



## Taxonomic Composition and Dominant Structure of the Macrozoobenthos in the Maritsa River and Some Tributaries, South Bulgaria

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**Abstract:** The aim of the study was to identify the current taxonomic composition and dominant structure of the macrozoobenthos in the Maritsa River and estuarine zones of its main tributaries (Chepelarska, Sazliyka, Stryama and Topolnitsa). The samples were collected from 15 sites in August and September 2020. The total number of the identified taxa was 165 belonging to 15 benthic groups. The orders Ephemeroptera and Trichoptera as well as, and the family Chironomidae (Diptera) were presented with the highest number of taxa. *Leuctra hirsuta* (Plecoptera) was reported for the first time for the Maritsa River. At the majority of sites, the order Ephemeroptera was represented by high proportion in the abundance of the benthic communities (up to 71.1%). *Caenis pseudorivulorum* was the species with the highest values of frequency of occurrence and dominance (pF = 73.3%, DF = 40%). The other constant species was *Baetis fuscatus*. Six taxa had the maximum degree of dominance and five of them occurred and dominated at one sampling site only. The number of taxa at each sampling site varied between 16 and 35. The cluster analysis of the taxonomic composition separated the sampling sites into three main groups: sites with low anthropogenic pressure, sites in the middle course of the Maritsa River and its tributaries, and sites in the lower stretches of the river.

**Key words:** benthic macroinvertebrates, dominant analysis, Maritsa River basin, river ecosystems

### Introduction

The transboundary position of the Maritsa River catchment area as well as the European and national water requirements impose the need to maintain the stability of the water communities and integrity of the aquatic ecosystems. The Maritsa River and its tributaries have been influenced by increased industrialisation and urbanisation that resulted in the

decline of the aquatic environment. Previous studies and analyses of the taxonomic composition and dominant structure of the macrozoobenthic communities in the Maritsa River have been carried out during the last 65 years. The most representative benthic groups were Diptera, Ephemeroptera, Oligochaeta, Simuliidae and Trichoptera (RUSSEV et al. 1981, UZUNOV et al. 1981, UZUNOV & KOVACHEV 1985).

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Topolnitsa River is a left tributary of the Maritsa River; its mid-course (650–400 m a.s.l.) passes close to an industrial region, thus pollution was reported for the last decades of the 20th Century (METCHEVA et al. 1987, JANEVA et al. 1997). The coefficient of species similarity was high (45.7%) for the river section above of the pollutants discharge and low (20%) for the section below (JANEVA et al. 1997). The orders Ephemeroptera and Trichoptera (15 taxa in each group) were the most dominant benthic groups, and Oligochaeta were quantitatively abundant in 1995–1996 (JANEVA et al. 1997). In 1987, the examinations of water saprobic state and biological sufficiency determined unfavourable conditions for the benthic animals in the Maritsa River catchment area (UZUNOV et al. 1991). GENINA et al. (2017) published data about the substrate composition of the riverbed (gravel and sand with organic slimes) and reported the impacts of organic pollutants on the sediments in Maritsa, Chepelarska and Stryama rivers near the city of Plovdiv. In the Maritsa River, the benthic macroinvertebrates are the most abundant on stones and pebbles (UZUNOV & KOVACHEV 1981).

This study aimed to identify the current taxonomic composition and dominant structure of the macrozoobenthic communities in the Maritsa River and estuarine zones of its main tributaries.

## Materials and Methods

### Study area

The Maritsa River is the largest river on the Balkan Peninsula. It originates from the Rila Mountains

(Bulgaria), flows to the southeast part of the country, passes through Turkey and Greece and flows into the East Aegean Sea. The length of the river in Bulgaria is 321 km and its catchment area (21,084 km<sup>2</sup>) is one of the river region units of the East Aegean Sea River Basin (MOEW 2016a, 2016b). Totally, 15 sites were sampled. Most of them were selected along the course of the Maritsa River in Bulgaria (site 1, 2, 4–9, 12, 14–15) (Fig. 1). The other sites were located at the estuarine zones of four of its main tributaries: Topolnitsa River in Pazardzhik (site 3), Chepelarska River under the Kemera Bridge (site 10), Stryama River near the village of Manole (site 11) and Sazliyka River before the estuary of Musatjevska River (site 13) (Fig. 1).

### Field works and data analysis

The study was conducted during the period 11 August – 17 September 2020. The geographic coordinates and altitudes of each sampling site were determined using GPS application (My Altitude 2.8.2) on a mobile device. The classification of the substrate in the riverbed was based on the size of the particles: large boulders (20–40 cm), boulders / stones (6–20 cm), cobbles (2–6 cm), pebbles (0.2–2 cm), sands (0.063–2 mm) and silt / mud (< 0.063 mm). The land use and (or) disturbance around the sampling sites were also observed. Benthic invertebrates were collected applying a multi-habitat sampling approach (CHESHMEDJIEV et al. 2011) according to the EU standards and national water legislation (standards BDS EN ISO 10870:2012 and EN 16150:2012). The taxa were identified in a laboratory after cleaning

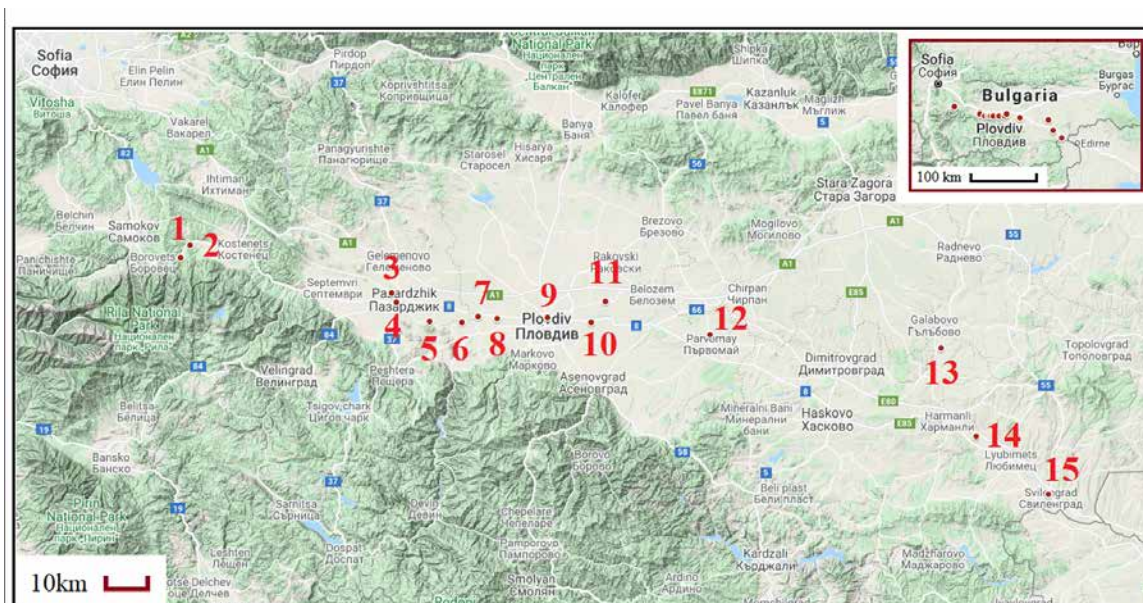


Fig. 1. Map of the 15 sampling sites in the Maritsa River catchment area.

and sorting the samples. The nomenclature of the macroinvertebrates followed in general Fauna Europaea (DE JONG et al. 2014). Additional keys were used for identification of various systematic groups: BAUERNFEIND & SOLDAN (2012) for Ephemeroptera, MURÁNYI (2008) and DE WALT et al. (2021) for Plecoptera, KUMANSKI (1985, 1988), HOLZENTHAL (2011), WARINGER & WOLFRAM (2011) and MORSE (2020) for Trichoptera, PAPE et al. (2011) for Diptera, SCHMIDT (1993), ANDERSEN et al. (2013) and BITUSIK & HAMERLIK (2014) for Chironomidae (Diptera), CHEKNOVSKAYA (1962) and ERESUS et al. (2008) for Oligochaeta and HRBÁČEK (1980), NAGEL (1989) for the other insect orders.

The frequency of occurrence (pF), frequency of dominance (DF), and degree of dominance (DT)

were calculated according to the dominant analysis of DE VRIES (1937) and KOZHOVA (1970). In addition, cluster analysis (Average group method, Sørensen resemblance) in PRIMER-E, Version 6, was performed to present the similarity in the taxonomic composition of the macrozoobenthos between the studied sites.

## Results

### Short description of the sampling sites

The difference in the altitude between the highest (site 1) and the lowest (site 15) sampling sites was about 800 m, and the total length of the Maritsa River between them was 236.4 km (Table 1). Sites 1 and 2 were at higher elevation than the other ones and were about 50 km apart from the next one (site 3). Seven

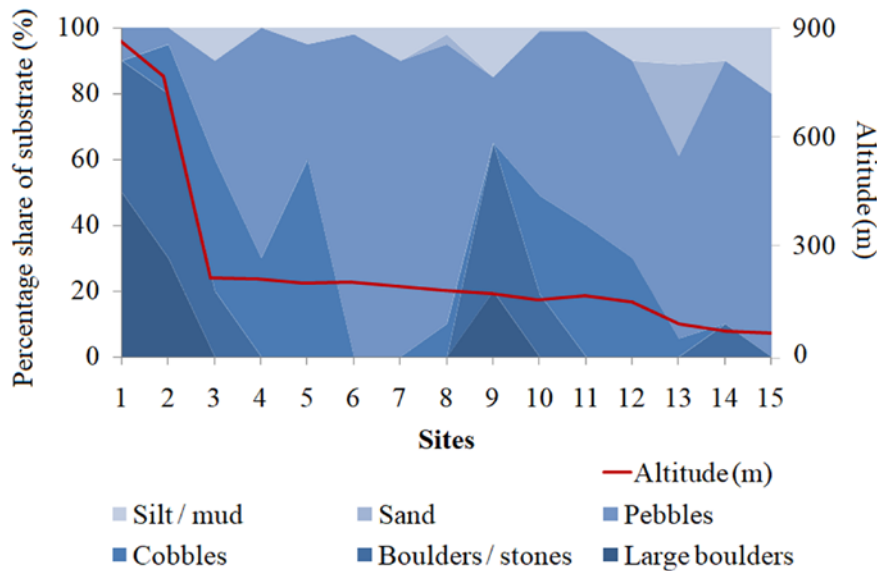


Fig. 2. Percentage share of substrate at each sampling site.

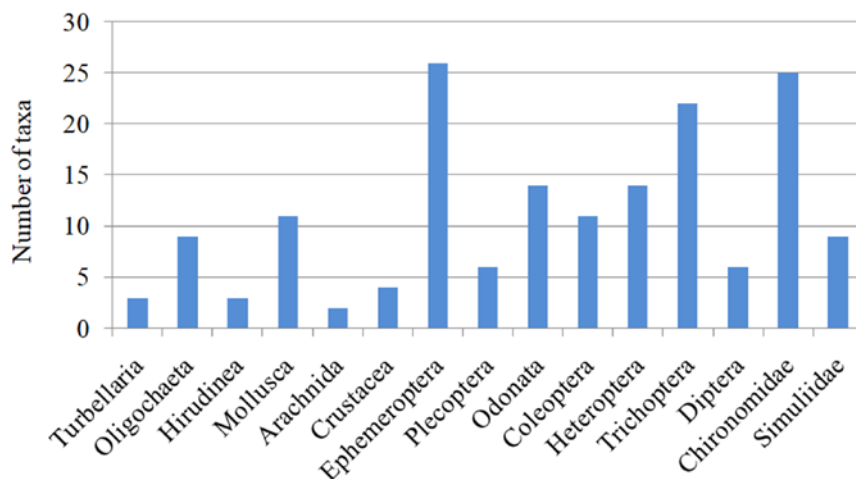


Fig. 3. Number of the taxa belonging to the 15 basic benthic groups found at all sampling sites.

**Table 1.** Names and some features of the sampling sites.

Site no.	Name of the site	River type*	Abbreviations	Geographical coordinates (N, E)	Altitude (m)	Natural/HMWB**	Substrate composition (%)						Land use / disturbance
							Large boulders	Boulders / stones	Cobbles	Pebbles	Sand	Silt / mud	
1	Maritsa River - near the village of Raduil	R3	M_RADUIL	42.28165, 23.68543	869	Natural	50	40	0	10	0	0	Meadows, fields, gardens, hiking trail
2	Maritsa River before the town of Dolna Banya	R3	M_DBANYA	42.30681, 23.71452	762	Natural	30	50	15	5	0	0	Fields, meadows
3	Topolnitsa River - Pazardzhik, the bridge for Boshulia village, before estuary	R5	TOPOLNITSA_R	42.20655, 24.29543	206	HMWB	0	20	40	30	0	10	Arable agricultural land. Illegal extraction of aggregates. Waste disposal.
4	Maritsa River - Pazardzhik - before the first bridge of the town	R12	M_PAZARDZHIIK	42.18563, 24.31067	205	HMWB	0	0	30	70	0	0	Urbanized area. Road bridge. The trees on the bank are logged.
5	Maritsa River Ognyanovo village, after Luda Yana River	R12	M_OGNYANOVO	42.14482, 24.40597	193	HMWB	0	0	60	35	0	5	Tree vegetation - only on the right bank. On the left bank - 10% pasture, 10% drain conduit, 30% litter
6	Maritsa River, Govedare village	R12	M_GOVEDARE	42.14281, 24.499538	195	HMWB	0	0	0	98	0	2	Arable agricultural land. Afforestation with 40% invasive species, 10% fishing. Invasive aquatic vegetation ( <i>Elodea</i> sp.).
7	Maritsa River, Stamboliyski - the bridge	R12	M_STAMBOLIYSKI	42.15476, 24.54677	184	HMWB	0	0	0	90	0	10	Arable agricultural land. Urbanized area - road bridge, concrete dam. Migration barrier after the sampled area; water diversion 95%.
8	Maritsa River, before Vacha River, landfill of Plovdiv	R12	M_VACHA	42.15078, 24.60184	171	HMWB	0	0	10	85	3	2	Tree vegetation - only on the right bank. On the left bank -landfill, stone and concrete threshold, drainage hole.
9	Maritsa River, Plovdiv, walkways, HMS 304	R12	M_PLOVDIV	42.153513, 24.745623	163	Natural	20	45	0	20	0	15	Urbanized environment 100% - concrete bridge, stone threshold.
10	Chepelarska River, the bridge of Kemera	R5	CHEPELARSKA_R	42.14373, 24.87182	145	HMWB	0	19	30	50	0	1	Arable agricultural areas. Digging in the riverbed. Stabilized erosion processes.
11	Stryama River - Manole village - bridge	R13	STRYAMA_R	42.18691, 24.91335	157	Natural	0	0	40	59	0	1	Arable agricultural land. Fishing, poaching. Waste disposal.

Table 1. Continuation.

12	Maritsa River, bridge for Parvomay, after the bridge of Parvomay, left shore before Mechka River	R12	M_PARVOMAY	42.11675, 25.21602	140	Natural	0	0	30	60	0	10	Tree vegetation - on the right bank- natural; on the left - artificial ( <i>Populus Gen. sp., Amorpha sp.</i> )
13	Sazliyka River - before estuary; bridge for Svirkovo village and Troyan village	R13	SAZLIYKA_R	42.0871, 25.88515	79	HMWB	0	0	5	50	25	10	Wastewater discharge from cow farms. Heavy pollution upwards the river flow.
14	Maritsa River, after Harmanli, Complex "Getgana", HMS	R12	M_HARMANLI	41.89772, 25.98478	61	Natural	0	10	0	80	0	10	Stone threshold, barrier. Many invasive plants ( <i>Amorpha</i> sp.)
15	Maritsa River, Svilengrad, before the old bridge	R12	M_SVILENGRAD	41.77254, 26.19356	54	Natural	0	0	0	80	0	20	Arable agricultural land. Urbanized environment - road bridge, concrete thresholds (barriers). Invasive mammals ( <i>Myocastor coypus</i> ).

\*R3: Mountain rivers in the ecoregion 7; R5: Semi-mountain rivers with gravel substrata; R12: Large lowland rivers with fine substrata in the ecoregion 7; R13: Small and medium-size lowland rivers with fine substrata in Aegean Region.  
\*\*HMWB (Heavily Modified Water Body).

of the sampling sites were located at natural water bodies and the others (8) were at heavily modified water bodies, where significant anthropogenic pressures by waste discharge from agriculture, farms, industries and domestic wastewaters was registered.

At most of the sampling sites (4, 6-8, 10-15), pebbles had the highest proportions (up to 98%), and tended to increase downstream (Table 1, Fig. 2). Exceptionally, at the site 9, the share of boulders and stones was the highest (45%). Upstream (> 700 m a.s.l.), the percentages of the large boulders and stones were as high as 50%. At the sites 3 and 5, cobbles amounted between 40 and 60%.

### Taxonomic composition of macrozoobenthos

Totally, 165 taxa of benthic macroinvertebrates belonging to 134 genera and 69 families were recorded (Table 2). They were representatives of 15 systematic benthic groups (Fig. 3). The order Ephemeroptera was presented with the highest number of taxa (26), followed by the Chironomidae (25) and the Trichoptera (22). The species *Leuctra hirsuta* (Plecoptera) was found at the Site 1 and reported for the first time for the Maritsa River. The number of taxa found at each sampling site varied between 16 at the site 14 (Maritsa River after Harmanli) and 35 at the site 11 (Stryama River) (Fig. 4).

Considering the quantitative proportions of the benthic groups at each sampling site, the order Ephemeroptera had the highest values at ten sites (up to 71.1%) (Fig. 5). The order Trichoptera dominated at the sites 9 and 10 (52.7% and 74.5% resp.), Odonata and Chironomidae at the site 13 (23.7% each) and Mollusca at the downstream sites (up to 48.1%). Plecoptera was the second largest group upstream (35.2% at the site 2). Taxa of Chironomidae were recorded at all sites but their shares were relatively low (av. 11.5%).

### Dominant analysis

According to the frequency of occurrence, 11 taxa can be considered as "constant" (pF > 50%). *Baetis fuscatu*s and *Caenis pseudorivulorum* (Ephemeroptera) occurred more frequently in the study area (pF=73.3%) (Table 2). Other taxa with high values of this index were Simuliidae gen. sp. (pF=66.7%), *Asellus aquaticus* and *Gammarus* sp. of Crustacea, *Conchapelopia* sp., *Cricotopus* sp. and *Polypedilum* sp. of the family Chironomidae (pF=60%), and *Hydropsyche bulbifera* and *Hydropsyche* sp. of Trichoptera (pF=53.3%). The number of accompanying taxa (pF=25-50%) was 16 and the other taxa were less common (occurring only at one to three sampling sites).

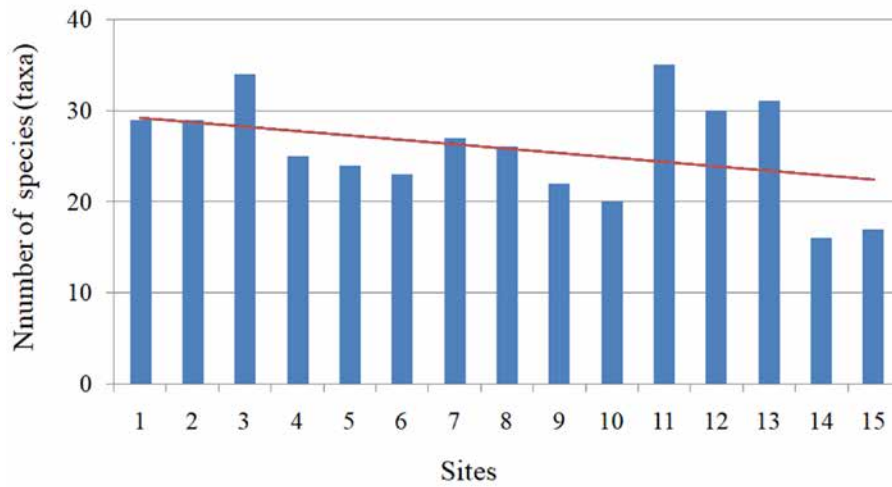


Fig. 4. Number of the taxa found at each sampling site in 2020.

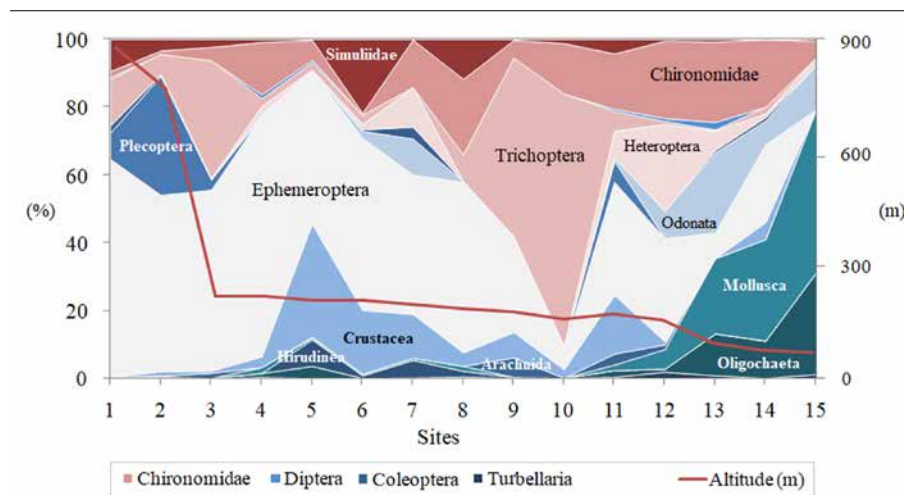


Fig. 5. Quantitative proportions of the 15 benthic groups at each sampling site.

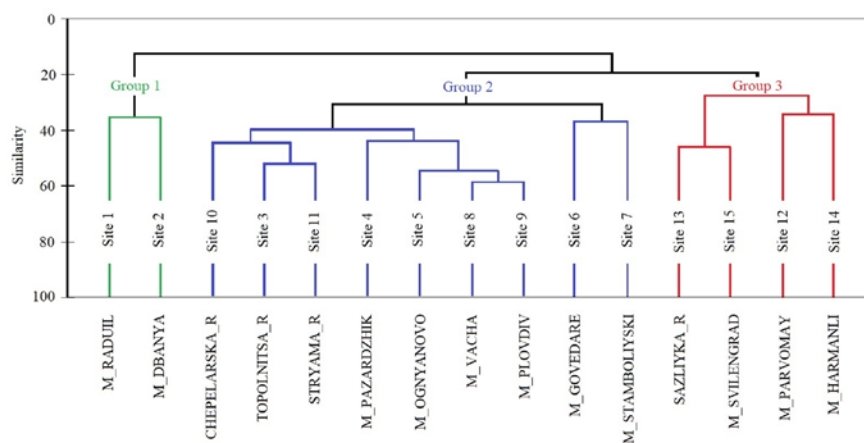


Fig. 6. Cluster analysis of the similarity of the macrozoobenthos taxonomic composition from each sampling site.

**Table 2.** Taxa found in Maritsa River and some of its main tributaries in 2020 with their frequency of occurrence (pF), frequency of dominance (DF) and degree of dominance (DT).

Taxa	Stations	pF (%)	DF (%)	DT (%)
<b>TURBELLARIA</b>				
Dugesiidae				
<i>Girardia tigrina</i> Gerard, 1850	4,13,15	20.0		
<i>Schmidtea lugubris</i> (Schmidt, 1861)	11	6.7		
<i>S. polychroa</i> (Schmidt, 1861)	12	6.7		
<b>OLIGOCHAETA</b>				
Naididae				
<i>Branchiura sowerbyi</i> Beddard, 1892	15	6.7		
<i>Rhyacodrilus coccineus</i> (Vejdovsky, 1875)	4	6.7		
<i>Nais variabilis</i> Piquet, 1906	8,15	13.3		
<i>Limnodrilus hoffmeisteri</i> Claparède, 1862	12,15	13.3		
<i>L. claparedeanus</i> Ratzel, 1868	12,13	13.3		
<i>L. sp.</i>	7,11,13,14,15	33.3	6.7	20.0
<i>Psammoryctides albicola</i> (Michaelsen, 1901)	13	6.7		
Lumbriculidae gen. sp.	8	6.7		
Lumbricidae gen. sp.	2,5,11,14	26.7		
<b>HIRUDINEA</b>				
Erpobdellidae				
<i>Erpobdella octoculata</i> (Linnaeus, 1758)	5,6,7,8,9	33.3		
Rhynchobdellida				
Glossiphoniidae				
<i>Helobdella stagnalis</i> (Linnaeus, 1758)	7,8	13.3		
<i>Helobdella sp.</i>	5	6.7		
<b>MOLLUSCA</b>				
<b>BIVALVIA</b>				
Sphaeriida				
Sphaeriidae				
<i>Musculium sp.</i>	13	6.7		
<i>Pisidium sp.</i>	2	6.7		
<i>P. casertanum casertanum</i> (Poli, 1791)	13	6.7		
Venerida				
Cyrenidae				
<i>Corbicula fluminea</i> (O. F. Müller, 1774)	12,13,14,15	26.7	20.0	75.0
Gastropoda				
Bithyniidae				
<i>Bithynia sp.</i>	4,12	13.3		
Planorbidae				
<i>Ancylus fluviatilis</i> (O. F. Müller, 1774)	11	6.7		
<i>Planorbis planorbis</i> (Linnaeus, 1758)	5	6.7		
Basommatophora				
Lymnaeidae				
<i>Radix auricularia</i> (Linnaeus, 1758)	13,15	13.3		
Physidae				
<i>Physella acuta</i> (Draparnaud, 1805)	5,6,7,8,13,15	40.0	6.7	16.7
Heterotropha				

**Table 2.** Continuation

Valvatidae				
<i>Valvata piscinalis piscinalis</i> (O.F.Müller, 1774)	6,8,13,15	26.7		
Hygrophila				
Lymnaeidae				
<i>Radix labiata</i> (Glöer, 2002)	2,6,12	20.0		
ARACHNIDA				
Araneae gen. sp.	11,12	13.3		
Hydracarina gen. sp.	1,2,3,5,9,11,12	46.7		
CRUSTACEA				
Malacostraca				
Isopoda				
Asellidae				
<i>Asellus aquaticus</i> (Linnaeus, 1758)	2,3,5,6,7,8,9,10,11	60.0	6.7	11.1
Amphipoda				
Gammaridae gen. sp.	6	6.7	6.7	100.0
<i>Gammarus</i> sp.	2,3,4,5,7,8,9,11,12	60.0	20.0	33.3
Decapoda				
Potamidae				
<i>Potamon ibericum</i> (Bieberstein, 1808)	9,14	13.3		
INSECTA				
Ephemeroptera				
Baetidae				
<i>Alainites muticus</i> (Linnaeus, 1758)	2	6.7		
<i>Baetis alpinus</i> (Pictet, 1845)	2	6.7	6.7	100.0
<i>B. buceratus</i> Eaton, 1870	6,8,9	20.0	13.3	66.7
<i>B. fuscatus</i> (Linne, 1761)	3,4,5,6,7,8,9,10,11,12,14	73.3	20.0	27.3
<i>B. melanonyx</i> (Pictet, 1845)	1,2	13.3	13.3	100.0
<i>B. nexus</i> (Navás, 1918)	4,5,6	20.0		
<i>B. rhodani</i> (Pictet, 1845)	1,2	13.3	6.7	50.0
<i>B. vardarensis</i> Ikonmov, 1962	10,12	13.3		
<i>B.</i> sp.	3,4,5,8,10,11	40.0	6.7	16.7
<i>Procloeon pulchrum</i> (Eaton, 1885)	4	6.7	6.7	100.0
<i>Cloeon dipterum</i> (Linnaeus, 1761)	6,7,12,13	26.7	6.7	25.0
<i>Labiobaetis atrebatinus</i> (Eaton, 1870)	6	6.7		
<i>L. tricolor</i> (Tshernova, 1928)	8,12,14	20.0		
<i>Procloeon pennulatum</i> (Eaton, 1870)	6,7	13.3		
<i>Pseudocentropiloides nana</i> (Bogoescu, 1951)	12,13	13.3	6.7	50.0
<i>Raptobaetopus tenellus</i> (Albarda, 1878)	9	6.7		
Heptageniidae				
<i>Ecdyonurus helveticus</i> (Eaton, 1883)	2	6.7		
<i>E. (Helvetoraeticus)</i> sp.	1	6.7	6.7	100.0
<i>E. (Ecdyonurus)</i> sp.	3	6.7		
<i>E.</i> sp.	3,11	13.3		
<i>Heptagenia sulphurea</i> (Müller, 1776)	13,14	13.3		
Ephemerellidae				
<i>Serratella ignita</i> (Poda, 1761)	2,3,4,8,11	33.3		
Caenidae				

Table 2. Continuation

<i>Caenis macrura</i> (Stephens, 1835)	3,4,10,11	26.7		
<i>C. pseudrivulorum</i> (Keffermüller, 1960)	3,4,5,6,7,8,9,11,12,13,14	73.3	40.0	54.5
Leptophlebiidae				
<i>Habroleptoides confusa</i> Sartori & Jacob, 1986	1	6.7		
Ephemeridae				
<i>Ephemera</i> sp.	3	6.7		
Plecoptera				
Nemouridae				
<i>Protonemura intricata intricata</i> (Ris, 1902)	1	6.7		
<i>P. montana</i> Kimmins, 1941	1	6.7		
<i>P. praecox praecox</i> (Morton, 1894)	1	6.7		
Leuctridae				
<i>Leuctra fusca fusca</i> (Linnaeus, 1758)	1,2,3,10,11	33.3	6.7	20.0
<i>L. hirsuta</i> Bogoescu & Tabacaru, 1960	1	6.7		
Perlidae				
<i>Perla marginata</i> (Panzer, 1799)	1	6.7		
Odonata				
Gomphidae				
<i>Gomphus flavipes</i> (Charpentier, 1825)	12	6.7		
<i>G. vulgatissimus</i> (Linnaeus, 1758)	13	6.7		
<i>Onychogomphus forcipatus forcipatus</i> (Linnaeus, 1758)	11	6.7		
<i>O. forcipatus</i> ssp.	3	6.7		
Aeshnidae gen. sp.	6	6.7		
Calopterygidae				
<i>Calopteryx splendens</i> (Harris, 1780)	6,13,14,15	26.7		
<i>C. virgo</i> (Linnaeus, 1758)	8,12	13.3		
<i>C.</i> sp.	11	6.7		
Coenagrionidae gen. sp.	15	6.7		
<i>Ischnura elegans</i> (Vander Linden, 1820)	7	6.7	6.7	100.0
Libellulidae gen. sp.	12,15	13.3		
<i>Libellula</i> sp.	4	6.7		
<i>Orthetrum</i> sp.	13	6.7		
Platycnemididae				
<i>P. pennipes</i> (Pallas, 1771)	6, 13	13.3	6.7	50.0
Coleoptera				
Dytiscidae gen. sp. Ad.	4,13,14	20.0		
Dytiscidae gen. sp. Lv.	7	6.7		
<i>Hydaticus transversalis</i> (Pontoppidan, 1763) Ad.	5	6.7		
Gyrinidae gen. sp. Lv.	3	6.7		
Elmidae gen. sp. Lv.	1	6.7		
<i>Limnius</i> sp. Ad.	13	6.7		
Haliplidae gen. sp. Lv.	1	6.7		
Hydrophilidae gen. sp. Ad.	3,7	13.3		
<i>Helophorus</i> sp. Ad.	6	6.7		
Hydraenidae gen. sp. Lv.	1,2	13.3		
Coleoptera Indet. Lv.	10	6.7		
Heteroptera gen. sp.	13	6.7		

**Table 2.** Continuation

Aphelocheiridae				
<i>Aphelocheirus aestivalis</i> (Fabricius, 1794)	14	6.7		
Corixidae gen. sp.	11,12	13.3	6.7	50.0
<i>Corixa</i> sp.	4,7,13	20.0		
<i>Micronecta</i> sp.	13,15	13.3		
Gerridae gen. sp.	13	6.7		
Hydrometridae				
<i>Hydrometra</i> sp.	7,13	13.3		
Mesoveliidae				
<i>Mesovelia</i> sp.	7	6.7		
Naucoridae				
<i>Ilyocoris cimicoides</i> ssp.	7	6.7		
Nepidae				
<i>Nepa cinerea</i> (Linnaeus, 1758)	7	6.7		
Notonectidae				
<i>Notonecta</i> sp.	11	6.7		
Pleidae				
<i>Plea minutissima minutissima</i> (Leach, 1817)	6	6.7		
Veliidae gen. sp.	7	6.7		
<i>Velia</i> sp.	6	6.7		
Trichoptera				
Rhyacophilidae				
<i>Rhyacophila</i> (s. str.) sp.	2,3	13.3		
<i>R. (s. str.)</i> gr. <i>nubila-obliterata</i>	1,2,11	20.0		
Glossosomatidae				
Agapetinae gen. sp.	3,11	13.3		
<i>Agapetus</i> sp.	3	6.7		
Philopotamidae				
<i>Philopotamus montanus</i> (Donovan, 1813)	1	6.7		
Psychomyiidae				
<i>Psychomyia pusilla</i> (Fabricius, 1781)	3,9,10,11	26.7		
Hydropsychidae				
<i>Cheumatopsyche lepida</i> (Pictet, 1834)	3	6.7		
<i>Hydropsyche angustipennis</i> (Curtis, 1834)	9,10	13.3		
<i>H. bulbifera</i> McLachlan, 1878	4,5,6,7,8,9,10,11	53.3	13.3	25.0
<i>H. incognita</i> Pitsch, 1993	9,10,11	20.0		
<i>H. instabilis</i> (Curtis, 1834)	1	6.7		
<i>H. modesta</i> Navas, 1925	8,9,10,14	26.7	6.7	25.0
<i>H. tabacaru</i> Botosaneanu, 1960	1	6.7		
<i>H.</i> sp.	2,3,4,5,8,9,10,11	53.3	20.0	37.5
Limnephilidae				
<i>Potamophylax</i> sp.	1,2	13.3		
Chaetopterygini gen. sp.	1	6.7		
Sericostomatidae				
<i>Sericostoma</i> cf. <i>flavicornis</i> Schneider, 1845	1	6.7		
Odontoceridae				
<i>Odontocerum hellenicum</i> Malicky, 1972	1	6.7		

Table 2. Continuation

Leptoceridae gen. sp.	10	6.7		
<i>Mystacides azurea</i> (Linnaeus, 1761)	11	6.7		
Hydroptilidae gen. sp.	12,13,14	20.0		
<i>Hydroptila</i> sp.	4,8,9,11	26.7		
Diptera				
Tipulidae gen. sp.	5	6.7		
Diptera Indet.	12	6.7		
<i>Tipula</i> sp.	1,12	13.3		
Psychodidae gen. sp.	4,5	13.3		
Culicidae gen. sp.	13	6.7		
Ceratopogonidae gen. sp.	11	6.7		
Chironomidae				
<i>Ablabesmyia</i> sp.	7,14	13.3		
<i>Brillia</i> sp.	1,2	13.3		
<i>Chironomus</i> sp.	2,7,8,9	26.7		
<i>Cladotanytarsus</i> sp.	3	6.7		
<i>Conchapelopia</i> sp.	2,3,4,5,9,10,11,12,13	60.0		
<i>Corynoneura</i> sp.	5,8,9	20.0		
<i>Cricotopus</i> sp.	4,5,7,8,9,11,12,13,15	60.0	6.7	11.1
<i>Cryptochironomus</i> sp.	12	6.7		
<i>Diamesa</i> sp.	10	6.7		
Diamesinae gen. sp.	1,10	13.3		
<i>Eukiefferiella</i> sp.	1,2,3,8	26.7		
<i>Glyptotendipes</i> sp.	12	6.7		
<i>Krenopelopia</i> sp.	1	6.7		
<i>Micropsectra</i> sp.	10	6.7		
<i>Microtendipes</i> sp.	4	6.7		
<i>Parametrioctenus</i> sp.	2	6.7		
<i>Paratanytarsus</i> sp.	4,5,6,7,9,11,12,14	53.3	13.3	25.0
<i>Polypedilum</i> sp.	2,3,5,7,8,11,12,14,15	60.0		
<i>Pothastia</i> sp.	3	6.7		
<i>Procladius</i> sp.	7,13,15	20.0		
<i>Prodiamesa olivacea</i> (Meigen, 1818)	2,11	13.3		
<i>Rheocricotopus</i> sp.	3,10,12	20.0		
<i>Rheotanytarsus</i> sp.	5	6.7		
Tanytarsini gen. sp.	2	6.7		
<i>Tanytarsus</i> sp.	8	6.7		
Simuliidae gen. sp.	1,2,3,4,5,6,8,9,10,11	66.7	13.3	20.0
Stratiomyidae gen. sp.	2,11	13.3		
<i>Stratiomys</i> sp.	7	6.7		
Tabanidae				
<i>Tabanus</i> sp.	4,13,15	20.0		
Athericidae gen. sp.	3	6.7		
<i>Ibis marginata</i> (Fabricius, 1781)	3,12	13.3		
Empididae gen. sp.	2,3	13.3		
Dolichopodidae gen. sp.	1	6.7		
Sciomyzidae gen. sp.	4	6.7		

The number of dominant and subdominant taxa was 27. The species with the highest frequency of dominance was *Caenis pseudorivulorum* (DF=40%).

Six taxa had the highest degree of dominance (DT=100%): Gammaridae gen. sp. (Amphipoda), *Baetis alpinus*, *B. melanonyx*, *Procladius pulchrum*, *Ecdyonurus (Helvetoraeticus)* sp. (Ephemeroptera) and *Ischnura elegans* (Odonata). All of them had low values of the frequency of occurrence and dominance indices (pF=6.7%, DF=6.7% or 13.3%). *Baetis melanonyx* was recorded at two sites (1 and 2), while the other five taxa were found only at one site (1, 2, 4, 6 and 7) (Table 2).

The cluster analysis of similarity of the macrozoobenthos taxonomic composition separated the sampling sites into three main groups (Fig. 6). The first group was formed by sites, which belonged to the mountain type of water bodies (R3) and were characterised with low anthropogenic pressure (site 1 – M\_RADUIL and site 2 – M\_DBANYA). The second group included most of the sites and was divided into three subgroups. The sites from the first subgroup were located on the tributaries of the Maritsa River (site 10 – CHEPELARSKA\_R, site 3 – TOPOLNITSA\_R, and site 11 – STRYAMA\_R). The second subgroup was formed by the closely situated sites within the main Maritsa River (site 4 – M\_PAZARDZHIK, site 5 – M\_OGNYANOVO, site 8 – M\_VACHA, and site 9 – M\_PLOVDIV), which were distinguished by different types of human impacts (Table 1). The third subgroup consisted of sites (site 6 – M\_GOVEDARE, and site 7 – M\_STAMBOLIYSKI), which were positioned in arable agricultural lands. The third cluster covered the sites, which were located in the lower stretches of the Maritsa River (sites 12-15).

## Discussion

The formation of the macrozoobenthic communities is strongly influenced by the substrate composition in rivers as the proper substrates provide shelters from the river flow and supply food (UZUNOV et al. 1981, RUSSEV & JANEVA 1983, MOLOKWU et al. 2014). The dominance of mayflies in the Maritsa River is related to the pebbles, which are the preferable substrate to them (RUSSEV & JANEVA 1983). The high proportions of stones and boulders at the sites 9 and 10 create favourable conditions for the dominance of caddisflies (Figs. 2 and 5). The order Plecoptera is presented by relatively high proportions upstream, where the percentage of boulders and stones is higher (Figs. 2 and 5). The taxonomic

composition of the macrozoobenthos indicates that the conditions there can be considered close to the natural ones. This is also evidenced by the presence of *Leuctra hirsuta* (Plecoptera); this oligosaprobic species is a Balkan endemic and falls into the category of Vulnerable (VU) species (TYUFEKCHIEVA et al. 2019). The higher frequency of occurrence of stoneflies at sites with stones and pebbles than at sites with silt and sand has been found in the study by UZUNOV & KOVACHEV (1981).

In 1976-1977, the total number of taxa reported for the Maritsa River was 229 belonging to 130 genera; it had gradually decreased in comparison with the numbers (305 species) in 1955 and (284 species) in 1966 (UZUNOV et al. 1981). The tendency of reduction of the taxonomic diversity has been continuing over the last 65 years (165 taxa in 2020). The order Ephemeroptera has been recorded as the group with the highest taxa richness but it has decreased considerably when compared with previous studies. The number of species identified was 51 (18 genera and 11 families) in 1955-1966, and 56 (16 genera and 9 families) in 1976–1977 (RUSSEV & JANEVA 1983) but in 2020 only 26 species (14 genera and 6 families) were found, i.e. less than the half reported before. The composition of mayfly assemblages could vary depending on the geological and hydrological conditions as well as due to the sensitivity to the ecological changes (RUSSEV & JANEVA 1983). Furthermore, this is one of the most important and representative groups in the formation of the benthic communities in rivers. The decrease of the diversity of Ephemeroptera in the Maritsa River indicates the considerable changes in the ecological situation caused by human impacts.

The number of taxa of macrozoobenthos decreases downstream, which is a tendency opposite of the natural one. Most of the sampling sites are located either close to arable agricultural lands and pastures or in urbanised areas (Table 1). Furthermore, excessive amounts of waste disposal and discharge of wastewater were observed at the riversides. Macroinvertebrates respond to water quality changes and impacts of anthropogenic pressures on macrozoobenthic communities in the Maritsa River have been reported in previous studies (METCHEVA et al. 1987, UZUNOV et al. 1991, JANEVA et al. 1997, GENINA et al. 2017). Thus, the water pollution along the river has led to the decreasing trend in the taxa diversity downstream, despite the self-purification abilities of the river and the adaptations of the more tolerant species.

The dominant species within the mayflies (Ephemeroptera) have changed in comparison to the

previous study periods. *Baetis vernus* (pF=46.3%, DF=14.7%, DT=31.8), which was a common species in the period of 1976–1977 (RUSSEV & JANEVA 1983), was currently replaced by *B. fuscatus* in 2020. The species has considerably increased its frequency of occurrence (pF=73.3%) compared to 1976–1977 (pF = 6.3%) (RUSSEV & JANEVA 1983). Another mayfly species, i.e. *C. pseudorivulorum*, has the highest values of frequency of occurrence and dominance (pF=73.3%, DF=40%). It is more frequent in recent years and can be found in large numbers (VIDINOVA 2003, VIDINOVA et al. 2018).

The fact that all six taxa with the maximum degree of dominance have very low values of pF and DF indices means that the species occur and dominate under some specific environmental conditions, which differ along the river even in the same river type (Table 1). This is supported also by the results from the cluster analysis of similarity of the macrozoobenthos taxonomic composition. *Baetis alpinus* inhabits stony streams at 200–2,600 m a.s.l. and *B. melanonyx* occurs at 600–1,400 m a.s.l.; these two species move upstream to lay eggs on stable rocks (LEYS et al. 2016). They are typical for the upper river stretches characterised by high flow velocity, low temperature and high dissolved oxygen content. Their DT values have dramatically increased during the last decades in comparison with the ones in 1976–1977, which were 41.6 % and 9.2 % for *B. alpinus* and *B. melanonyx*, respectively (RUSSEV & JANEVA 1983).

## Conclusion

The taxonomic composition and dominant structure of the macrozoobenthos in the studied stretches of the Maritsa River and some its tributaries varied greatly. They indicated both habitat heterogeneity (including the substrate composition) and differences in the environmental conditions, even at short distances. The taxonomic composition and the great taxa richness upstream testify to conditions close to the natural ones. The change of the ecological situation has led to a considerable reduction of the invertebrate fauna downstream the Maritsa River.

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