COMPARATIVE ANALYSIS OF FRESHWATER NEMATODE COMMUNITIES FROM THREE SITES IN THE DNIESTER RIVER

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Abstract. Species diversity, trophic and ecological groups, biomass of freshwater nematode communities from three sites of the Dniester River were studied. Forty-three species from nine orders of phylum Nematoda were revealed. The most diverse and numerous nematode communities were in the littoral area of the Dubossari Reservoir (29 species) than below Soroca city (16) and near Tudora village (9). Among the trophic groups the algivores (Tobrilidae) and bacteriovores (Monhysteridae, Plectidae, Panagrolaimidae and Rhabditidae) were dominant. The common species *Dorylaimus stagnalis* prefers the standing polluted water. Among the ecological groups the hydrobionts and amphibionts were dominant. The greatest biomass of freshwater nematode community was revealed near Tudora village though the species diversity was poor. This biomass was formed by the large nematode species such as *Mononchus aquaticus* and *Dorylaimus stagnalis*. Therefore, the species level study is necessary to permit further advances in understanding the role of nematodes in freshwater ecosystems.

Keywords: freshwater nematodes, species diversity, trophic and ecological groups, biomass, the Dniester River.

Rezumat. Analiza comparativă a comunităţilor de nematode din trei sectoare ale Fluviului Nistru. A fost studiată diversitatea speciilor, grupările trofice şi ecologice, biomasa comunităţilor de nematode acvatice din trei sectoare ale Fluviului Nistru. Au fost determinate patruzeci şi trei specii ce fac parte din nouă ordine a phylum Nematoda. Cel mai divers după numărul de specii si cu efectivul numeric ridicat a fost sectorul bazinul de acumulare Dubăsari (29 specii) urmat de sectorul oraşului Soroca (16) şi sectorul Tudora (9). Printre grupele trofice, predomină algofagii (Tobrilidae) şi bacteriofagii (Monhysteridae, Plectidae, Panagrolaimidae şi Rhabditidae). Specia *Dorylaimus stagnalis* ce are o răspândire largă şi preferă apele poluate, a fost gasită în toate sectoarele studiate. Hidrobionţii şi amfibionţii predomină între grupările ecologice. Biomasa cea mai mare a comunităţilor de nematode acvatice este detectată in sectorul Tudora, cu toate că diversitatea specifică era scăzută. Biomasa acestui sector este formată in mare măsură de speciile de nematode mari aşa ca *Mononchus aquaticus* şi *Dorylaimus stagnalis*. Prin urmare, este necesară studierea la nivel specific a comunităţilor de nematode de apă dulce pentru a permite întelegerea rolului lor în ecosistem.

Cuvinte cheie: nematodele acvatice, diversitatea specifică, grupările ecologice şi trofice, biomasa, fluviul Nistru.

INTRODUCTION

Free-living and plant parasitic nematodes are usually the most abundant metazoans inhabiting benthic or soil ecosystems. Their life cycles strongly depend on temperatures, which can be from 13-20 months at low temperatures (7°C) (GERLACH & SCHRAGE, 1972) to 2-30 days at 18-33°C, characteristic for most free-living nematodes (HOPPER et al., 1972). The key of their success is their adaptability and ecological diversity. Most genera and species have cosmopolitan distribution and they are present in almost every environment where moisture is available. Free-living nematodes play important functional roles in the ecosystem. They are of major energetic importance in benthic systems; they form a significant part of the diet of many other animals. For sediment they facilitate the mineralization of organic matter, influence the physical stability of sediments and the exchange of materials between the sediment and water column. Nematodes are an important group in sediment/soil habitats. However our knowledge of the taxonomy and ecology of freshwater nematodes is still very poor, because the methods of extraction, processing and identification of species are difficult. In Republic of Moldova, the soil nematodes of natural and agricultural ecosystems, their species composition, feeding grouping, life cycle, reproductive potential, agriculturally damaging species of different crops have been studied for long time (NESTROV, 1979; POIRAS, 2008; POIRAS et al., 2008). However, the taxonomy and ecology of freshwater nematodes and their role in the trophic relationships of the meiobentos communities have not caught the attention of the Modavian nematologists yet (ANTOFICA, 2007; ANTOFICA & POIRAS, 2007, 2009). This paper is assigned to the comparative analyses of the taxonomic and ecological data of freshwater nematodes from the different places along the Dniester River.

MATERIAL AND METHODS

Site description

The Dniester River is one of the largest rivers of south-eastern Europe. Beginning its course in the western Ukraine, it rushes through the northern slopes of the Carpathian Mountains, and falls into the Dniester Liman of the Black Sea (southwest of Odessa). Its length is 1410 km with a drainage area of 72000 sq km. The long and narrow drainage area is pressed between two adjacent rivers – the Prut and the Southern Bug (only about 50 km wide). The river network in the upper-mountain region of the drainage is particularly developed; the river crosses the Volyno-Podolskoye Plateau and receives only small tributaries in the lower regions. It is the most important water source for Republic of Moldova. Three sampling sites were studied along the Dniester River in R. Moldova: the north part of the river below city Soroca (El 223; $48^0$10'059"N; $028^0$13'770"E), the central part of the Dubossari Reservoir (El 27; $47^0$17'143"N; $029^0$07'463"E) and the south part near Tudora village (El 20; $46^0$26'544"N; $030^0$01'574"E).

Sampling and extraction

Samples were collected in autumn 2009 from different habitats of the sampling sites. The sediment samples were collected with a hand-held Perspex core tube in littoral zone at the 10 cm depth of sediment. Temperature during sampling time varied between 13 - 22^0 C for water, 15 - 22^0 C for soil and 19 - 25^0C for air. Nematodes were extracted alive by sieving and decanting using standard methods of brass screens (40, 60, 325 and 500 mesh) and Baermann funnels. The samples were fixed in hot 4% formaldehyde (60^0C). Than specimens of nematodes were counted and some of them (near 60 specimens) were picked out and processed to pure glycerin (SEINHORST, 1959; REIMANN, 1988). The slide collection with data of sampling sites and species is stored in the Institute of Zoology ASM. The nematode species were identified by NESTEROV (1979), NICKLE (1991), JAIRAJPURI (1992), GAGARIN (1993, 2001), LOOF (1999), SIDDIQI (2000), ZULLINI (1982, 2005), ANDRASSY (2005), EYUALEM-ABEBE et al., (2006). Classification of Phylum Nematoda accepted in the "Fauna Europaea" database (www.faunaeur. org) and also taxonomic keys for family Tobrilidae by TSALOLICHIN (2001), ANDRASSY (2007) were used in this paper. The nematode trophic groups were given according to YEATS et al. (1993) and ecological groups to GAGARIN (2001). The biomass of nematode communities was calculated using ANDRASSY (1956) and TSALOLIKHIN formulas (1981).

RESULTS AND DISCUSSIONS

Taxonomical analyses

According to the results of the taxonomic study, 43 species of freshwater and terrestrial nematodes species were revealed in the littoral zone of the different sampling localities – below the wastewater treatment station of Soroca city, along the Dubossari Reservoir and near Tudora village (Table 1).

The identified species belong to 29 genera, 18 families and 9 orders. The most numerous species belong to the order Rhabditida (8 species), than to Monhysterida (7) and Enoplida (7), Plectida (6 species), Dorylaimida (5), *Triplonchida* (3), Tylenchida (3), Chromadorida (2), Aphelenchida (1), and Mononchida (1). The more representative families were Monhysteridae (5), Plectidae (5), Dorylaimidae (4), Tobrilidae (4 species), and Rhabditidae (3).

The nematode communities were diverse at Dubossari Reservoir sampling site - 29 species, than at Soroca – 16 species and Tudora – 9 species. The species *Brevitobrilus stefanskii* and *Dorylaimus stagnalis* were common for all tree sampling sites. Some species were identified for the first time in the fauna of R. Moldova such as *Neotobrilus longus*, *N. longior*, *Ironus* sp. and *Eumonhystera similis.* The species *Mononchus aquaticus*, a typical hydrobiont and predator, was numerous in the sediment samples from the Dubossari Reservoir and Tudora.

Diverse and numerous hydrobionts belonging to the orders Monhysterida (5 species), Enoplida (2), and Triplonchida (5) were revealed in the sampling site near the Dubossari Reservoir. In other sampling localities, hydrobionts were poorly represented and there appeared only some amphibionts, especially from the genera *Chronogaster, Plectus, Panagrolaimus* and *Poikilolaimus*.

Table 1. Nematode species from three sampling localities in the Dniester River and some ecological data.
Tabel 1. Speciile de nematode din trei statiuni ale Fluviului Nistru şi analiza ecologică a lor.

No.	Species	Trophic groups	Ecological groups	MI groups	Sampling localities		
					Soroca	Dubossari	Tudora
1	*Prochromodora* sp.	bacterivore	hydrobiont	3	-	+	-
2	*Punctadora* sp.	bacterivore	edaphobiont	3	-	+	-
3	*Daptonema dubium* (BUTSCHLI 1873)	bacterivore	hydrobiont	3	-	+	-
4	*P. dolichorus* (DE MAN 1880)	bacterivore	amphibiont	3	-	+	-
5	*Alaimus* sp.	bacterivore	amphibiont	4	+	-	-
6	*Brevitobrilus stefanskii* (MICOLETZKY 1925)	algivore	hydrobiont	3	+	+	+
7	*Neotobrilus longior* (DADAY 1905)	algivore	hydrobiont	3	+	-	-
8	*N. longus* (LEIDY 1852)	algivore	hydrobiont	3	+	+	-
9	*Tobrilus gracilis* (BASTIAN 1865)	algivore	hydrobiont	3	+	+	-
10	*Ironus tenuicaudatus* (DE MAN 1876)	algivore	hydrobiont	4	-	+	-
11	*Ironus cp Gagarini* (TSALOLIKHIN 1987)	algivore	hydrobiont	4	-	+	-
12	*Tripyla affinis* (DE MAN 1880)	predator	hydrobiont	3	-	+	-
13	*T. glomerans*(BASTIAN 1865)	predator	hydrobiont	3	-	+	-
14	*Eumonhystera dispar* (BASTIAN 1865)	bacterivore	hydrobiont	2	-	+	-
15	*E. filiformis* (BASTIAN 1865)	bacterivore	hydrobiont	2	-	+	-
16	*E. similis* (BUTSCHLI 1873)	bacterivore	hydrobiont	2	-	+	-
17	*Monhystera paludicola* (DE MAN 1881)	bacterivore	hydrobiont	2	+	-	-
18	*M. stagnalis* (BASTIAN 1865)	bacterivore	hydrobiont	2	-	+	-
19	*Monhystera* sp.	bacterivore	hydrobiont	2	-	+	-
20	*Mononchus aquaticus* (COETZEE 1968)	predator	hydrobiont	4	-	+	+
21	*Aporcelaimellus* sp.	omnivore	amphibiont	5	-	+	-
22	*Dorylaimus montanus* (STEFANSKI 1923)	omnivore	amphibiont	4	-	+	-

23	*D. stagnalis* (DUJARDIN 1845)	omnivore	amphibiont	4	+	+	+
24	*Mesodorylaimus mesonyctius* (KREIS 1930)	omnivore	amphibiont	4	-	+	-
25	*M. potus* (HEYNS 1963)	omnivore	amphibiont	4	+	+	-
26	*Plectus acuminatus* (BASTIAN 1865)	bacterivore	amphibiont	2	-	+	-
27	*P. cirratus* (BASTIAN 1865)	bacterivore	amphibiont	2	-	+	+
28	*P. palustris* (DE MAN 1880)	bacterivore	amphibiont	2	-	+	-
29	*P. rhizophilus (*DE MAN 1880)	bacterivore	amphibiont	2	+	-	-
30	*Plectus* sp.	bacterivore	amphibiont	2	-	+	-
31	*Chronogaster typica* (DE MAN 1921)	bacterivore	amphibiont	2	+	-	+
32	*Cephalobus persegnis* (Bastian 1865)	bacterivore	edaphobiont	2	-	-	+
33	*Heterocephalobus elongatus* (DE MAN 1880)	bacterivore	edaphobiont	2	+	-	-
34	*Diplogaster rivalis* (LEYDIG 1854)	predator	hydrobiont	1	-	+	-
35	*Panagrolaimus hygrophilus* (BASSEN 1940)	bacterivore	hydrobiont	1	+	+	-
36	*Panagrolaimus* sp.	bacterivore	amphibiont	1	+	-	-
37	*Poikilolaimus oxycerca* (DE MAN 1895)	bacterivore	amphibiont	1	+	-	-
38	*Bursilla monhystera (*BUTSCHLI 1873)	bacterivore	amphibiont	1	-	+	-
39	*Caenorhabditis* sp.	bacterivore	amphibiont	1	+	-	-
40	*Helicotylenchus erythrinae* (ZIMMERMANN 1904)	plant parasite	edaphobiont	2	-	-	+
41	*Rotylenchus robustus* (DE MAN 1876)	plant parasite	edaphobiont	2	-	-	+
42	*Hirschmanniella* sp.	plant parasite	hydrobiont	2	-	+	+
43	*Aphelenchus* sp.	fungivore	amphibiont	2	+	-	-
	Number of species in sampling localities				16	29	9

Ecological analyses

In the sampling locality situated below the wastewater treatment station of Soroca city, the species *Tobrilus gracilis, Neotobrilus longiors, Neotobrilus longus, Brevitobrilus stefanskii, Monhystera paludicola, Plectus cf. rhizophilus, Chronogaster typica, Panagrolaimus* sp., *Panagrolaimus hygrophilus, Ceanorhabditis* sp., *Aphelenchus* sp.*, Poikilolaimus oxycerca, Dorylaimus stagnalis* and *Mesodorylaimus* sp. were revealed (Table 1). The species belonging to the family Tobrilidae were diverse and numerous; their populations consisted in maturity females, males and juveniles. Among tobrilids, the species of the genus *Neotobrilus* were dominated. Among the trophic groups, the algivores (*Tobrilidae)* and bacterivores (Monhysteridae, *Plectidae,* Cephalobidae, Panagrolaimidae and Rhabditidae) were dominated. The common species *Dorylaimus stagnalis* prefers the standing polluted water. Between the ecological groups the hydrobionts and amphibionts were dominant.

In the samples collected from the sediments at the Dubossari Reservoir, there were revealed numerous populations of tobrilids, tripylids and monhysterids including females, males and juveniles. Among tobrilids the mature females, males and juveniles of *Brevitobrilus stefanskii* were prevailed in the entire nematode community. Predator species such as *Tripyla affinis* and *Diplogaster rivalis* (predator of saprobiotic condition) and omnivore species – *Dorylaimus stagnalis* (this species prefers the waste water) were numerous.

In the sediment samples taken near Tudora village the species *Mononchus aquaticus* (hydrobiont, predator) and *Dorylaimus* – group (hydrobiont, omnivore) registered unusually numerous populations. Both of these genera are typical for polluted water.

a - Biomass of nematode communities (by ANDRASSY, 1956 and TSALOLICHIN, 1981) (Fig. 1)

According to both used formulas, the biomass of nematode communities showed almost the same data. Comparing the sampling sites, the greatest biomass of nematode community was registered at Tudora, though the species diversity was the poorest. This biomass was formed by large nematode species such as *Mononchus aquaticus* and *Dorylaimus stagnalis.* The species diversity of nematode community in the Dubossari Reservoir was the greatest, but their number and biomass were the most reduced. The nematode communities from Soroca and Dubossari mostly consist of numerous bacterivores with small-sized bodies.

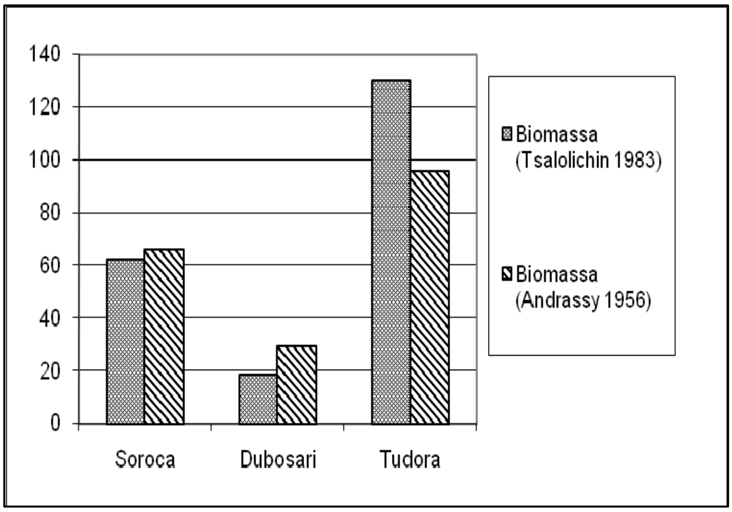


Figure 1. Biomass of nematode communities from the sampling sites (by TSALOLIKHIN, 1981 and ANDRASSY, 1956).
Figura 1. Biomasa comunităților de nematode din siturile de colectare (după TSALOLIKHIN, 1983 and ANDRASSY, 1956).

b - Trophic grouping (by YEATS et al., 1993; MOENS et al., 2004) and their biomass (Figs. 2; 3)

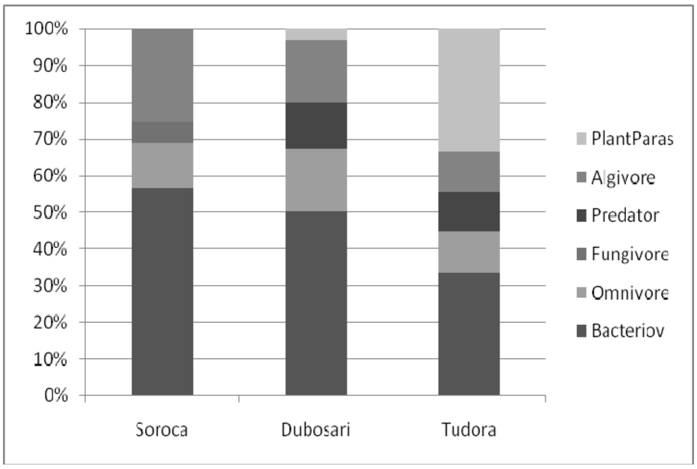


Figure 2. Trophic groups of freshwater and terrestrial nematode species from the different sampling sites. / Figura 2. Gruparea trofică a nematodelor acvatice şi terestre din siturile de colectare.

Nematodes often occur in various environmental water/sediment/soil conditions; they occupy positions at the base of the food chains that ultimately sustain other animals. They are the main catalyst of some water/sediment/soil processes, especially mineralization and humification of dead organic matter, responsible for cycling of sediment/soil nutrients and self-purification of water; due to their interaction with bacteria, algae and fungi (WASILEWSKA, 1997; BONGERS et al., 1998; BONGER & FERRIS, 1999). The trophic preferences of nematodes give some information about the structure of nematode communities that reflects the ecological situation at the studied time. Predominance or absence of some trophic groups can be a signal of negative or positive processes occurring in the environment.

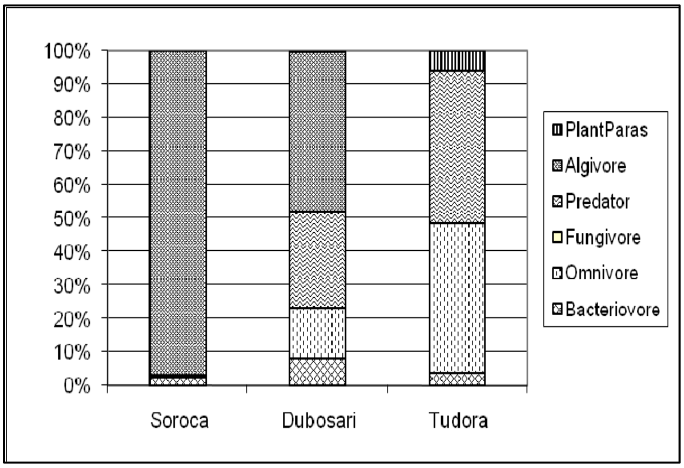


Figure 3. Biomass (by ANDRASSY,1956) of nematode species according to trophic groups (by YEATS). / Figura 3. Biomasa (după ANDRASSY, 1956) speciilor de nematode potrivit grupării trofice (după YEATS).

According to the received data, bacterivores were dominated by number of species in some sampling sites (Fig. 2). However, in the sampling site near Soroca city (northern part of the Dniester River) the bacterivores represented more than half of the nematode community. There were absent predator and plant parasite species. Algivore species were diverse and numerous at Soroca and the Dubossari Reservoir. In the studied site near Tudora village the nematode community was represented by all trophic groups. According to the trophic groups and their biomass, the algivores were predominant in some sampling places such as Soroca and Dubossari. At Tudora site the biomass of omnivore and predators were prevalent and/or equal (Fig. 3).

c - Ecological grouping and their biomass (by GAGARIN, 2001) (Figs. 4; 5)

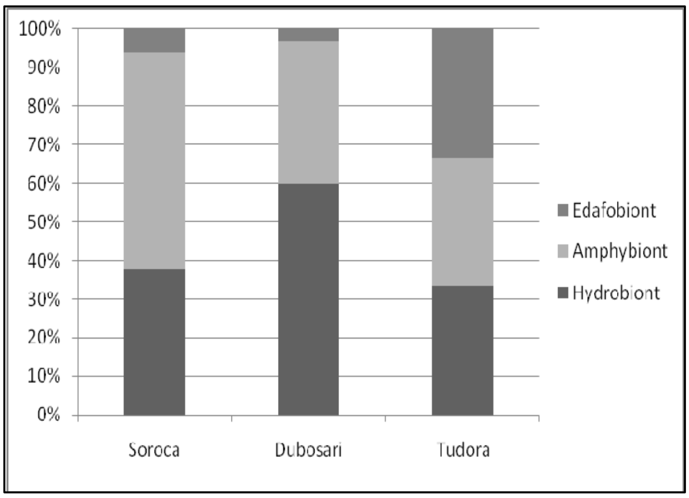


Figure 4. Ecological grouping from the different sampling sites. Figura 4. Gruparea ecologica din siturile de colectare.

The analysis of the composition of the nematode species in the littoral zones of some sampling localities of the Dniester River has revealed 3 ecological groups: hydrobionts, amphibionts and edaphobionts (Table 1). The first ecological group including the hydrobionts of the sediment are formed by three subgroups such as 1 - true hydrobionts (rather oxygen consumers) that include species belonging to the family Tobrilidae and some species from genera *Tripyla, Mononchus* (*M. aquaticus*), *Monhystera, Daptonema, Chronogaster* and species *Eumonhystera dispar, E. filiformis* etc.; 2 - freshwater saprobionts (adapted to the deficiency of oxygen) that include the species *Panagrolaimus* sp. and *Diplogaster rivalis;* 3 - phytoparasitic nematodes of freshwater macrophytes that include the species of genus *Hirschmanniella*. The second ecological group – amphibionts that includes species live in freshwater, moss and humidified soil. The nematode species – amphibionts are not demanding the

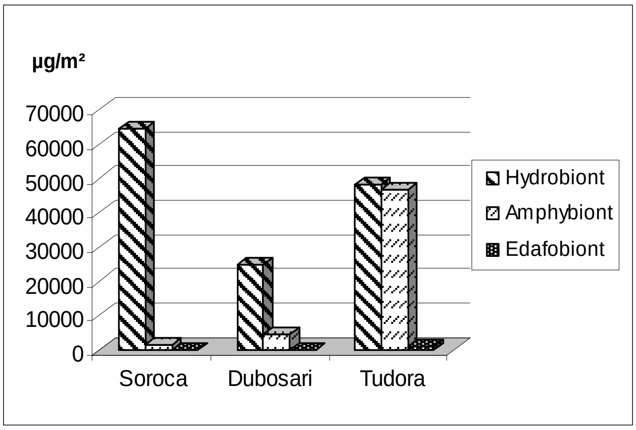
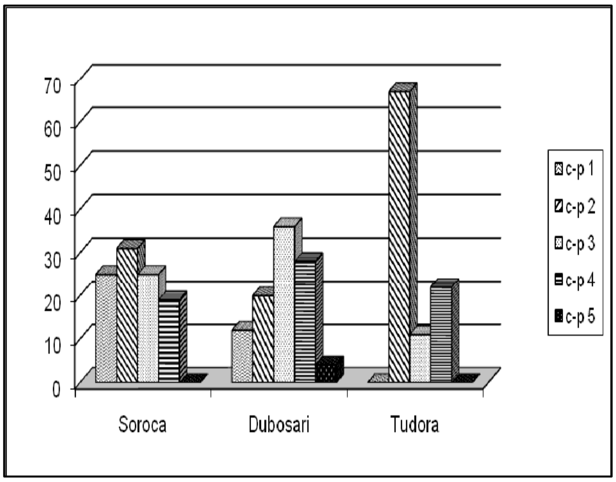


Figure 5. Biomass (by ANDRASSY, 1956) of nematode communities by ecological grouping (by GAGARIN, 1956) (µg/m²).
Figura 5. Biomasa (după ANDRASSY, 1956) comunităţilor de nematode conform grupării ecologice (după GAGARIN, 1956).

maintenance of oxygen in the aquatic environment. This group concerns the majority of species of the genera *Eumonhystera, Plectus, Mesodorylaimus, Eudorylaimus,* as well as the species *Panagrolaimus rigidus* and *Poikilolaimus oxycerca.* The third ecological group is edaphobionts which includes species adapted to the terrestrial conditions, which appear in freshwater conditions casually. These species are not adapted for the living in the aquatic environment for a long time as they suffer from the deficiency of oxygen easily. This group includes practically the majority of the terrestrial species from Rhabditida, Tylenchida, Aphelenchida and Dorylaimida orders. The group of amphibionts was prevalent at Soroca; the hydrobionts – in the Dubossari Reservoir and all ecological groups were equally present at Tudora (Fig. 4).

d - Grouping according to life strategy (by BONGERS, 1999) (Fig. 6)



One of the potential parameters to measure the impact of disturbances and to monitor changes in structure and functioning of the below-ground ecosystem is the nematode Maturity Index (BONGERS, 1999); it is an index based on the different life strategy. Taxonomic units (genera and families) are classified into 5 groups each with different life strategy, from colonizers (r-strategists) to persisters (K-strategists).

According the life strategy scale in all studied places we mostly found the domination of species with c-p 2 and c-p 3 life strategy. These species are resistant to different pollutants and survive under extreme conditions (Fig. 6).

Figure 6. Grouping of nematodes according to the life strategy (c-p scale).
Figura 6. Gruparea nematodelor conform strategiei de viaţă (c-p).

CONCLUSIONS

As the result 43 species of freshwater nematodes belonging to 29 genera, 18 families and 9 orders were revealed in the littoral zone of three sampling localities: the Dubossari Reservoir (29 species), downstream Soroca city (16) and near Tudora village (9 species).

The most numerous species belong to the order *Rhabditida* (8 species), followed by Monhysterida (7) and Enoplida (7), Plectida (6 species), Dorylaimida (5), Triplonchida (3), Tylenchida (3), Chromadorida (2), *Aphelenchida* (1) and Mononchida (1). The most numerous families were Monhysteridae (5), Plectidae (5), Dorylaimidae (4), Tobrilidae (4 species), and Rhabditidae (3).

At the first time species *Neotobrilus longus, N. longior, Ironus* sp., and *Eumonhystera similis* were found in the fauna of the Republic of Moldova. The species *Brevitobrilus stefanskii* and *Dorylaimus stagnalis* were common for all tree sampling sites. The species *Mononchus aquaticus,* a typical hydrobiont and predator, was numerous in the sediment samples from the Dubossari Reservoir and near Tudora village.

The hydrobionts and amphibionts were dominant among the ecological groups. The greatest biomass of freshwater nematode community was revealed near Tudora village though the species diversity was poor. This biomass was formed by the large nematode species such as *Mononchus aquaticus* and *Dorylaimus stagnalis.* Therefore the species-level study is necessary to permit further advances in understanding the role of nematodes in freshwater ecosystems.

Biomass, trophic, ecological and life grouping of nematode communities have been done for three sampling sites along the Dniester River. The ecological study revealed the predominance of bacterivores and algivores found in the north part of the Dniester River (Republic of Moldova) both as number and biomass, which shows the intensive organic decompositions and water flowering.

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