

QUALITATIVE AND QUANTITATIVE STRUCTURE OF ZOOPLANKTON ASSOCIATIONS IN THE DANUBE THERMAL DISCHARGE AREA OF NUCLEAR POWER PLANT CERNAVODA

MIRELA IULIANA ȘUNDRI⁽¹⁾, MARIAN-TRAIAN GOMOIU⁽²⁾

⁽¹⁾Constanta Maritime University, 104 Mircea cel Batran St, 900663 Constanta, Romania

e-mail: iuliana_sundri@yahoo.com

⁽²⁾National Institute of Marine Geology and Geo-ecology (GeoEcoMar), 23-25 Dimitrie Onciul St, 024053 Bucharest, Romania

e-mail: mtg@cier.ro

Abstract: The authors presents the structure of zooplankton community recorded in the Danube River sector influenced by the thermal discharge from the Nuclear Power Plant at Cernavoda (Romania). On the basis of samples collected in the summer season of the 1999-2001 and 2007, in three key stations (Danube River waters upstream NPP – St.1, thermal effluent – St. 4 and downstream effluent – St.6) 31 species were recorded; zooplankton associations, having relative high densities and biomasses, vary from one station to another, but there are 38% species, in the first period and 43% species in the second period which were found in all three stations. The general conclusion is that the higher temperature of NPP effluent does not affect the zooplanktonic diversity of the analyzed ecosystem.

Key words: Danube River, Nuclear Power Plant Cernavoda, aquatic thermal pollution, freshwater zooplankton

INTRODUCTION

Nuclear power plants (NPP) convert heat resulted from fission nuclear reactions into electrical power. NPP produce steam, which feeds a turbo-generator system with a conversion efficiency of about 30-40%. The remaining 70-60% of the produced heat is dispersed into the aquatic environment through a cooling system (Langford, 1983).

The cooling system of the Unit-1 (U1) of Nuclear Power Plant Cernavoda needs an income flow of 54 m³/s water (ICIM, 2002) for 100% electrical power. The cooling agent is water provided by the Danube-Black Sea Canal; the thermal polluted water is discharged into the Danube River, through a canal - a heated effluent that could be an ecological stressing factor for the river ecosystem in the area of its influence that is downstream of the thermal canal (Clark, 1969).

For the assessment of the eventual perturbations due to the thermal effluent discharge and thermal impact levels some knowledge of the significant environmental physical,

chemical and biological parameters are necessary (Gomoiu *et al.*, 2005).

The determination of taxonomic pattern and the taxa richness is an essential condition for the ecosystem assessment.

The zooplankton plays a very important role in the energetic and tropho-dynamic cycles of aquatic ecosystems, being a link between phytoplankton and zooplankton fish eaters; at the same time zooplankton populations can represent sensible biological indicators of the state of aquatic ecosystems exposed to stress conditions (Laws, 2000).

In this study are presented a few results concerning the thermal pollution of the Cernavoda Danube ecosystems, having the following objectives:

- Spatial and temporal monitoring of the zooplankton populations dynamics in certain points of Cernavoda area;
- Evaluation of the taxonomic structure upstream and downstream of Cernavoda Danube zone in relation to warm water discharge of NPP Cernavoda.

METHODS

For the study 6 sampling stations (S1÷S6) were chosen initially, around Cernavoda Danube area (Fig. 1):

- **S1** – it is placed on the Danube, 500 m upstream the confluence between the Danube – Black Sea Canal (DBSC); this is considered a reference station because the ecosystem is not affected by thermal discharge from the NPP Cernavoda and by the waste waters of the town.
- **S2** – is a sampling point of the income water basin in NPP area; here the water is coming from DBSC, but due to the low flow this area could be assimilated as a limnic ecosystem.
- **S3** – is a point situated on the effluent discharge canal of NPP, upstream the aeration fall; here the temperature of the water is expected to be maxim.
- **S4** – it is placed downstream the aeration fall of the NPP discharge canal, but 100 m upstream the confluence between this canal and the river. Here the depth of the canal is about 3.5 m with steady water which represents an attractive area for many species of fishes.
- **S5** – situated on the Danube, 100 m upstream the confluence between the NPP discharge canal and the river; here

there is the discharge point of the waste water provided by the town.

- **S6** – this station is placed on the Danube, 500 m downstream the confluence between NPP discharge canal and the river; here the water is expected to reflect the influence of the thermal discharge of the Danube aquatic ecosystem.

We have analysed data about zooplankton populations from this stations, in the summers of two periods of time: 1999-2001 and 2007.

For a better characterisation of the taxa, more samples from different depths were taken, in steps of 0.5 m or 1 m. Thus we obtained a spatial distribution (by depth) for each station. The final data were calculated as the mean value of these samples (Gomoiu and Skolka, 2001).

For the preliminary evaluation of the results we selected three stations **S1**, **S4** and **S6** for the best characterisation of these ecosystems. For **S1** we used 7 depth samples of 1 m steps, for **S4** 7 depth samples of 0.5 m steps and for **S6** 5 depth samples of 1 m steps.

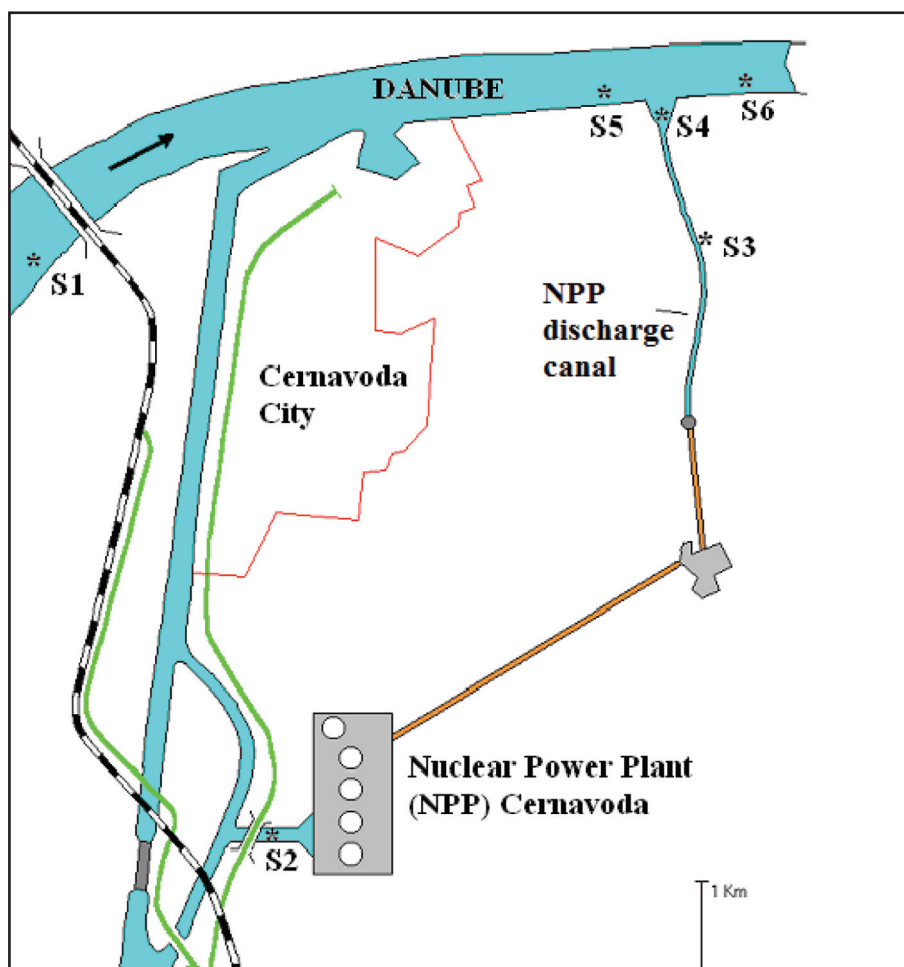


Fig. 1 Sampling Stations Position

Commonly used methods were applied for zooplankton investigations and species identification ((Damian-Georgescu, 1963, 1966; Krebs, 1999; Negrea, 1983; Rudescu, 1960; Wetzel, 2001).

The samples were collected with a Schindler-Patalas plankton trap with an 80 µm mesh-size and fixed in 4% buffered formaldehyde.

RESULTS AND DISCUSSIONS

Thermal pollution is reflected by the relations between the temperatures of the reference water (S1), the effluent water of NPP (S4) and the final mixing water (S6) (Table 1).

Table 1 The thermal conditions of the studied sites (T °C)

Data	S1	S4	S6
11.08.1999	25,9	35,1	29,4
10.08.2000	26,5	35,0	31,1
03.08.2001	25,1	33,9	30,8
05.08.2007	25,3	34,2	30,9

The zooplankton associations have a higher specific diversity, the populations consisting of 35 taxa, excluding age groups, which can increase the total number of different organisms to 38 forms. 32 types of organism were found in the samples collected in first period (1999 – 2001) and 31 types in the second period of time (2007).

As preliminary result from the data analyses it has been remarked the following aspects:

1. From the 32 types of organisms recorded in the first period (Table 2), 12 (37.5%) had a maximum frequency (constancy), being euconstant forms, 3 (9.4%) occurred only in two of the three stations, and the rest of 17 forms occurred in a single station.

2. From the 31 types of recorded organisms in the second period (Table 3), 15 (43.4%) had a maximum frequency (constancy), being euconstant forms, 7 (22.6%) occurred only in two of the three stations, and the rest of 9 forms occurred in a single station.

3. On the basis of the comparative analysis of the taxonomic structure of zooplankton population in both periods of time, some aspects can be revealed:

a) Diversity (Fig. 2):

- Rotifera represents the dominant form of specific diversity in all three stations for both periods of time;
- Cladocera taxa number decreases from upstream discharge point (S1) to canal effluent (S4) and increases downstream of discharge point (S6) for both period of time.

- Number of taxa for Cyclopida is approximately the same in both periods.

b) Density (Fig. 3):

- Rotifera forms are dominant by densities in all three stations for both periods of study; on the second place there are Bivalvia larvae.

4. Zooplankton associations vary from one station to another, but the species which are found in all three sample points represent 52% – 67% from specific diversity of each station in the first period and 58% - 88% in the second period of study.

5. A comparative analysis between both periods of this study shows that for the monitoring groups of organism, excepting Bivalvia, density increases in each station from the first to second period.

CONCLUSIONS

It has to be mentioned that no unwanted environmental event due to the discharge of the heated effluent from NPP Cernavoda into the Danube was identified during the sampling periods. Excepting the temperature increase, no significant changes in the Danube ecosystems conditions were detected at any time.

As final conclusions emerging from the analysis of zooplankton found in the Cernavoda Danube ecosystems it is worth mentioning that the supplementary heated water in the discharged effluent vs. “normal” aquatic environment in the research area cannot be a limiting factor for the zooplankton populations which are well developed and diversified providing an appreciated food source for fish.

The zooplankton communities from the Danube River ecosystem in the area near NPP Cernavoda are represented in 2007 by populations having relative higher densities than 6 ÷ 8 years before.

The greatest environmental danger related to the thermal effluent discharge into the Danube does not reside in the effect of the increased temperatures. As the temperature rises gradually when the unit begins to function, the organisms which do not tolerate the increased temperatures may evade the area while the others can accommodate to the new conditions. The danger of mass kills occurs during wintertime when the ambient temperatures are very low. If the nuclear power plant will stop suddenly, the organisms, especially the ones attracted in the discharge canal by the higher temperatures and caught here by the interruption of the warm effluent flow, may die by cold shock. It must be mentioned that now with two units of NPP Cernavoda in function, the chance that they should both stop suddenly during winter is insignificant, thus minimizing the risk of mass kills.

Table 2 Variation of zooplankton populations – density (indvs.m⁻³) and species diversity in the Danube thermal discharge area of NPP Cernavoda in the summer period – average for 1999, 2000, 2001

No.	Species	Station 1 (indvs.m ⁻³)	Station 4 (indvs.m ⁻³)	Station 6 (indvs.m ⁻³)
	PRIMARY CONSUMERS	29009.52	16209.52	11200.27
	ROTATORIA	20123.81	9333.33	8600.00
1	<i>Brachionus calyciflorus</i> var. <i>amphiceros</i>	17895.24	8466.67	7826.67
2	<i>Brachionus calyciflorus</i> var. <i>pala</i>	1285.71	123.81	266.67
3	<i>Brachionus diversicornis</i>			13.33
4	<i>Brachionus falcatus</i>	57.14		
5	<i>Brachionus quadridentatus</i> var. <i>brevispinus</i>	38.10		66.67
6	<i>Brachionus quadridentatus</i> var. <i>cluniorbicularis</i>	209.52	19.05	93.33
7	<i>Euchlanis parva</i>	209.52	123.81	
8	<i>Keratella quadrata</i>		295.24	80.00
9	<i>Keratella valga</i> f. <i>heterospina</i>		38.10	
10	<i>Lecane closteroerca</i>		95.24	
11	<i>Lecane luna</i>			13.33
12	<i>Platys quadricornis</i>		28.57	
13	<i>Rotaria</i> sp.	28.57	142.86	53.33
14	<i>Synchaeta pectinata</i>	266.67		
15	<i>Trichocerca dixon-nutalli</i>			53.33
16	<i>Trichocerca gracilis</i>			66.67
17	<i>Trichocerca</i> sp.			66.67
18	<i>Trichotria tetractis</i>	133.33		
	BIVALVIA	7476.19	5923.81	1533.40
19	BIVALVIA -larvae	7476.19	5923.81	1533.40
	CLADOCERA	247.62	485.71	773.33
20	<i>Alona rectangula coronata</i>			120.00
21	<i>Bosmina coregoni</i>			26.67
22	<i>Bosmina longirostris</i>	123.81	180.95	200.00
23	<i>Daphnia cucullata</i>			13.33
24	<i>Macrothrix laticornis</i>	38.10		
25	<i>Moina micrura dubia</i>	85.71	304.76	386.67
26	<i>Pleuroxus aduncus aduncus</i>			26.67
	CYCLOPIDA	1161.90	466.67	293.53
27	<i>Nauplius ciclopid</i>	819.05	304.76	200.13
28	<i>Copepodit ciclopid</i>	342.86	161.90	93.40
	SECONDARY CONSUMERS	714.29	533.33	80.00
	ROTATORIA	685.71	228.57	66.67
29	<i>Asplanchna brightwelli</i>	47.62	38.10	40.00
30	<i>Acanthocyclops vernalis</i>	638.10	190.48	26.67
	CYCLOPIDA	28.57	304.76	13.33
31	<i>Cyclops vicinus</i>		85.71	
32	<i>Mesocyclops crassus</i>	28.57	219.05	13.33
	TOTAL	29723.81	16742.86	11280.27

Table 3 Variation of zooplankton populations – density (indvs.m⁻³) and species diversity in the Danube thermal discharge area of NPP Cernavoda in the summer 2007

No.	Species	Station 1 (indvs.m ⁻³)	Station 4 (indvs.m ⁻³)	Station 6 (indvs.m ⁻³)
	PRIMARY CONSUMERS	30232.16	21434.70	24798.23
	ROTATORIA	21233.55	10933.09	21031.27
1	<i>Brachionus calyciflorus</i> var. <i>amphiceros</i>	18266.51	9233.03	18533.04
2	<i>Brachionus calyciflorus</i> var. <i>pala</i>	1066.25	233.98	1333.04
3	<i>Brachionus falcatus</i>			66.96
4	<i>Brachionus quadridentatus</i> var. <i>brevispinus</i>	33.26	66.51	66.96
5	<i>Brachionus quadridentatus</i> var. <i>cluniorbicularis</i>	233.98		133.04
6	<i>Euchlanis parva</i>	166.28	266.05	
7	<i>Keratella cochlearis</i>			33.04
8	<i>Keratella quadrata</i>	233.98	600.23	133.04
9	<i>Keratella valga</i> f. <i>monospina</i>			33.04
10	<i>Rotaria</i> sp.	266.05	233.98	333.04
11	<i>Synchaeta pectinata</i>	300.92		
12	<i>Trichocerca gracilis</i>	233.98	133.03	100.00
13	<i>Trichocerca</i> sp.	266.05	166.28	133.04
14	<i>Trichotria tetractis</i>	166.28		133.04
	BIVALVIA	6966.74	8933.72	2333.04
15	<i>BIVALVIA</i> -larvae	6966.74	8933.72	2333.04
	CLADOCERA	764.90	600.23	1000.00
16	<i>Alona rectangula coronata</i>	66.51		133.04
17	<i>Bosmina longirostris</i>	166.28	233.98	300.00
18	<i>Bunops serricaudata</i>	133.03		66.96
19	<i>Daphnia cucullata</i>			33.04
20	<i>Daphnia longispina</i>	66.51		66.96
21	<i>Diaphanosoma orghidani</i>	33.26		
22	<i>Macrothrix laticornis</i>			33.04
23	<i>Moina micrura dubia</i>	266.05	366.25	366.96
24	<i>Pleuroxus aduncus aduncus</i>	33.26		
	CYCLOPIDA	1266.97	967.66	433.92
25	<i>Nauplius ciclopid</i>	833.03	433.95	266.96
26	<i>Copepodit ciclopid</i>	433.95	533.72	166.96
	SECONDARY CONSUMERS	966.05	661.05	233.92
	ROTATORIA	565.79	326.77	133.92
27	<i>Asplanchna brightwelli</i>	133.03	133.03	66.96
28	<i>Asplanchna herricki</i>	66.51		
29	<i>Acanthocyclops vernalis</i>	366.25	193.75	66.96
	CYCLOPIDA	400.26	334.28	100.00
30	<i>Cyclops vicinus</i>	233.98	133.03	
31	<i>Mesocyclops crassus</i>	166.28	201.26	100.00
	TOTAL	31198.21	22095.75	25032.15

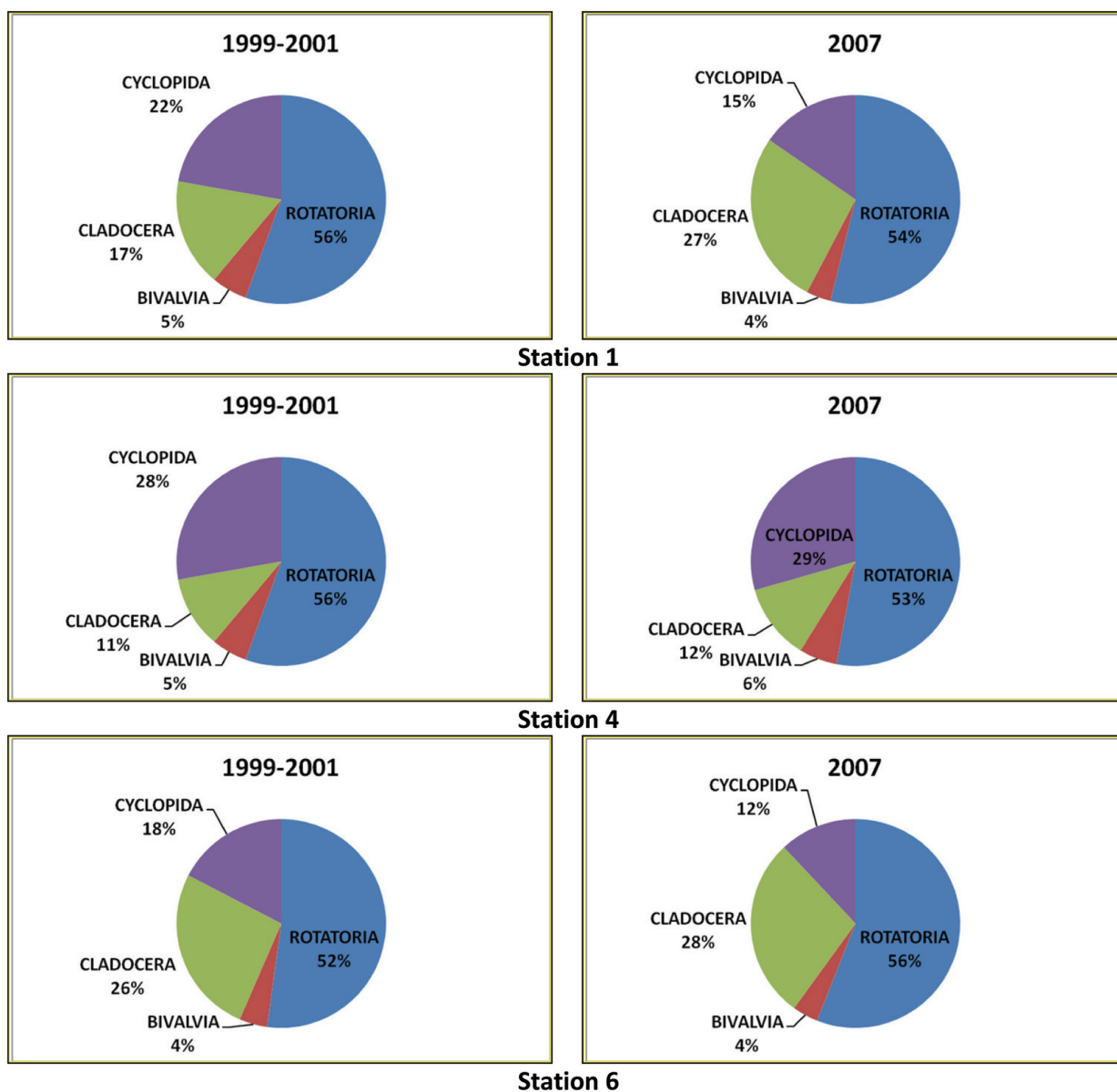


Fig. 2 Taxonomic structure of zooplankton community

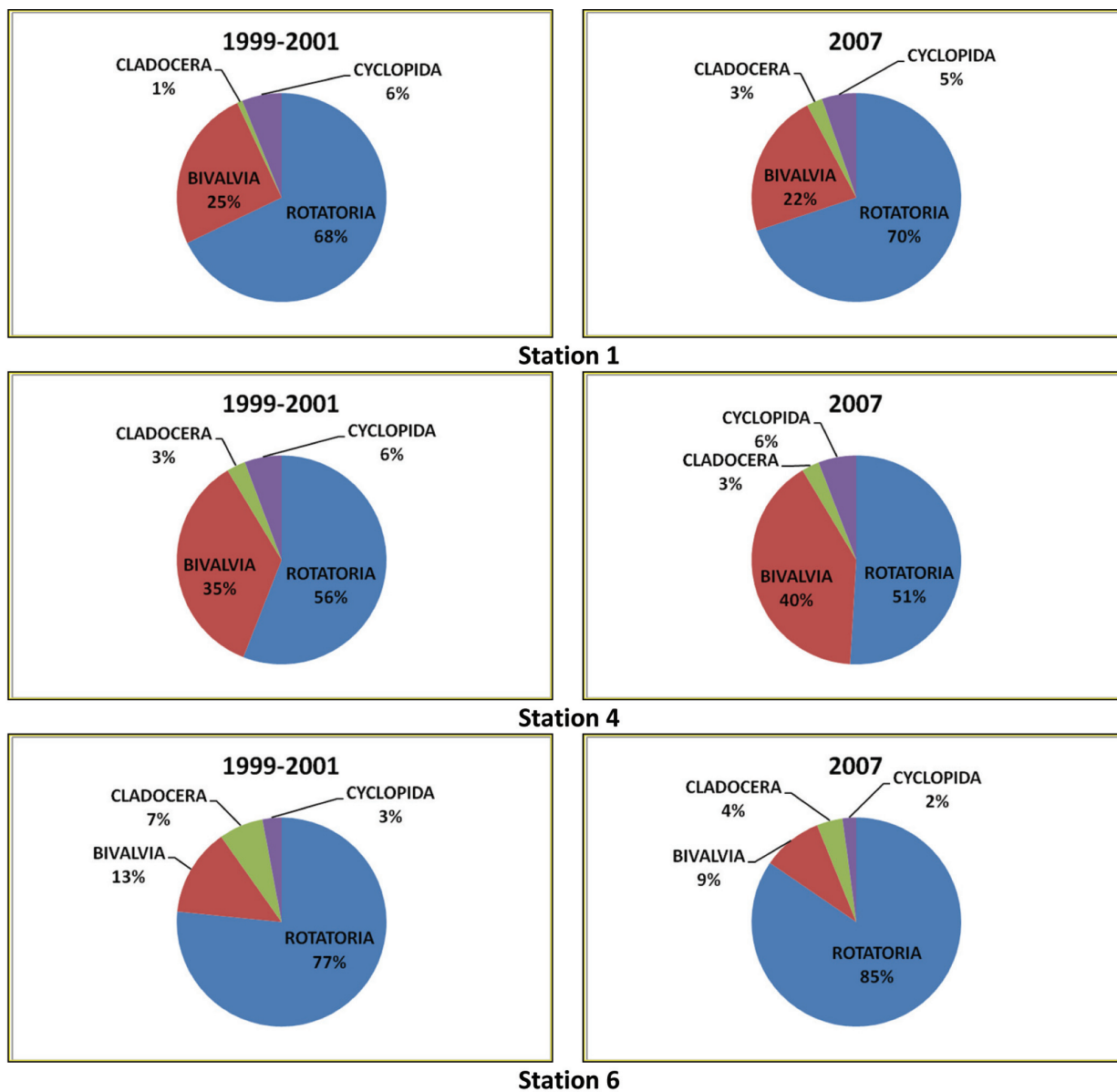


Fig. 3 Taxonomic structure of zooplankton density

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