< 1	< 1	2,22	68	42	100
Terschellingia communis	12	100	56	< 1	2,41	1,38	32	84	90
Terschellingia longicaudata	336	521	443	8,10	12,55	10,94	100	100	100
Axonolaimus setosus	181	96	195	4,36	2,31	4,81	74	68	100
Other species (D<1%) cumulatively	526	820	983	12,68	19,76	24,27			

large extent determine nematode assemblage structure although, for characterization of a particular assemblage, a low abundant but highly constant species may be just as important. Apart from highly dominant species (D>5%) a rather high degree of constancy was observed for several subdominant, recendent and subrecendent species. Some of them were common and characteristic for two or three sites, e.g. *Spilophorella euxina, Axonolaimus setosus, Theristus* sp.3, *Spilophorella paradoxa*, *Neotonchus pseudocorcundus, Nuada pachydermatus, Halalaimus* sp.2*, Richtersia staresensis, Terschellingia communis, Sphaerolaimus ostreae, Epacanthion buetschlii, Nuada* sp.2*, Halichoanolaimus lanceolatus, Daptonema conicum, Terschellingia gerlachi, Sabatieria ornata* and *Paralinhomoeus anteporus*. Some others may be regarded as species characteristic for a particular site: *Rhabdodemania mediterranea, Viscosia elon-*

gata, Marilynia bellula, Metoncholaimus sp. 2, *Prochromadorella* sp.1, *Desmodora deconincki, Paralinhomoeus brevibucca* and *Halalaimus* sp.1 for site SJ 005; *Ptycholaimellus ponticus, Anticoma acuminata, Prochromadorella* sp. and *Sphaerolaimus dispar* for site SJ 007, and *Actarjania lepida, Neotonchus cuanensis, Metalinhomoeus biratus, Longicyatholaimus longicaudatus, Theristus* sp. and *Sphaerolaimus glaphyrus* for site SJ 107.

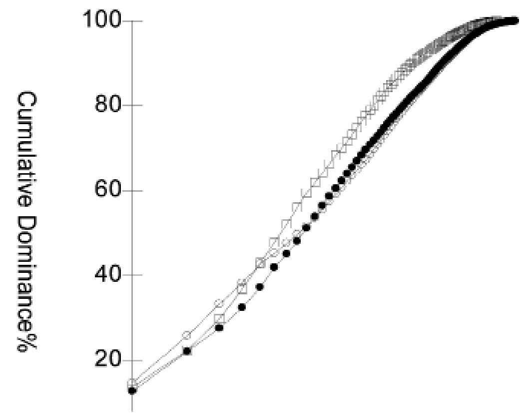

Fig. 5. k-dominance curves for nematode assemblages at the study sites

Univariate, distributional and multivariate aspects of the nematode assemblages structure

Nematofauna diversity estimated by means of standard analyses - based on the number of species and the number of individuals per species, was expressed by common univariate indices (Table 4). Sites SJ 007 and SJ 107 were distinguished by very close index values and from the univariate aspect did not differ significantly. In terms of diversity and species richness, site SJ 005 was somewhat poorer than the other two sites. Thus, in comparison to site SJ 007, it significantly differed in species richness while in comparison to site SJ 107 it differed by species richness, number of species, maximal diversity and the Shannon-Wienner index ($p<0.1$).

Although disturbance of community structure is usually associated with a decrease in diversity and equitability as well as in increase in dominance (HEIP *et al.*, 1985; PLATT & LAMBSHEAD, 1985; CLARKE & WARWICK, 1990), diversity indices calculated for these sites were comparable with values reported for highly diverse "sandy communities" (JUARIO, 1975; TIETJEN, 1977). The analysis of community structure with respect to most elements (abundance, dominance pattern, equitability, diversity) indicated a resemblance to typical silty-sand communities of undisturbed environments (HEIP *et al.*, 1982, 1985; BOUCHER, 1972; JUARIO, 1975; TIETJEN, 1977). It is only with the unexpected dominance of several muddy-preferable species that indicated that the community has not attained its former status due to a disturbance caused by anoxic stress in 1989 (TRAVIZI, 1996).

The general shape, position and elevation of k-dominance curves suggested a high level of similarity between the compared assemblages (Fig. 5). Mutual intersection of k-dominance curves suggested the same trend of distribution of individuals per species at all investigated sites.

Multivariate analyses based on qualitative composition of nematofauna and expressed by Sørensen's similarity coefficients indicated a fairly high affinity between particular assemblages ($QS_{007:107}$ =76%, $QS_{005:107}$ =70%, $QS_{005:007}$ =68%). As one might have supposed, somewhat lower faunistic affinities were revealed by calculation of Bray-Curtis similar-

Table 4. Univariate indices for nematofauna assemblages for the three sampling sites: number of species (S), Margalef's species richness (d), Pielou's eveness (J'), Dominance (D'), Brillouins diversity (H), Fisher's diversity (α), Shannon-Wiener's diversity (H'), Simpson's dominance (1λ') and Hill's diversity number (H1)

Site/Index	S	d	J'	D'	H	α	H' (log_2)	1λ'	H1
SJ 005	99	16,36	0,76	0,24	3,21	42,1	5,04	0,95	32,92
SJ 007	126	20,7	0,78	0,22	3,44	62,42	5,44	0,96	43,55
SJ 107	123	19,86	0,78	0,22	3,39	58,15	5,38	0,95	41,65

ity coefficients (QS $_{007:107}$ = 60%, QS $_{005:107}$ = 48%, QS $_{005:007}$ =56%) based on, apart from the presence/absence of data, data concerning single population densities.

CONCLUSIONS

The structure of the nematofauna of the northern Adriatic silty-sand offshore sediment was determined, with the distinctive dominance of four families (Chromadoridae, Comesomatidae, Cyatholaimidae and Linhomoeidae) and ten species (*Ptycholaimellus ponticus, Terschellingia longicaudata, Dorylaimopsis mediterranea, Marilinya complexa, Sabatieria ornata, S.granulosa, Spilophorella paradoxa, Setosabatieria hilarula, Rhabdodemania mediterranea* and *Axonolaimus setosus*), the notable contribution of 5-6 species (D>5%) per site and by rather high species diversity (S= 99-126 species site^{-1}, H'=5,04-5,44 bits/ind.). The investigated area is distinguished by considerable taxonomic diversity and substantial species richness in comparison to other Adriatic Sea regions. About 60% of nematode species already noted for the Adriatic Sea were found in the offshore silty-sand sediment.

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Fauna nematoda u sedimentima otvorenih voda sjevernog Jadrana: struktura zajednica i bioraznolikost

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SAŽETAK

Istraživana je struktura zajednica slobodnoživućih Nematoda na siltno-pjeskovitom dnu otvorenih voda sjevernog Jadrana sa ciljem određivanja temeljnih faunističkih pokazatelja koji bi u budućim istraživanjima mogli poslužiti kao komparativna osnova za procjenu lokalne (Jadransko more) i regionalne (Sredozemno more) bioraznolikosti i procjenu kvalitete morskog okoliša. Kvalitativni i kvantitativni sastav Nematoda je istraživan na tri sjevernojadranske pučinske postaje koje su smještene unutar cirkalitoralne zone i naseljene bentoskim zajednicama detritičnog dna. Istraživanje je obuhvaćalo glavne populacijske (gustoću, dominantnost, konstantnost) i biocenološke pokazatelje (taksonomski sastav, brojnost, bogatstvo vrsta, ravnomjernost raspodjele, raznolikost i faunistički afinitet). U cilju utvrđivanja specifičnosti prostorne raspodjele slobodnoživućih Nematoda, izdvojeno je i utvrđeno 12350 jedinki iz 57 uzoraka prikupljenih tijekom dvije godine. Rezultati multivarijatnih analiza ukazali su na visoku faunističku sličnost, kako u kvalitativnom (QS = 68-76%), tako i u kvantitativnom pogledu (QS = 48-56%). Međusobni odnos krivulja kumulativne dominantnosti ukazivao je na isti trend rspodjele jedinki unutar vrsta na svim istraživanim postajama. Ukupno je utvrđeno 168 vrsta slobodnoživućih Nematoda, zastupljenih unutar 101 roda i 29 porodica. Rezultati pokazuju da se istraživano područje odlikuje prilično visokom raznolikošću i zavidnim bogatstvom vrsta (60% ukupne faune Nematoda, do sada zabilježene u Jadranu) u odnosu na druga jadranska područja.

Ključne riječi: Nematoda, sjeverni Jadran, siltno-pjeskoviti sediment, struktura zajednica, bioraznolikost