CHANGES IN THE STRUCTURE OF BENTHIC BIOCOENOSES ON THE LOWER COURSE OF THE DANUBE FROM 1996 TO 2004

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Abstract. The aim of this study was to evaluate long-term changes in the distribution and diversity of benthic fauna in the lower (Romanian) sector of the Danube River from 1996 to 2004. Up to 43 taxa (also including developmental stages of some species) belonging to 22 supra-specific taxonomic groups were identified, with determination down to the level of the species made only for molluscs, polychaetes and ostracods, the other organisms being grouped according to supra-specific taxa. On the whole the most frequent benthic organisms were worms (represented by oligochaetes and nematods), with frequencies ranging from 65% to 100%, which can be regarded as euconstant and constant organisms. The other forms encountered are accessory or just accidental. In both years worms contributed with 90% to the constitution of the general densities of benthic fauna, while the taxonomic structure of the benthic biomass was dominated by molluscs with 99%. In 2004 rich populations of *Corbicula fulminea*, an alien species, occurred.

Key words: biodiversity, benthic fauna, Danube River, Danube Delta

1. INTRODUCTION

Benthic studies are of major importance in the benthic habitat biodiversity preservation strategy, especially in terms of understanding changes that occur at the level of qualitative community parameters, as well as habitats influenced by anthropic pressures. The zoobethos is an equally important link in the food chains, representing the main trophic basis of a benthophag fish fauna.

Among the numerous studies on benthic fauna on the lower course of the Danube (the Romanian sector) the first to be noted are those concerning mollusc fauna (Grossu, 1962; 1963; 1986; 1987; Grossu and Paladian, 1956), given the important ecologic part played by this group of organisms in benthonic biotopes (primary consumers, food source, water purification, or as bioindicators due to the sensitivity of some species to heavy metals). Then there are papers on other taxonomic groups, or on the whole benthonic association (Enăceanu, 1967 ; Enăceanu and Brezeanu, 1970 ; Popescu-Marinescu, 1990; 1992; Rîşnoveanu, 2003). Research carried out between the 50s and the 60s highlighted the presence of over 300 taxa, as well as a clearly increasing number of species encountered going downstream along the Danube (Gomoiu *et al.*, 1998).

2. MATERIALS AND METHODS

One of the aims of this paper was a parallel qualitative and quantitative characterisation of benthic fauna based on analysing samples collected from the entire Danube course between Baziaş and the sea mouths of the three branches and from the 9 tributary rivers in the summer of 1996 (51 stations) as part of the "European River-Ocean System - EROS 2000" Project using the ship "Semnal" and in the summer of 2004 (50 stations) as part of the Annual Geo-Monitoring Programme, using the research vessel "Istros". It must be noted that in 1996 the samples were collected from the Danube fairway, whereas in 2004 the samples were only collected from the left (that is, the Romanian) bank. As regards the main Danube tributaries, Cerna, Topolniţa, Jiu, Olt, Vedea, Argeş, Ialomiţa, Siret and Prut, the samples were collected 100 m upstream from the confluence.

For the study of benthic fauna quantitative samples were collected with a Van Veen type grab sampler, with subsamples taken from the first 10 cm of surface sediment by means of a plastic tube measuring 60 cm^2. The material was fixed and preserved by means of 4% neutralised formaldehyde. The samples were processed in the laboratory according to standard methods as follows: washing the material on a set of granulometric sieves with 1.000 mm, 0.500 mm 0.250 mm and 0.125 mm opening diameters to separate macro-, meio- and microfauna, followed by sorting, identifying and counting benthic forms. In the case of macrobenthic species biomasses were determined by weighing the organisms on analytic scales, and in the case of meio- and microbenthic forms average weight tables were used. All large molluscs on the bodengreifer surface were counted.

3. RESULTS AND DISCUSSION

The general feature noticed in the case of the benthos encountered along the Danube and on the main tributaries, both during fieldwork while the samples were collected and in the laboratory when they were processed, consists of the lower biodiversity in comparison with data from older literature. 43 taxa were identified in the two years (28 taxa in 1996 and 37 taxa in 2004, 22 of which were common) with determinations down to the species level made only for molluscs, polychaetes and some of the crustaceans, while the other organisms were grouped according to supra-specific taxa (including some development stages). However, no significant changes were noted on comparing 1996 results with those of the preceding year (Gomoiu *et al.*,1998). The larger diversity encountered in 2004 can also be due to the fact the sample collection took place closed to the shore, where the substratum is usually muddier, unlike the one in the river fairway, given that the distribution of many benthic organisms is connected to sediment composition.

The highest frequencies, 90% in 1996 and 100% in 2004, were recorded in the case of oligochaetes, in fact the only euconstant organisms. The only constant forms were the nematodes, with 63% in 1996 and 74% in 2004. Species that can be defined as accessory comprise Chironomidae larvae in both years, Gammaridae in 1996 and *Corbicula fulminea* in 2004, the other species being only accidental ones (with frequencies below 25%) (Table 1).

On analysing the general structure of the zoobenthos in terms of large groups of organisms it can be noted that the highest number was registered by worms (89%) represented by oligochaetes and nematodes, with total values of 9711 and 18816 individuals/ m^2, while the other groups (molluscs, crustaceans and varia) registered between 3 and 4%. As far as biomass is concerned, the highest values were recorded in the case of molluscs (especially the Lamellibranchia *Unio pictorum, Dreissena polymorpha, Corbicula fulminea*), with total values of 246 and 1513 g/m^2 (Table 1; Figs. 1, 2).

Although the number of taxa varied from one station to the other, ranging between 1 and 11, in 1996 there were only 3 taxa in more than half of the stations, indicating a very low diversity index. In the summer of 2004 on the other hand, although 8 was the maximum number of taxa encountered, in most stations there usually were between 4 and 6 organisms (Fig. 3).

The quantitative scarcity and heterogeneous distribution of benthic fauna are also shown by the density and biomass value variation curves (Fig. 3). The higher density values appearing in some stations along the Danube are almost exclusively due to oligochaete and nematode populations, mostly juvenile, which entails a low biomass. The sectors with high biomass values are those where mollusc populations are usually to be encountered and their uneven distribution makes biomass values differ considerably from one station to another. The presence of large mollusc populations such as those of *Dreissena polymorpha*, in some Danube sectors can be regarded as an indication of ecosystem recovery and water purification (Gomoiu *et al.*, 1998). It can be noted in figure 4 that the diversity and abundance of mollusc species was higher in 2004 than in 1996. Whereas in 1996 *Corbicula fulminea* was not yet present, being encountered for the first time in 1997 between Baziaş and Moldova Nouă (Skolka and Gomoiu, 2001), in 2004 it was already quite abundant along the entire Danube course and in the Danube Delta.

The fauna encountered in the samples collected from the nine rivers is scarce, with the exception of the river Prut (Fig. 5). The worms represented by nematodes and oligochaetes are constantly present. Crustaceans can be encountered occasionally, and molluscs only appear in the Cerna, and Prut rivers (Fig. 5). Lower values for all parameters were recorded especially in the case of samples collected from some Danube tributaries with a higher degree of pollution, such as Topolnița, Jiu, Olt, Argeş, Ialomița.

Analyses of average density variation according to dominance in the case of the first 10 taxa reveal that the lists of organisms are almost the same for the two years. In 1996 there was a relatively large proportion of larval stages for molluscs and oligochaetes, unlike 2004 when these were present to a considerably lesser extent but there was instead a numeric dominance of *Corbicula fulminea* (Fig. 6) to be noted. The same crustacean groups appear in both years, with small differences in terms of average density values. The same can be said about the polychaete *Hypania invalida*, a Ponto-Caspian relict species.

In terms of biomass dominance molluscs rank among the first, but occupy different position in the two years, and the same is true of oligochaetes and Gammaridae (Fig. 7)

Table 1 General average values of ecological parameters characterising benthic populations from the Danube river and main tributaries in 1996 and 2004

No. crt.	Species	1996 summer							2004 summer						
		F%	Davg	DD	RkD	Bavg	DB	RkB	F%	Davg	DD%	RkD	Bavg	DB%	RkB
1	*Ammonia tepida*								2	186.4	0.776	12	0.0093	0.0006	24
2	Briozoa	2	0.00	0.00	28	0.000	0.000	28							
3	Spongia	4	6.20	0.06	17	0.455	0.182	11	2	3.44	0.014	28	0.1376	0.0090	17
4	Turbelaria	8	14.43	0.13	14	0.005	0.002	16	2	10.32	0.043	23	0.0041	0.0003	28
5	Nematoda	63	3808	35.1	**2**	0.010	0.004	13	74	6062	25.240	**2**	0.0110	0.0007	15
6	Oligochaeta	90	5072	46.7	**1**	3.105	1.241	**4**	100	12124	57.814	**1**	3.0344	0.1995	**4**
7	Coconi oligochaeta	22	580.9	5.35	**3**	0.142	0.057	**10**	10	55.04	0.229	11	0.0028	0.0002	23
8	*Hypania invalida*	14	235.2	2.17	**6**	0.240	0.096	**9**	8	574.5	2.392	**6**	0.4940	0.0325	13
9	Hirudinea	2	1.55	0.01	23	0.005	0.002	20							
10	*Anodonta cygnea*	4	2.27	0.02	21	138.7	55.41	**2**	2	3.44	0.014	29	104.09	6.8448	**5**
11	*Dreissena polymorpha*	18	172.6	1.59	**7**	29.12	11.64	**3**	12	330.2	1.375	**7**	176.16	11.583	**3**
12	*Sphaerium* sp.	12	29.41	0.27	11	6.018	2.404	**5**	8	34.4	0.143	13	17.624	1.1589	**6**
13	*Pisidium sp.*								2	3.44	0.014	30	0.0172	0.0011	22
14	*Corbicula fulminea*								32	161.7	0.673	**5**	188.49	12.394	**2**
15	*Unio pictorum*	10	5.24	0.05	16	65.52	26.18	**1**	12	22.36	0.093	14	944.27	62.091	**1**
16	*Bythynia tentaculata*								2	6.88	0.029	25	0.6480	0.0426	14
17	*Viviparus viviparus*	6	2.18	0.02	19	6.081	2.430	**6**	6	12.04	0.050	20	11.727	0.7711	**8**
18	*Theodoxus danubialis*	2	0.49	0.00	26	0.002	0.001	22							
19	*Esperia esperi*								2	3.44	0.014	31	65.360	4.2978	**7**
20	*Lythoglyphus naticoides*								4	10.32	0.043	21	4.6072	0.3029	**9**
21	Gasteropoda var. juv.	2	3.10	0.03	22	0.002	0.001	25	2	10.32	0.043	24	0.0052	0.0003	27
22	Ponta mollusca	8	214.5	1.98	**8**	0.452	0.181	**8**							
23	*Advenocypris alpherovi*								2	3.44	0.014	32	0.0002	0.0000	34
24	*Candona sp.*								6	13.76	0.057	17	0.0009	0.0001	29
25	*Cypridopsis vidua*								2	6.88	0.029	26	0.0004	0.0000	33
26	*Cyprideis littoralis*	2	1.55	0.01	24	0.000	0.000	26							
27	*Darwinula stevensoni*								2	3.44	0.014	33	0.0002	0.0000	35
28	*Ilyocypris gibba*								4	6.88	0.029	22	0.0004	0.0000	30
29	*Limnocythere inopinata*								2	3.44	0.014	34	0.0002	0.0000	36
30	*Paracandona albicans*	2	0.06	0.00	27	0.000	0.000	27	2	3.44	0.014	35	0.0002	0.0000	37
31	Harpacticidae	6	26.33	0.24	13	0.002	0.001	19	14	96.32	0.401	**9**	0.0025	0.0002	21
32	Gammaridae	31	259.7	2.39	**4**	0.321	0.128	**7**	26	326.8	1.361	**4**	0.2824	0.0186	**10**
33	Corophidae	14	49.37	0.45	**9**	0.030	0.012	14	12	92.88	0.387	**10**	0.0372	0.0024	16
34	Cumacea								6	13.76	0.057	18	0.0090	0.0006	20
35	*Astacus* sp.(Decapoda)								2	1.72	0.007	37	3.6120	0.2375	11
36	*Jaera sarsi* (Isopoda)	10	61.18	0.56	**10**	0.003	0.001	17	12	130.7	0.544	**8**	0.0142	0.0009	18
37	Hidracarina	2	1.55	0.01	25	0.002	0.001	23	6	24.14	0.101	15	0.0132	0.0009	19
38	Bezzia	8	10.84	0.10	15	0.003	0.001	18	8	13.76	0.057	16	0.0019	0.0001	25
39	Chironomida larvae	27	258.2	2.38	**5**	0.051	0.020	12	46	591.2	2.462	**3**	0.1181	0.0078	12

Table 1 (continuation)

No. crt.	Species	1996 summer							2004 summer						
		F%	Davg	DD	RkD	Bavg	DB	RkB	F%	Davg	DD%	RkD	Bavg	DB%	RkB
40	Chironomida pupae								6	13.76	0.057	19	0.0021	0.0001	26
41	Trichoptera	2	10.84	0.10	18	0.002	0.001	24	2	3.44	0.014	36	0.0007	0.0000	32
42	Insecta varia pupae	10	20.14	0.19	12	0.021	0.008	15							
43	Insecta varia larvae	4	3.10	0.03	20	0.002	0.001	21	2	6.88	0.029	27	0.0007	0.0000	31
	Worms		9711	89.49		3.50	1.40			18816	89.72		3.542	0.2329	
	Molluscs		430	3.96		245.9	98.24			598.6	2.85		1513.0	99.488	
	Crustaceans		398	3.67		0.36	0.14			703.5	3.35		3.960	0.2604	
	Varia		312	2.88		0.54	0.22			853.3	4.07		0.288	0.0189	
				100			100				100			100	

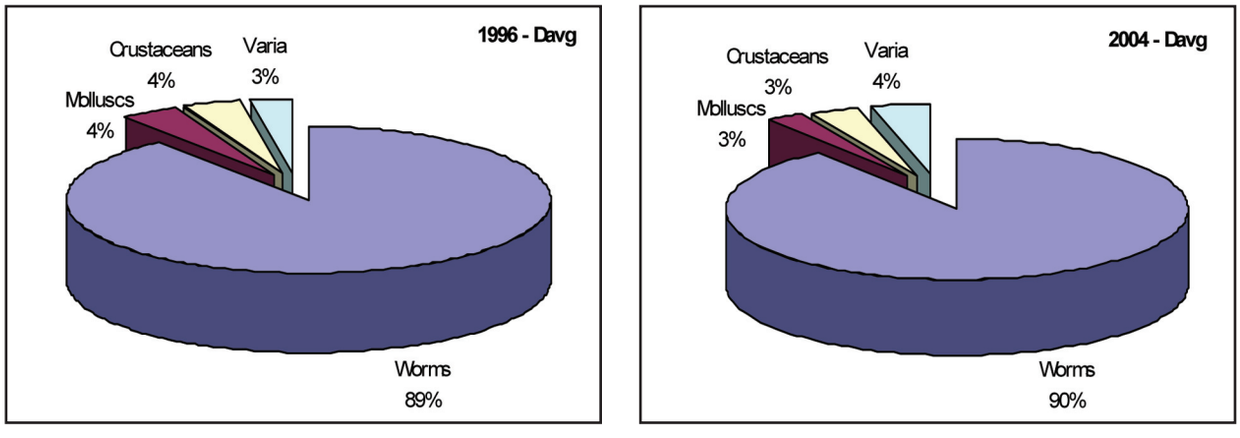
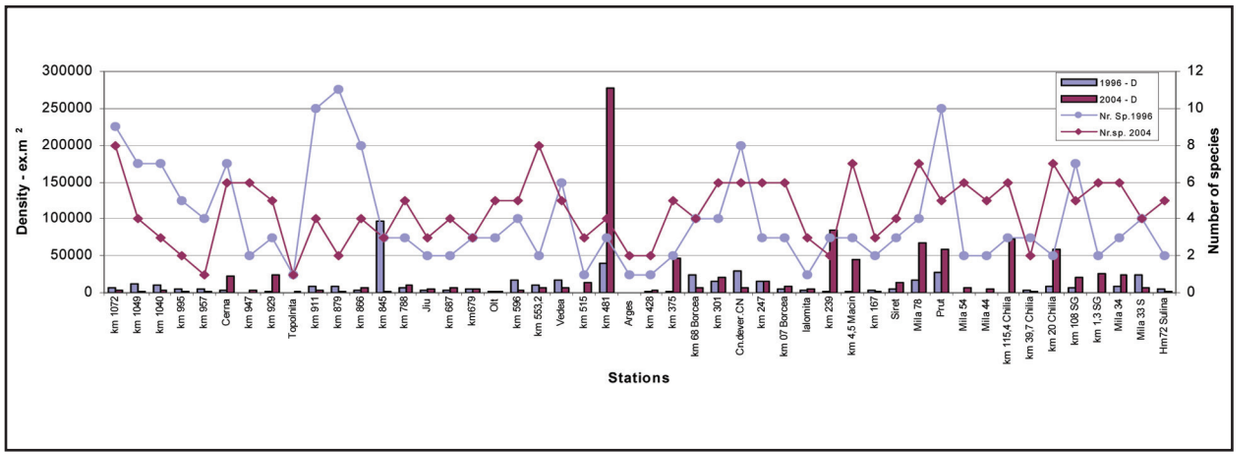


Fig. 1 The general taxonomic structure of zoobenthic populations in the Danube and main tributaries in 1996 and 2004 according to density

Fig. 2 The general taxonomic structure of zoobenthic populations in the Danube and main tributaries in 1996 and 2004 according to biomass



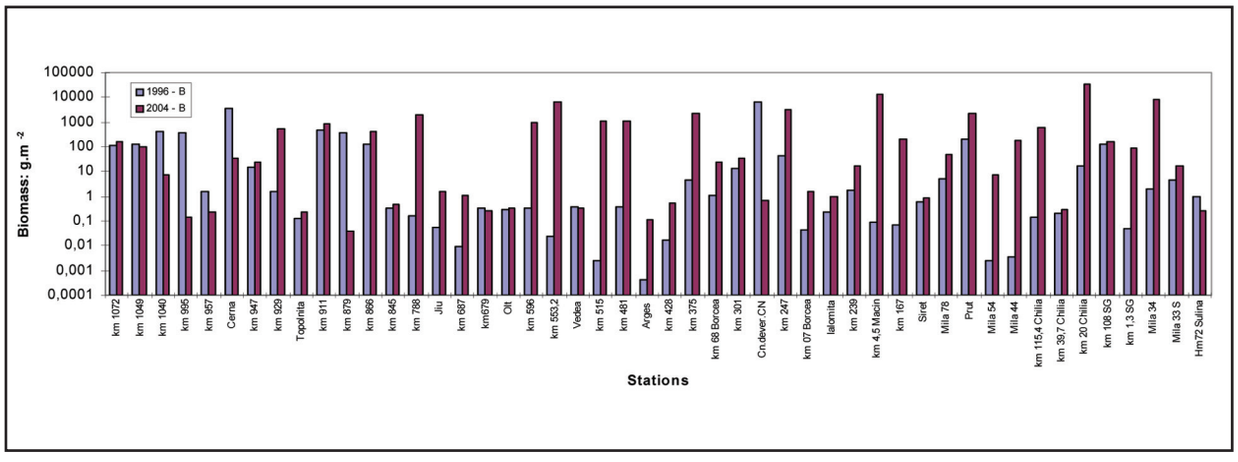


Fig. 3 The variation of densities, biomasses and taxa number in the Romanian Danube sector in 1996 and 2004

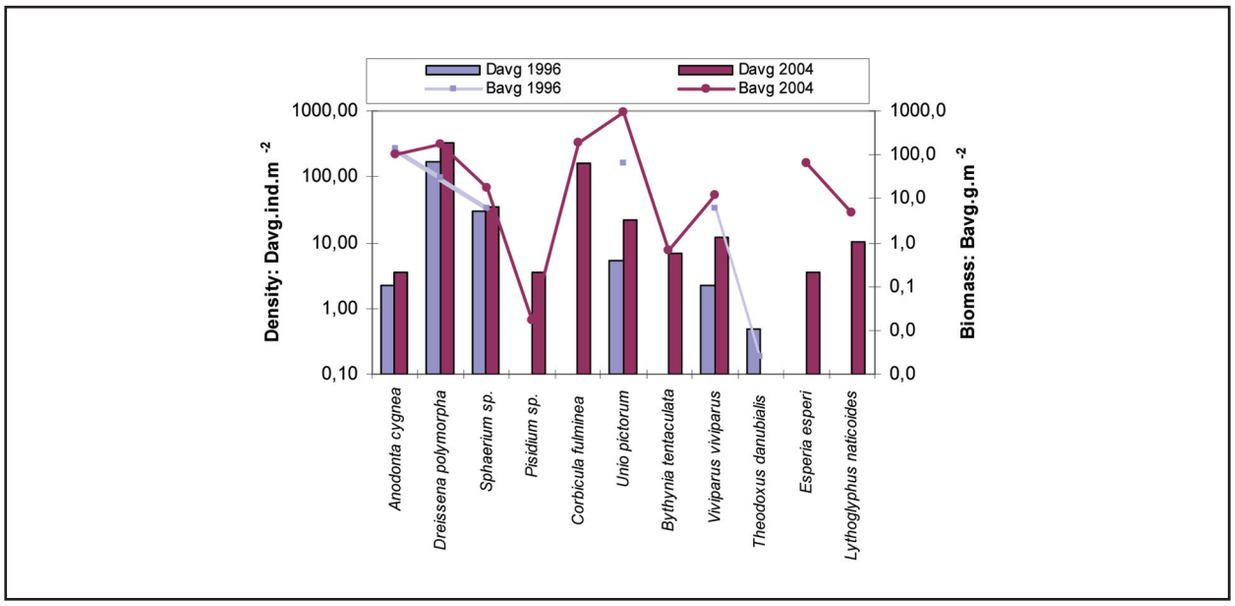


Fig. 4 The qualitative and quantitative structure of mollusc populations

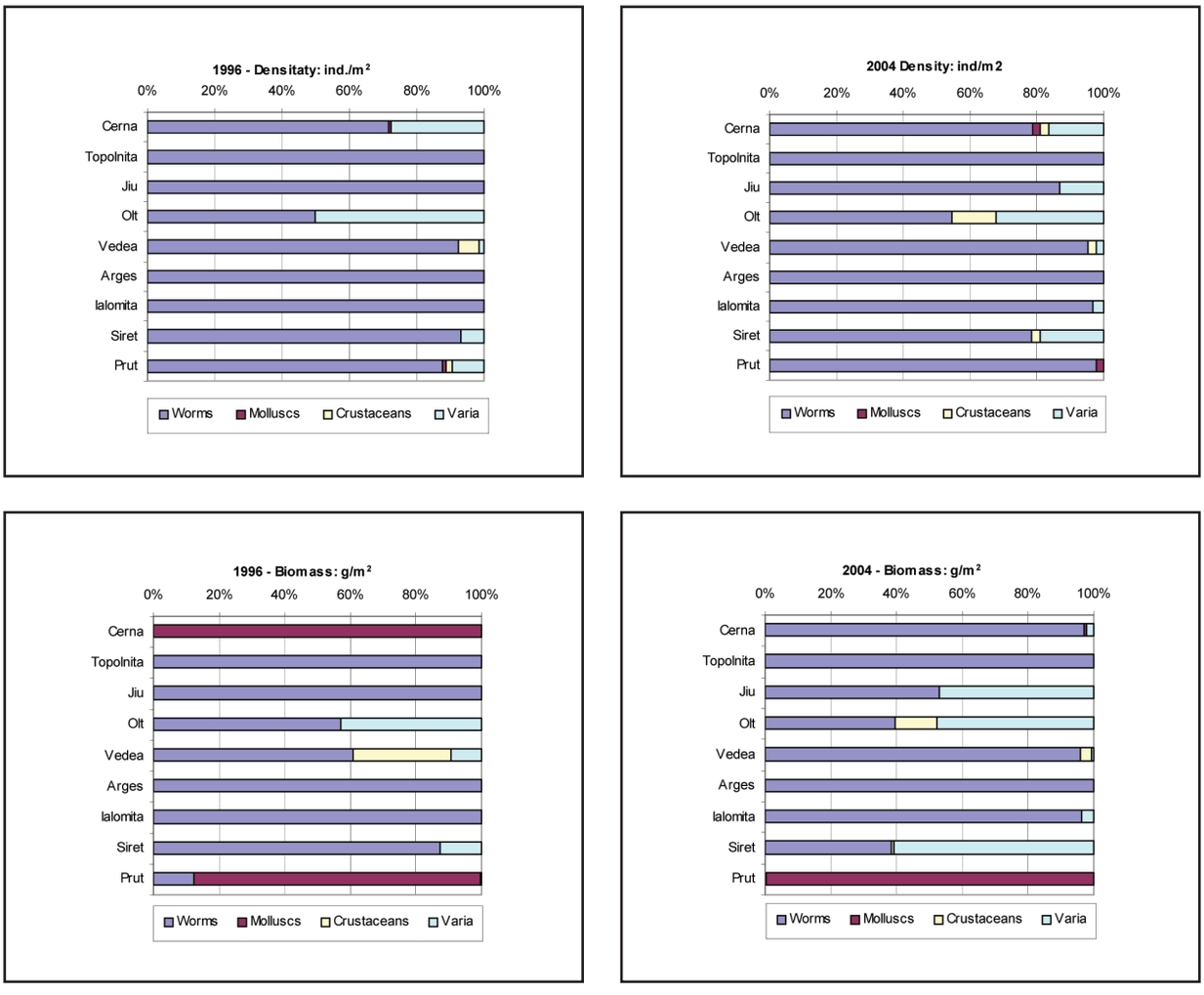


Fig. 5 The qualitative and quantitative structure of benthic populations encountered in the main Danube tributaries in 1996 and 2004

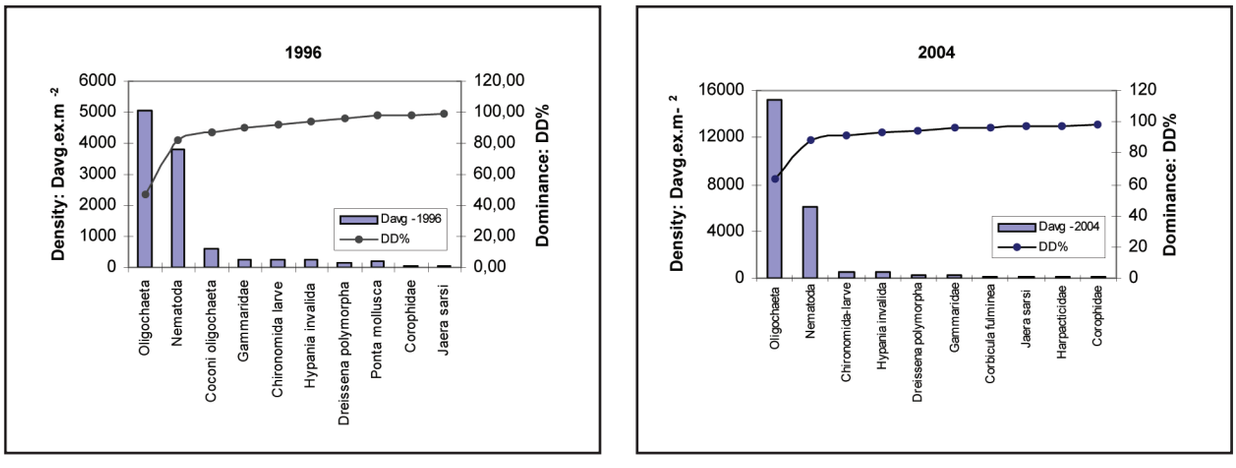


Fig. 6 Average density values for the first 10 species according to dominance in 1996 and 2004

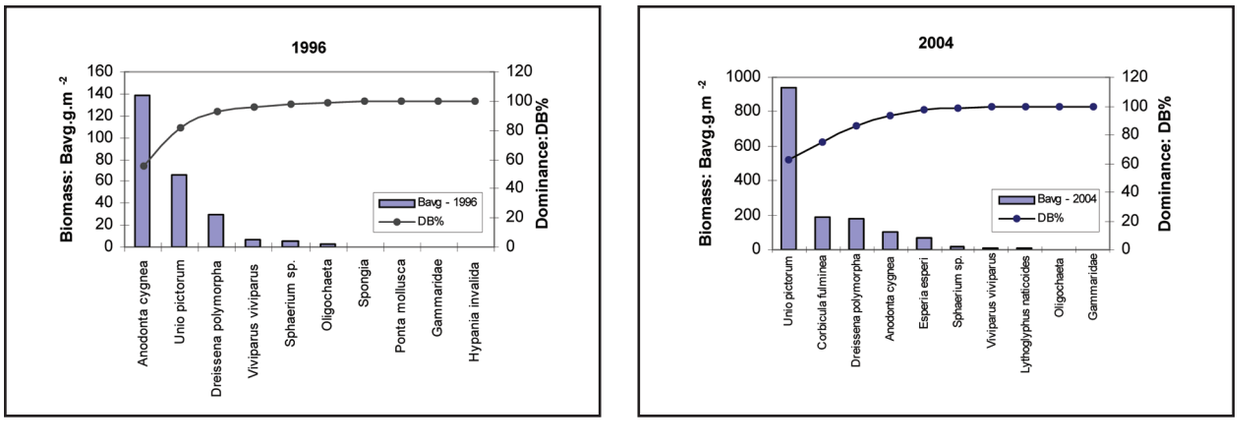


Fig. 7 Average biomass values for the first 10 species according to dominance in 1996 and 2004

4. CONCLUSIONS

The qualitative and quantitative analysis of benthic fauna along the Danube highlighted the presence of 43 taxa, which represents a low biodiversity. The fauna encountered in 1996 and 2004 is dominated by the presence of worms, especially oligochaetes and nematodes, crustaceans (especially Gammaridae) and the molluscs *Dreissena, Unio*, *Anodonta* and *Corbicola*.

Corbicola fulminea populations, whose presence is relatively recent in Danube biocoenoses and which were only encountered in 2004, seem to gain increasing terrain in the competition with other organisms, replacing in some sectors the once prosperous *Sphaerium* sp. populations.

The differences between the two years in terms of the density and biomass abundance of some taxa can also be attributed to the different methods of sample collection used. In 1996 sapling stations were located in the Danube fairway, where the sediment consists mainly of sand, water depth is higher and water current is implicitly stronger, resulting in scarcer populations in the case of many species. Since 2004 samples were collected closer to the bank, from lower depths, where the sediment was muddier and current speeds lower in the majority of cases, there was greater diversity and some species displayed higher densities and biomasses.

Crustaceans were mainly represented by Gammaridae and Corophidae (with *Corophium curvispinum* as the most frequent), less frequently by isopods (*Jaera sarsi*) and cumaceans (*Schizorhynchus scabriusculus* f. *danubialis*). Ostracods, quite rarely encountered along the Danube on previous occasions, appear sporadically, in rivers or in the vicinity of confluence areas, preferring calmer biotopes.

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