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Free–living nematodes recovered from sewage disposal sites at the Rybinsk water reservoir, Borok, Russia

Vladimir G. Gagarin

Institute of Inland Waters Biology of Russian Academy of Sciences, Borok, Jaroslavl region, 152742, Russia.

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Summary. In sewage disposal sites at the Borok settlement 47 nematode species were recovered including 13 secernentean species. Several trends in species and nematofauna distribution along the pollution gradient were determined.

Key words: free-living nematodes, fresh water ecology, antropogenous pollution.

There is a relative paucity of information available on the nematofauna of water basins polluted with domestic and industrial sewage. However, the nematofauna of the river Seveso in Italy was extensively studied with nematodes being collected at locations affected by domestic and industrial sewage waters (Zullini, 1976). Also, some data on this subject have been reported by Tsalolikhin (1976) and Gagarin (1977, 1978, 1981).

MATERIAL AND METHODS

The nematofauna of water outlets from sewage disposal basins in the Borok settlement (Jaroslavl region) was investigated in 1990. Nematodes were sampled at four stations. Sampling station No. 1 (SS1) is situated at an excavated settling pond, 150 m from the collector (Fig. 1). The surface area of the pond is 500 m^2, with an average depth of 1 m. The sediment is a muddish sand covered with a thin layer of decaying domestic and industrial wastes. Aquatic plants are almost completely absent. Water in the pond is well mixed due to the continual water flow. Usually, the pond is not covered with ice in the winter. The next two sampling stations were in canals carrying water from the settling pond. The canals are 4 - 7 m wide and 0.5 - 1.5 m deep. The surface of the canals are covered with hygrophilous plants such as *Carex* spp., *Butomus umbellatus*, *Typha* spp., *Hydrocharis morsus-ranae*, etc. The canal bottoms are covered with a thick layer of coarse vegetable detritus. In summer the surface of the canals are densely covered with *Lemna* sp. A permanent oxygen deficiency occurs in the canals and during winter the water under the ice is saturated with hydrogen sulphide. Sampling stations 2 and 3 (SS2 and SS3) were located about 150 m and 350 m respectively from the settling pond. The control sampling station, No. 4 (SS4), was situated in a wide and deep canal connected with the Rybinsk reservoir and not connected to the cleaning structures (Fig. 1). The bottom sediment is a muddish sand.

At each sampling station three samples were taken with a corer, 3 cm inner diameter, on 20-21 May and 10-11 June, 1990. All sampling stations were situated close to the pond or canal banks at depths of 20 - 30 cm. The nematofauna was characterized by applying diversity (Shannon - Weaver) and evenness indices. For observation, measurement and identification the nematodes were mounted in glycerine slides and stained with methylene blue.

RESULTS

A total of 47 species from nine nematode orders were found (Table 1). The majority of species belong to the orders of the subclass Adenophorea: Enoplida, Dorylaimida, and Araeolaimida (8 - 9 species each). Thirteen species were from the orders of the subclass

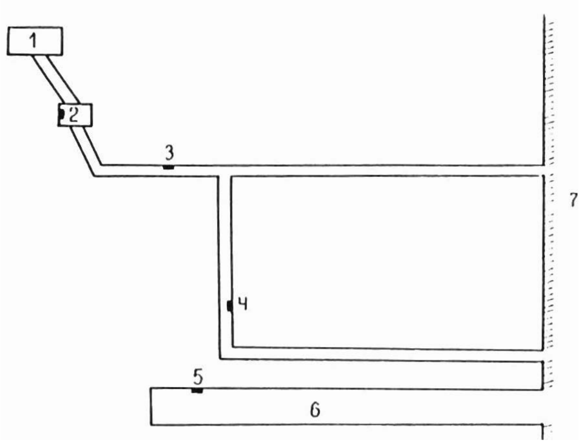

Fig. 1. Schematic map showing location of the sampling stations at the sewage cleaning basins, Borok. 1: Collector; 2: Settling pond (SS1); 3: SS2; 4: SS3; 5: SS4; 6: Wide and deep canal; 7: Rybinsk water reservoir.

Secernentea: Rhabditida, Diplogasterida, and Tylenchida.

The highest density of nematodes was found at SS1, although the species diversity here was quite low (Table 2). More than 70% of the specimens were represented by secernenteans, with two species, *Diplogasteritus aquaticus* and *Paroigolaimella anomala* being predominant (Table 3). At SS2 the density of nematodes was less, but the presence of secernenteans was greater. The evenness index was very low (1.10 - 1.24, Table 2), because 79 - 83 % of the nematodes belonged to a single species, *Diplogaster rivalis*. At SS3 the total nematode density was substantially reduced, but the species diversity was almost twice that of SS1 and SS2 (Table 2). The proportion of adenophoreans to secernenteans was almost equal. At SS4 the nematode density was low, but the diversity was greater than recorded at SS1, SS2 and SS3. The number of species and specimen density was greater with adenophoreans than with secernenteans. The species diversity at SS4 was very high (diversity index = 4.18 - 4.52; Table 2); the specimens being distributed almost equally among the species (evenness index = 0.92 - 0.94; Table 2). At all sampling stations the nematofauna was observed to be usually greater in spring.

DISCUSSION

Development and distribution of the nematofauna in sewage basins at Borok differed somewhat from that described by Zullini (1976). Having studied the nematofauna at sites of industrial and domestic sewage along the Seveso river, Zullini reported the following phenomena: 1). The percentage portion of secernentean nematodes in samples was directly proportional to chemical oxygen demand (COD) and inversely proportional to the quantity of the dissolved oxygen in the water; 2). Among secernentean nematodes members of the Diplogasteroidea were the most numerous at sampling stations characterized by medium and high degrees of pollution; members of the Rhabditoidea were specific for stations with extreme degrees of pollution.

The sewage cleaning at Borok differs markedly from that at the Seveso river. In Borok the sewage water flows as a small stream into a settling pond where waste products mix and partly settle. Accumulation of the wastes takes place only in a deep and broad canal where the current slows. It was in this canal that SS2 was located. The organic matter had time for oxygenization and partial decomposition during the period of passage from the collectors to SS1. Therefore, there is concentrated pollution at SS1 and this was where members of the Diplogasteroidea dominated. At SS2 the pollution was less extreme and this was where members of the Rhabditoidea prevailed. At SS2 and SS3 the species *Diplogaster rivalis* dominated which probably reflected a moderate or relatively low degree of pollution.

Analysis of the nematofauna revealed several pronounced trends in species diversity which were directly related to the location of the sampling stations and their distance from the sewage collector *viz.* maximum pollution. Greatest species diversity was directly proportional to increasing distance from the pollution source (Tables 1 & 2). The dominance of only a few species of the secernenteans in a sample was directly related to the proximity of the sampling station to the pollution source. In the settling pond (SS1) 50% of the nematofauna consisted of a single species; *Diplogasteritus aquaticus* in spring and *Paroigolaimella anomala* in autumn (Table 1). Species dominance was not present at the control sampling point (SS4). Nematode density became greater with increasing pollution and was greatest at SS1, which was in closest proximity to the sewage collector. Also, it was larger at

Table 1. Nematode species composition and density (thousands specimens/m^2) in spring and autumn at four sampling stations at sewage disposal facilities.

Species \ Season / Sampling stations	Spring				Autumn			
	1	2	3	4	1	2	3	4
Order Enoplida								
Alaimus primitivus De Man, 1880	-	-	-	-	-	2	-	-
Odontolaimus aquaticus Schneider, 1937	-	-	-	1	-	-	-	-
Prismatolaimus dolichurus De Man, 1880	-	-	2	1	-	-	-	-
Tobrilus gracilis (Bastian, 1865)	-	-	-	-	-	-	2	-
T. helveticus (Hofmaenner, 1914)	81	71	3	4	13	18	13	8
Semitobrilus gagarini (Ebsary, 1982)	-	-	3	3	-	-	4	3
Brevitobrilus stefanskii (Micoletzky, 1925)	-	-	-	-	2	-	-	-
Neotobrilus longus (Leidy, 1852)	81	25	3	2	40	-	-	-
Epitobrilus allophysis (Steiner, 1919)	-	-	-	3	-	-	-	-
Order Mononchida								
Mononchus truncatus Bastian, 1865	-	-	3	2	-	-	-	3
M. aquaticus Goetzee, 1968	-	-	10	4	-	-	3	1
Order Dorylaimida								
Dorylaimus stagnalis Dujardin, 1848	-	-	-	3	5	-	-	5
Mesodorylaimus derni Loof, 1969	-	-	2	1	2	-	-	1
M. litoralis Loof, 1969	-	-	-	1	-	-	-	-
Eudorylaimus carteri (Bastian, 1865)	-	-	-	3	-	-	-	1
Aporcelaimellus obscurus (Thorne & Swanger, 1936)	-	-	3	1	-	-	4	3
A. krygieri (Ditlevsen, 1926)	-	-	3	3	-	-	-	-
Thornia steatopyga (Thorne & Swanger, 1936)	-	-	-	1	-	-	-	1
Aquatides aquaticus (Thorne, 1930)	-	5	-	-	-	-	-	-
Order Monhysterida								
Monhystera stagnalis Bastian, 1865	-	-	-	2	-	-	-	1
Eumonhystera filiformis (Bastian, 1865)	-	-	-	-	-	2	2	3
E. vulgaris (De Man, 1880)	-	-	3	1	5	-	-	1
E. dispar (Bastian, 1865)	-	-	-	-	-	4	4	-
Order Araeolaimida								
Cylindrolaimus obtusus Cobb, 1914	-	-	-	1	-	-	-	-
Aphanolaimus aquaticus Daday, 1897	-	-	-	1	-	-	-	-
Plectus parietinus Bastian, 1865	-	5	2	1	-	2	2	1
P. cirratus Bastian, 1865	-	9	3	2	-	-	4	3
P. rhizophilus De Man, 1880	-	-	-	-	-	-	-	1
P. tenuis Bastian, 1865	-	-	-	-	-	-	2	3
P. parvus Bastian, 1865	-	-	2	1	-	-	2	1
Anaplectus granulosus (Bastian, 1865)	-	-	-	-	-	-	-	1
Order Chromadorida								
Prodesmodora circulata (Micoletzky, 1913)	-	-	-	1	-	-	-	-
Achromadora terricola (De Man, 1880)	-	-	-	-	-	-	1	-
Chromadorita leuckarti (De Man, 1876)	-	-	-	-	2	-	-	1
Order Diplogasterida								
Rhabditoides stigmatus (Steiner, 1930)	24	-	-	-	13	-	-	-
Diplogaster rivalis (Leydig, 1854)	-	434	28	10	-	130	48	5
Diplogasteritus aquaticus Gagarin, 1977	342	9	2	1	23	-	-	-
Paroigolaimella anomala Gagarin, 1977	106	-	-	-	195	-	-	-
Mononchoides striatus (Buetschli, 1876)	4	-	-	-	-	-	-	-
Order Rhabditida								
Pelodera punctata (Cobb, 1914)	42	-	-	-	2	-	-	-
Cephalobus sp.	-	-	-	1	-	2	-	-
Heterocephalobus elongatus (De Man, 1880)	-	-	2	1	-	-	-	-
Panagrolaimus rigidus (Schneider, 1866)	-	5	-	-	-	2	-	-
Order Tylenchida								
Aphelenchoides parietinus (Bastian, 1865)	-	-	-	1	-	2	-	1
A. bicaudatus (Imamura, 1931)	-	-	-	-	-	1	-	-
Tylenchus sp.	-	-	-	1	-	-	-	-
Hemicycliophora sp.	-	-	-	1	-	-	-	1

Table 2. Physico-chemical parameters at four sampling stations and characteristics of the nematofaunas.

Parameters and characteristics \ Season / Station number	Spring 1	Spring 2	Spring 3	Spring 4	Autumn 1	Autumn 2	Autumn 3	Autumn 4
Chemical oxygen demand of sediment, mg O/g	28	320	419	14	52	372	401	20
Oxygen content in water, O_2%	-	-	-	-	112	82	60	133
Total density of nematodes, ind/m^2	680	563	74	59	302	162	94	47
Portion of secernenteans, %	76	79	43	29	77	83	54	15
Species number	7	8	16	30	11	8	15	22
Diversity index	2.11	1.24	3.28	4.52	1.86	1.10	2.66	4.18
Evenness index	0.75	0.41	0.82	0.92	0.54	0.37	0.68	0.94

Table 3. Nematode trophic groups presented at four sampling stations.

Trophic group \ Season / Station	Spring 1	Spring 2	Spring 3	Spring 4	Autumn 1	Autumn 2	Autumn 3	Autumn 4
Saprobiotic bacteriophags (saprophags)	5	2	2	2	4	1	1	1
Detriophags and algophags	-	3	6	11	2	6	7	10
Predators	2	3	8	14	5	1	5	9
Micophags and phytohelminths	-	-	-	3	-	-	2	2

SS1 and SS2 in spring than in autumn but at the less polluted SS3 and at the control, SS4, a diurnal pattern was not evident.

The results of our study provide further information on the occurrence and distribution of nematodes associated with domestic and industrial sewage pollution. Furthermore, our results provide evidence of the valuable role nematodes offer as bioindicators of domestic and industrial pollution of waterways.

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Гагарин В.Г. Свободноживущие нематоды из участков сброса сточных вод в Рыбинское водохранилище, Борок, Россия.
Резюме. В водоемах очистки сточных вод поселка Борок и контрольном водоеме обнаружено 47 видов нематод, 13 из которых относятся к сецернентам. Выявлены закономерности в составе и обилии фауны нематод, связанные с удаленностью станций отбора проб от очистных сооружений.