THE BENTHIC FAUNA ASSOCIATIONS FROM THE MEANDERS AREA OF DANUBE – SFANTU GHEORGHE BRANCH, IN THE PERIOD 2016 - 2017

Ana Bianca PAVEL[1], Laura DUȚU[1], Neculai PATRICHE[2]

[1]*National Institute of Marine Geology and Geo-Ecology (GeoEcoMar), 23-25 Dimitrie Onciul St., 024053 Bucharest, Romania*
e-mail: ariadnas30@yahoo.com, laura.dutu@geoecomar.ro
[2]*Academy of Agricultural and Forestry Sciences "Gheorghe Ionescu - Siseşti", Research Institute for Aquatic Ecology, Fishing and Aquaculture Galați, 54 Portului St., Galați, Romania*
e-mail: neculai.patriche@gmail.com

Abstract. The study presents the results of qualitative and quantitative analysis of benthic fauna associations of Sfantu Gheorghe branch meanders of Danube Delta, Romania, performed in June 2016 and September 2017, respectively. Following the anthropogenic hydromorphological changes suffered by the Sfantu Gheorghe branch in '90s caused by cutting its length with about 35%, along with the increasing of industrialization and agricultural activities favoured by the opening of the channel to the navigation, the benthic fauna underwent a series of changes in terms of diversity and abundance. Based on 56 samples collected in 2016 and 2017, 51 taxa, belonging to 20 major groups in both years and average abundances of 265,440 ind.m^{-2}, in September 2016 and 12,402.4 ind.m^{-2} in June 2017 were found. Our findings suggest that a slightly improving of the quality of the environment within the study area has occurred after 2000's years due to progressive reducing of impact generated by the above-mentioned activities.

Key words: aquatic ecosystems, Danube River, Sfantu Gheorghe branch, benthic fauna, diversity, ecological structure indices

INTRODUCTION

The Danube is the second longest European river, more than a third of the river's length flowing through Romania. Sfantu Gheorghe is the southernmost of the three main branches through which the Danube flows into the Black Sea, carrying about 23% of the total water flow of the main river and 21% of the Danube sediment discharge (Jugaru Tiron *et al.*, 2009). St. Gheorghe branch is part of the Danube Delta UNESCO Biosphere Reserve, (Ramsar and World Heritage site declared since 80's), being surrounded in its lower part by strictly protected and buffer deltaic areas (Fig. 1).

However, during 80's and 90's, the Danube Delta has suffered major changes induced by transformation of large areas of natural land and water environments into artificial ecosystems used for agriculture, industry or navigation purposes. Thus, out of the thirty ecosystems types of the Danube Delta, seven of them were created by man. For instance, in order to improve the navigation, in the 1985-1990, the Sfantu Gheorghe branch was shortened from 108 km to 70 km by cutting six meanders along its length (Florescu *et al.*, 2013). This anthropogenic intervention led to creation of three distinct sections in the river branch: the free-flowing sector (FS), the meanders section (MS) and the newly built canal (NBC).

Several studies performed before showed that these changes had negatively affected the quality of the environment (Humborg *et al.*, 1997; Vosniakos *et al.*, 2008; Vosniakos *et al.*, 2012; Giosan *et al.*, 2012, Stanescu *et al.*, 2013) and, in particular, the diversity and the abundance of benthic fauna of the Mahmudia and Murighiol sectors of the Sfantu Gheorghe channel (Gheorghe *et al.*, 2013; Stoica *et al.*, 2013, 2014). Our study aims to present the biodiversity and the ecological structure in terms of abundance, dominance and frequency of benthic populations within the rectified meanders of the Sfantu Gheorghe branch, in the period 2016-2017.

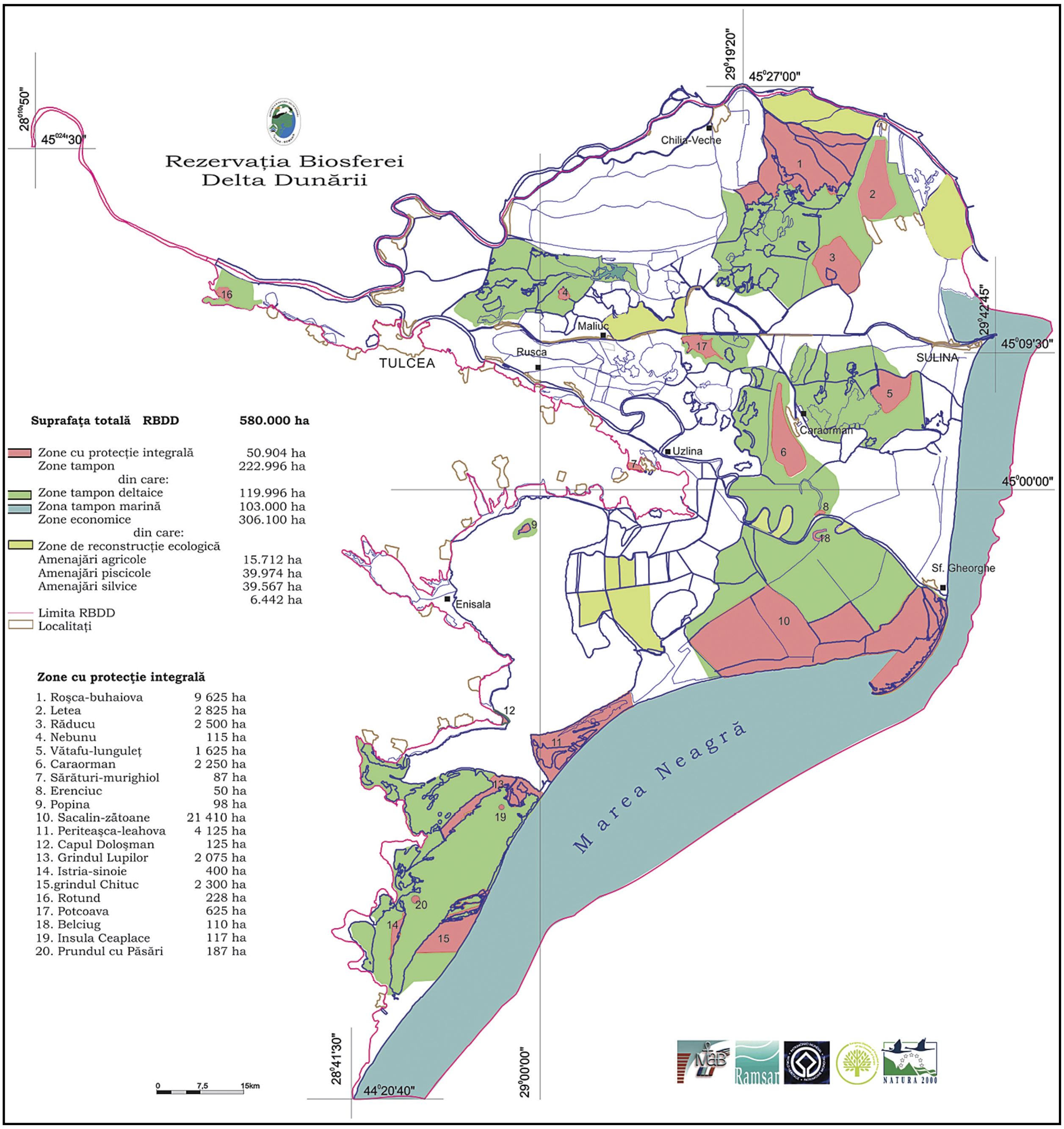

Fig. 1. The Danube Delta Biosphere Reserve (**red**: strictly protected areas; green: deltaic buffer areas; **blue**: marine buffer areas; **yellow**: economic and ecological reconstruction areas). http://www.ddbra.ro/en/danube-delta-biosphere-reserve/danube-delta/location

MATERIALS AND METHODS

The study was focused on the area approximatively delimited by the Mahmudia – Dunavățul de Jos localities and comprised both the natural meanders and the cut off artificial canal used for navigation, as well as the Uzlina lake, which communicates with one of the meander through a narrow channel (Fig. 2).

From ecological point of view, these areas differ significantly both in terms of hydrology and submerged vegetation coverage.

The Mahmudia meander (Big Meander of Uzlina – stations between A2, A3, B, C, D, E, F, G2) sampling area as well as the "Small M from Dunavat" (Old Danube – stations between I1, 2, J, K1, L2, M, CP1, N2) meander are characterized by a free flow water regime and rich vegetation along the banks (*Ceratophyllum* sp., *Myriophyllum* sp., *Elodea* sp and floating species like *Lemna minor* and *Salvinia natans*). The navigable channel between Murighiol and the confluence point of "small M from Dunavat" meander with the Sfantu Gheorghe channel has an active flow regime and no or little vegetation.

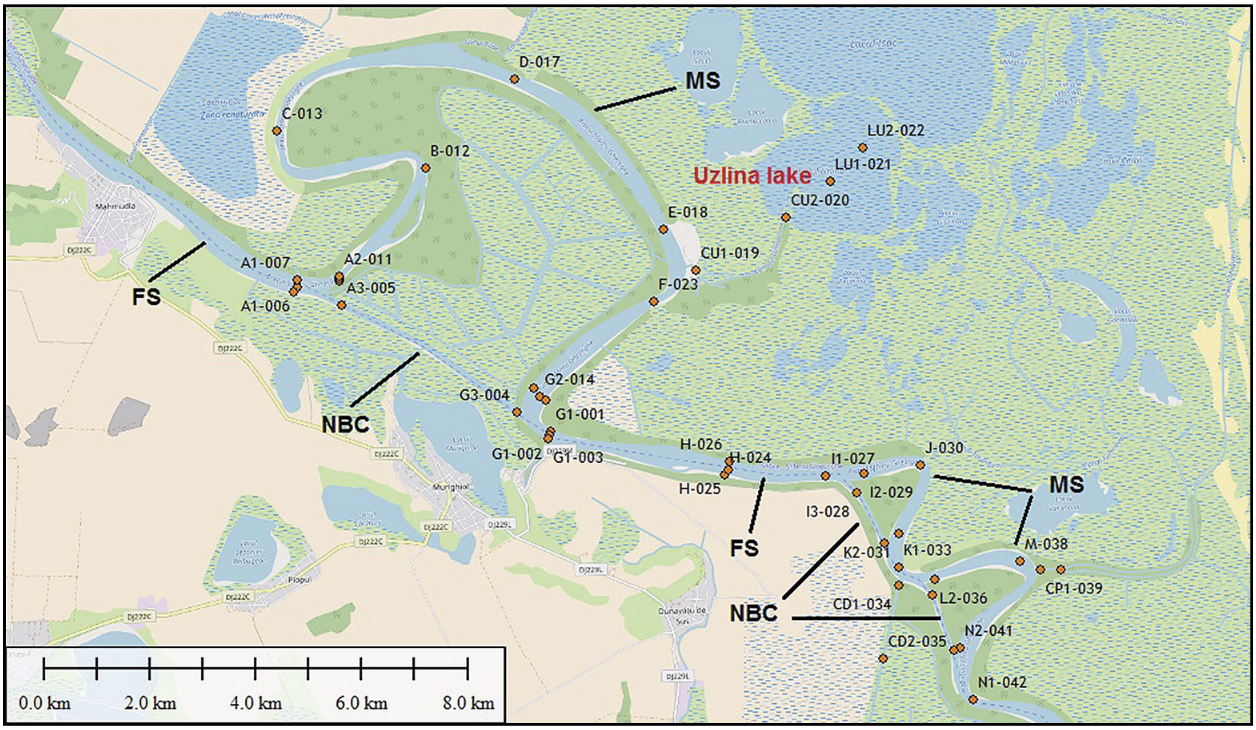

Fig. 2. Distribution of the stations on the Rectified Meanders Area of the Sfantu Gheorghe Branch (image A. Popa)
(**FS** - free-flowing sector, **MS** - the meanders section, **NBC** - the newly built channel)

The Uzlina Lake, on the other hand, represents a lentic eutrophicated system, rich in submerged vegetation, especially in the summer period (*Ceratophyllum demersum, Potamogeton sp., Trapa natans* and *Elodea nuttallii*). (Coops *et al.*, 1996; Covaliov and Coops, 2003).

The sampling strategy, according to the SR EN ISO 10870:2012, took into consideration the heterogeneity of substrate, which employed the multihabitat technique (a modified version of AQEM method used for water bodies monitoring in Romania – SR EN ISO 16150: 2012). According to this technique, the habitats types and the proportion between them have been established. Subsequently, a fiche of habitats has been filled in (SR EN ISO 16150:2012). All habitats with a coverage of more than 5% have been noted. The habitats (biocoenosis) were classified according to Pora E., Oros I., 1974. As result, in the next step, the method and sampling effort in each habitat have been set. In 2016, in deep zone, the quantitative samples were collected by using a Van Veen grab with mouth surface of 0.14 m^2. The results (number of individuals) were expressed at unit surface (1 m^2), using a multiplication factor of 7.4. Additionally, both in 2016 and 2017, the sweep and foot methods according to the SR EN ISO 10870:2012 were used for semiquantitative samples collecting in the littoral zone, where the macrophytes were present (Table 1). Thus, in order to collect the phytophilous organisms, the vegetation corresponding to a surface of 1 m^2 was swept by helping of a limnological net with 125 µm mesh size used aboard the boat. In total, 56 samples from 43 stations were collected.

On board the R/V Istros, the samples were washed through a 0.125 mm sieve in order to remove the excessive sediment particles and keep both meio- and macrofauna. A mixed solution of Rose Bengal and buffered formaldehyde 4% was used for fixation, staining and further preservation until subsequent analysis of benthic organisms in the laboratory.

In laboratory, the samples were sorted and the organisms were identified at the lowest taxonomical level possible using a Carl Zeiss SteREO Discovery V8 microscope and an Axiostar microscope. The taxonomic identification was done according to Godeanu, 2002. All organisms within a sample have been counted. The sample processing and analysis were carried out according to the SR EN ISO 5661-1:2008.

STATISTICAL ANALYSIS

In order to characterize the state of benthic populations, the calculation of the structural univariate indices (total individuals abundance (indv.m^{-2}), average and ecological densities per sample, frequency, dominance and index of ecological significance) was performed according to Stoica, 2012 and Stan, 1995. The dendrograms and the cumulative dominance curves depicting the relationships between samples, on the one hand, and between species, on the other hand, as well as the ranked dominance of taxons after abundance were performed using the software PRIMER 6 & PERMANOVA + (Clarke and Gorley, 2006) and PAST (Hammer *et al.*, 2001).

RESULTS AND DISCUSSIONS

The psammoreophyllic, psammopeloreophyllic biocoenoses occupied about 80% of the studied area, whereas the argillous-reophyllic biocoenosis was present in only 3 stations (K3-032, L3-037, and N3-043) (Table 1).

The faunistic research performed in the studied sector highlighted the presence of 44 taxa of invertebrates in 2016 and 41 taxa in 2017, respectively, belonging to 20 major taxonomic groups (Table 2).

In the area of the meanders, the oligochaetes were the most numerous with an average abundance of 265,440 ind.m^{-2} in 2016 (G1-16-003, CP2–16-040, LU1-16-021) and 12,402.4 ind.m^{-2} in 2017 (N2-17-041, G2-17-016, L2-17-036).

The molluscs were represented by a small number of species, the most frequent being: *Dreissena polymorpha* (Pallas, 1771), *Esperiana esperi* (Férussac, 1823), *Lithoglyphus naticoides* (C. Pfeiffer, 1828), *Theodoxus danubialis* (C. Pfeiffer, 1828), *Viviparus viviparus* (Linnaeus, 1758), and *Stagnicola palustris* (O.F. Müller, 1774) (Table 2). Rarely found were *Bithynia leachi* (Sheppard, 1823), *Dreissena bugensis* (Andrusov, 1897), *Lymnaea stagnalis* (Linnaeus, 1758), *Unio pictorum* (Linnaeus, 1758) and *Corbicula fluminea* (O.F. Müller, 1774). The bivalves were found within the psamopeloreophilic biocoenosis (fine mud and fast water stream habitats) at low depths, with the exception of the species *D. polymorpha,* which inhabits the stony facies from depths of 3 to 25 m (Pora E., Oros I., 1974).

The gammarid and corophiid species among the crustaceans were represented by few species. The dominant species throughout the studied area was the Ponto-Caspian relict *Chelicorophium curvispinum* (G.O. Sars, 1895) constituting 72% of the total amphipods abundance. It inhabits all the biocenoses in the meanders, from depths of 1 to 30 m.

Generally, the populations of *C. curvispinum* have been encountered associated with *D. polymorpha*, which is in accordance with Sebestyén (1938) observations in the Balaton Lake. On contrary, the highly successful invasion potential of the muddy tube-building *C. curvispinum* was associated by several authors with its capacity to outcompete the stony inhabiting species such as *D. polymorpha* (Van der Velde *et al.*, 2000), several larvae of chironomid species, isopods and other amphipods, by exerting a mud swamping effect on their habitats. Also present, but in smaller quantities were found *C. robustum* (G.O. Sars, 1895), *Dikerogammarus haemobaphes* (Eichwald, 1841), *D. villosus* (Sowinsky, 1894), *Chaetogammarus tenellus behningi* (Martynov, 1919), *Uroniphargoides spinicaudatus* (Cărăușu, 1943), *Pontogammarus obesus* (Sars, 1896), *Chelicorophium curvispinum* (G.O. Sars, 1895), *Euxinia sarsi* (Sowinsky, 1898), *Stenogammarus carausui* (Derzhavin & Pjatakova, 1962) and *S. compressus similis* (Sars, 1894).

Two species of mysids - *Paramysis bakuensis* (G.O. Sars, 1895) and *P. ullskyi* (Czerniavsky, 1882) - were identified, one species of cumacean: *Pseudocuma cercarioides* (Sars, 1894).

The isopod species *Jaera istri* (Veuille, 1979) was found only sporadically in 2017, despite that the isopod is widespread in the Danube and recently has been reported as invader of many aquatic systems (Tittizer, 1997; Schleuter and Schleuter, 1995).

The ostracods were represented also by few species that reached very low abundances. In 2016, seven species were identified: *Darwinula stevensoni* (Brady & Robertson, 1870), *Cypria ophtalmica* (Jurine, 1820), *Pseudocandona albicans* (Brady, 1864), *Ilyocypris sp.* (Brady & Norman, 1889), *Cypridopsis vidua* (O. F. Müller, 1776), *Fabaeformiscandona fabaeformis* (Fischer, 1851), whereas only one species *Ilyocypris sp*., was found in 2017. This could be explained through the greater number of sediments dwellers species found in 2016 than in 2017, when the number of samples collected in vegetation was higher (Table 1).

Among the Ponto-Caspian relicts, the polychaete *Hypania invalida* (Grube, 1960), with an average abundance of 9,352 ind.m^{-2} in 2016 and 407 ind.m^{-2}, in 2017 respectively was present. It inhabits various substrate types (hard and soft bottoms), at depths ranging between 1 and 30 m.

The most important representatives of the Insecta were the larvae of Chironomidae, Trichoptera and Ephemeroptera, and seldom Odonata (Zygoptera) and Lepidoptera. Out of the Trichoptera, species from Hydropsychidae, Polycentropodidae, Leptoceridae and Hydroptilidae families have been present. The Ephemeroptera larvae were represented by the Caenidae and Baetidae. The insects belonging to the Ceratopogonydae were dominated by the species of *Bezzia*, with an average abundance of 336 ind.m^{-2}, in 2016 and the Heteroptera were dominated by *Coriza dentipes* (Thomson, 1869) and *Paracorixa concinna* (Fieber, 1848), in 2017.

Overall, the average density of the benthic populations in the study area was of 481,868 ind.m^{-2} in September 2016 and 58,467.4 ind. m^{-2}, in June 2017. In 2016, the oligochaetes, polychaetes and gammarids dominated as abundance, whereas in 2017, the oligochaetes, crustaceans (Gammaridae and Corophiidae) and Chironomidae larvae prevailed (Fig. 3). The greatest abundances were found within the stations CP2-16-040 and LU1-16-021, in 2016 and within the stations N2-17-2-17 and LU2-17-2017, in 2017, respectively. This can be related to the presence of luxuriant submerged vegetation both in the stations located in Uzlina Lake and the present of psamopeloreophilic biocoenosis on the natural "small M from Dunavat" meander.

Table 1. Synopsis of the macrozoobenthos stations,

Crt. No.	Station	Depth (m)	Van Veen Grab		Limnological Net		Coordinates		Sediment description (SR EN ISO 16150:2012)	Biocoenosis Types (Pora E., Oros I., 1974)
			2016	2017	2016	2017	Lat. (α)	Long. (λ)		
1	**G1-001**	7.50	x	x			45°02'45,9"N	29°11'24,5"E	Psammal – sand	Psammoreophyllic
2	**G1-002**	15.70	x				45°02'43,3"N	29°11'23,2"E	Psammal – sand	Psammoreophyllic
3	**G1-003**	16.20	x				45°02'41,3"N	29°11'22,5"E	Psammal – sand	Psammoreophyllic
4	**G3-004**	21.36	x				45°02'57,7"N	29°10'56,4"E	Psammal – sand	Psammoreophyllic
5	**A3-005**	18.10	x	x			45°04'06,2"N	29°08'28,3"E	Psammal – sand	Psammoreophyllic
6	**A1-006**	10.20	x				45°04'17,9"N	29°07'49,6"E	Psammal – sand	Psammoreophyllic
7	**A1-007**	6.20		x			45°04'21,9"N	29°07'50,0"E	Psammal – sand	Psammoreophyllic
8	**A1-008**	10.50	x				45°04'14,9"N	29°07'47,3"E	Psammal – sand	Psammoreophyllic
9	**A2-009**	1.40	x				45°04'20,7"N	29°08'26,6"E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
10	**A2-010**	0.70	x				45°04'21,9"N	29°08'26,7"E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
11	**A2-011**	1.30				x	45°04'23,2"N	29°08'26,0"E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
12	**B-012**	4.50	x			x	45°05'28,0"N	29°09'43,0"E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
13	**C-013**	4.10	x		x		45°05'53,0"N	29°07'36,1"E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
14	**G2-014**	4.50	x				45°03'07,2"N	29°11'15,9"E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
15	**G2-015**	1.20	x				45°03'04,6"N	29°11'21,0"E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
16	**G2-016**	4.20		x			45°03'12,1"N	29°11'11,1"E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
17	**D-017**	4.20				x	45°06'21,1"N	29°11'02,1"E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
18	**E-018**	4.10	x				45°04'47,0"N	29°13'07,0"E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
19	**CU1-019**	8.10	x			x	45°04'21,1"N	29°13'33,9"E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
20	**CU2-020**	2.40	x				45°04'52,0"N	29°14'52,6"E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
21	**LU1-021**	1.20	x				45°05'12,9"N	29°15'32,0"E	Psammopelal - mixture of sand with mud	Psammopelophyllic

Table 1 (continued)

Crt. No.	Station	Depth (m)	Van Veen Grab		Limnological Net		Coordinates		Sediment description (SR EN ISO 16150:2012)	Biocoenosis Types (Pora E., Oros I., 1974)
			2016	2017	2016	2017	Lat. (α)	Long. (λ)		
22	**LU2-022**	1.20	x			x	45^{0}05′33,5″N	29^{0}16′00,0″E	Psammopelal - mixture of sand with mud	Psammopelophyllic
23	**F-023**	14.40	x				45^{0}04′03,1″N	29^{0}12′57,2″E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
24	**H-024**	4.50	x				45^{0}02′16,6″N	29^{0}13′53,5″E	Psammal – sand	Psammoreophyllic
25	**H-025**	4.30	x				45^{0}02′19,0″N	29^{0}13′56,4″E	Psammal – sand	Psammoreophyllic
26	**H-026**	4.40		x			45^{0}02′24,1″N	29^{0}13′57,8″E	Psammal – sand	Psammoreophyllic
27	**I1-027**	8.40	x				45^{0}02′13,8″N	29^{0}15′20,8″E	Psammal – sand	Psammoreophyllic
28	**I3-028**	11.10		x	x		45^{0}02′03,2″N	29^{0}15′47,2″E	Psammal – sand	Psammoreophyllic
29	**I2-029**	4.50	x				45^{0}02′14,9″N	29^{0}15′53,2″E	Psammal – sand	Psammoreophyllic
30	**J-030**	4.60	x	x			45^{0}02′18,9″N	29^{0}16′41,7″E	Psammal – sand	Psammoreophyllic
31	**K2-031**	4.30	x				45^{0}01′37,8″N	29^{0}16′22,1″E	Psammal – sand	Psammoreophyllic
32	**K3-032**	9.60		x			45^{0}01′32,2″N	29^{0}16′09,4″E	Argyllal - clay	Argillous-reophyllic
33	**K1-033**	18.80	x				45^{0}01′16,7″N	29^{0}16′21,1″E	Psammal – sand	Psammoreophyllic
34	**CD1-034**	3.30	x				45^{0}01′05,8″N	29^{0}16′21,0″E	Psammal – sand	Psammoreophyllic
35	**CD2-035**	3.50	x				45^{0}00′21,5″N	29^{0}16′05,9″E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
36	**L2-036**	4.10	x	x			45^{0}01′09,0″N	29^{0}16′51,7″E	Psammal – sand	Psammoreophyllic
37	**L3-037**	14.30				x	45^{0}00′59,4″N	29^{0}16′49,4″E	Argyllal - clay	Argillous-reophyllic
38	**M-038**	2.10	x			x	45^{0}01′18,6″N	29^{0}18′05,3″E	Psammal – sand	Psammoreophyllic
39	**CP1-039**	1.60	x			x	45^{0}01′12,8″N	29^{0}18′22,9″E	Psammal – sand	Psammoreophyllic
40	**CP2-040**	1.60	x				45^{0}01′13,0″N	29^{0}18′40,0″E	Psammal – sand	Psammoreophyllic
41	**N2-041**	5.50	x	x	x		45^{0}00′27,1″N	29^{0}17′12,1″E	Psammopelal - mixture of sand with mud	Psammopeloreophyllic
42	**N1-042**	12.50	x				44^{0}59′55,4″N	29^{0}17′21,6″E	Psammal – sand	Psammoreophyllic
43	**N3-043**	12.80		x			45^{0}00′25,4″N	29^{0}17′06,7″E	Argyllal - clay	Argillous-reophyllic

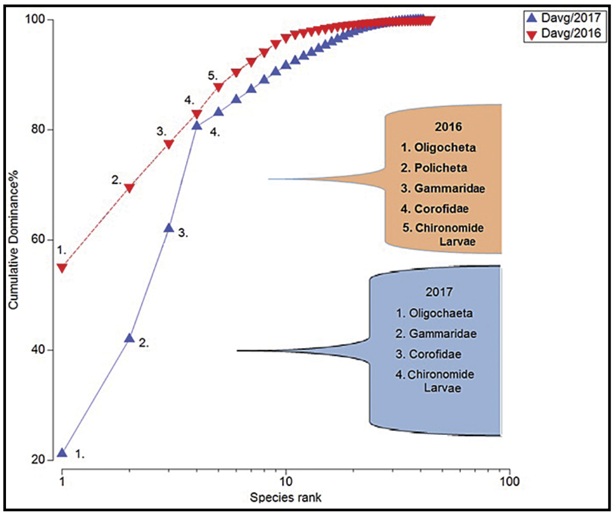

Fig. 3. The cumulative curve of the average density of benthic populations in the investigated area in 2016 and 2017.

The similarity indices Bray – Curtis, based on the presence – absence transformed abundance data of benthic species within stations displayed against the index of association of species showed that the euconstant taxa were oligochaetes, gammarids and Chironomidae larvae in 2016 and oligochaetes, gammarids, corophiids, the gastropod *Lithoglyphus naticoides* and Chironomidae larvae, in 2017 (Fig. 4 and 5).

Our results bring new evindences on the structure and biodiversity of the rectified meanders, confirming the results of other studies, which showed that the oligochaetes, chironomids, gasteropods and bivalves are the dominant taxa within the Danube Delta branches (Ignat *et al.*, 1997, Vădineanu *et al.*, 2000, Tudorancea and Tudorancea, 2006, Martinovič-Vitanovič *et al.*, 2013, Dobrin *et al.*, 2013, Atanackovič *et al.*, 2013).

These results evince a structure that is still influenced by the changes occurred in the years 80's - 90's, when a pronounced simplification of aquatic biocenoses was reported

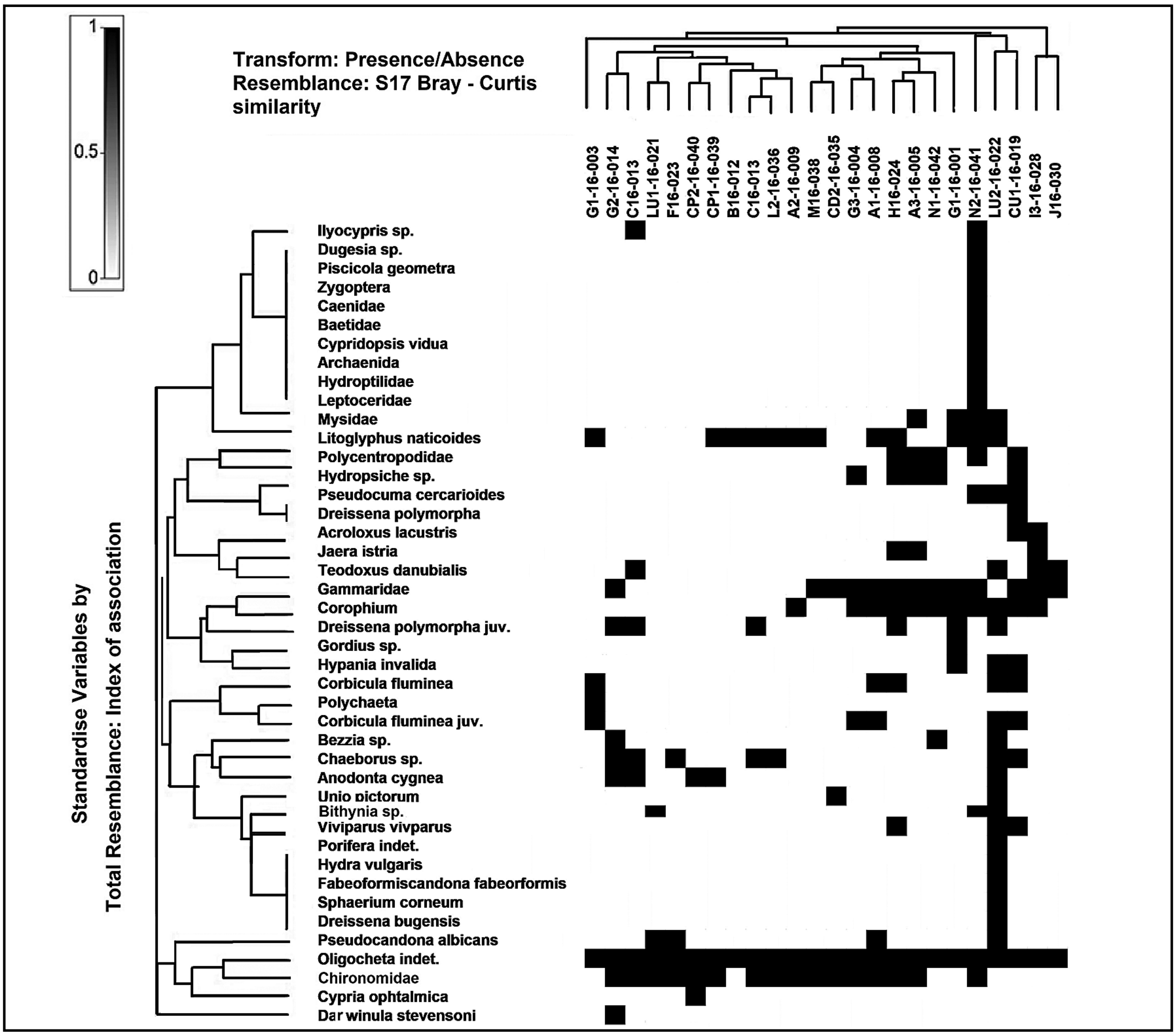

Fig. 4. The index of association between macrobenthic species (vertical) and the Bray-Curtis similarity (presence / absence data transformation) between stations (horizontally), in 2016.

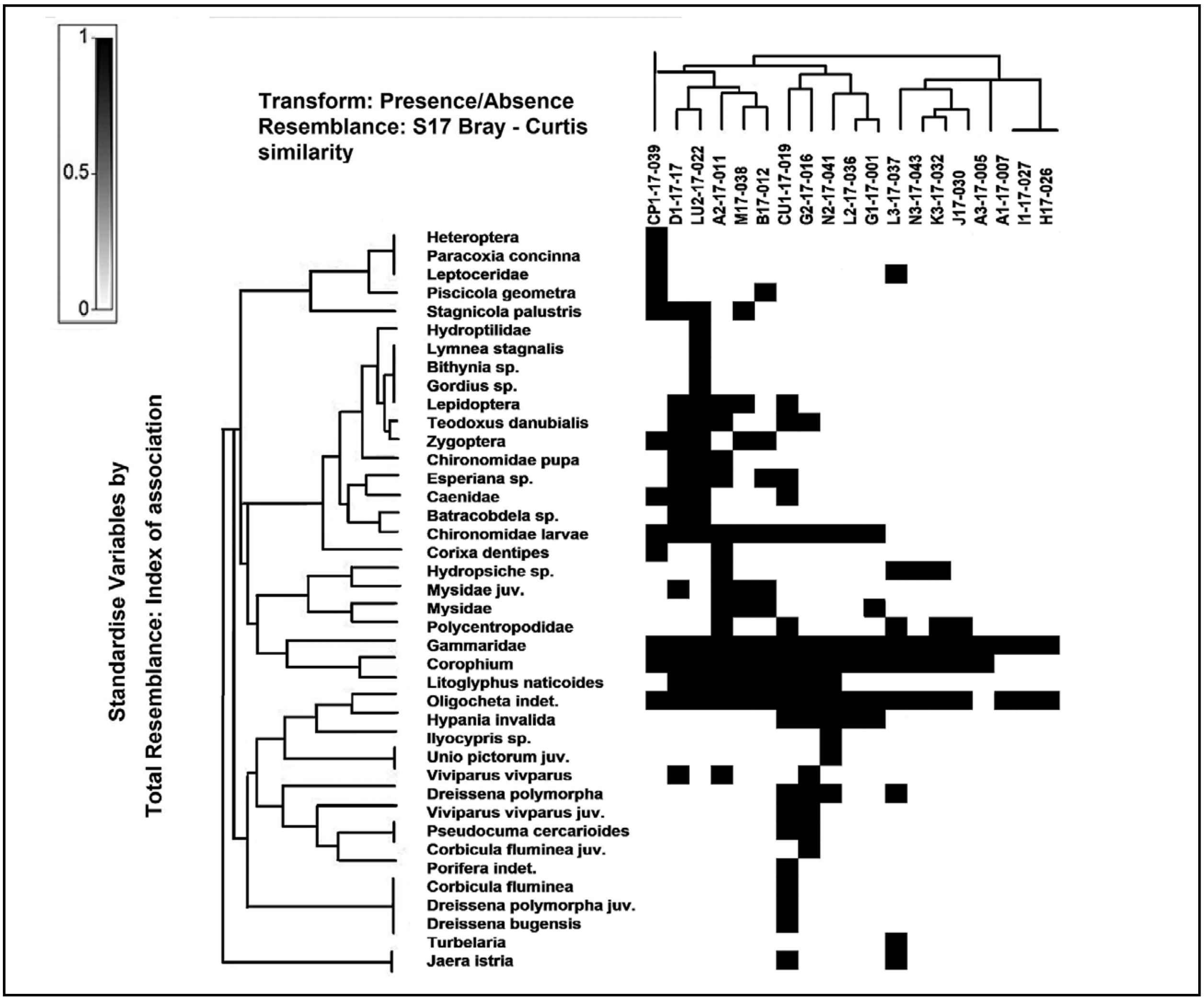

Fig. 5. The index of association between macrobenthic species (vertical) and the Bray-Curtis similarity (presence / absence data transformation) between stations (horizontally), in 2017.

(Rîşnoveanu, 1993; Ignat *et al.*, 1997; Stănescu *et al.*, 2013). After 2000's, a period of slightly restoration of the structure and composition of benthic invertebrate fauna was highlighted, in spite of the evidences of presence of some remnant pollutants both in water and sediments (Stoica *et al.*, 2014).

CONCLUSIONS

The total average density of invertabrates determined in the Sfantu Gheorghe rectified meanders area in September 2016 was eight times higher than in June 2017, as an effect of seasonal changes. Over the spring – autumn, the abundance of benthic organisms increases progressively. Hence, according to our results, the benthic communities recorded a maximum of abundance in autumn (481868 ind.m^{-2}), while in summer, the density was about eight times lower (58467 ind.m^{-2}). The greatest average densities of benthic fauna were recorded within the stations located on the natural meanders, while the minimum ones within the rectified channels, probably due to decreasing of water level and intensified decomposing processes within the water. However, the rectification of meanders, which led to increasing of shipping traffic as well as of touristic, have also greatly affected the benthic communities within these channels. (Jugaru Tiron *et al.*, 2009).

In 2016, the organisms with constant populations belonged to Oligochaeta and Chironomidae larvae and several pulmonary gastropods such as *Lymnea stagnalis, Planorbarius corneus*, and prosobranchs such as the genus *Viviparus sp*., especially abundant in the stations located in the Murighiol area, probably because of rich organic matter and epiphyton presence at the surface of the sediments. Their high densities could also be related to their preferences for the psammal substrate and their tolerance to a large variety of pollutants still remnant in the sediment and water (Stoica *et al.*, 2014; ICPDR, 2015). The highest values of the numerical density and diversity of benthic invertebrates were determined at the Uzlina Lake stations as well at the stations situated on the

Table 2. General characterization of the benthic populations in the area of the rectified meanders on the Sfantu Gheorghe branch 2016 – 2017

		2016							2017						
Crt. no.	Species	A	D %	Noc	F%	Davg	Deco	W	A	D %	Noc	F%	Davg	Deco	W
1.	*Porifera* indet.	56	0.01	1	4	2.24	56	0.21	44.4	0.076	1	5.26	2.34	44.4	0.63
2.	*Hydra* vulgaris	56	0.01	1	4	2.24	56	0.21	0	0	0	0	0	0	0
3.	*Gordius* sp.	56	0.01	1	4	2.24	56	0.21	214.6	0.36	1	5.26	11.29	214.6	1.38
4.	*Turbellaria*	0	0	0	0	0	0	0	66.6	0.11	1	5.26	3.50	66.6	0.77
5.	*Dugesia* sp.	112	0.023	1	4	4.48	112	0.30	0	0	0	0	0	0	0
6.	*Hypania invalida* Grube, 1960	9,352	1.94	3	12	374.08	3117.33	4.82	407	0.69	5	26.31	21.42	81.4	4.28
7.	*Polychaeta* indet.	69,888	14.50	1	4	2795.52	69888	7.61	0	0	0	0	0	0	0
8.	*Oligochaeta* indet.	265,440	55.08	23	92	10617.6	11540.87	71.18	12402.4	21.21	18	94.73	652.76	689.02	44.82
9.	*Piscicola geometra* Blainville, 1818	56	0.01	1	4	2.24	56	0.21	44.4	0.075	4	21.05	2.33	11.1	1.26
10.	*Batracobdella* sp. Viguier, 1879	0	0	0	0	0	0	0	44.4	0.075	2	10.52	2.33	22.2	0.89
11.	*Bithynia* sp. Leach, 1818	1064	0.22	3	12	42.56	354.66	1.63	155.4	0.26	1	5.26	8.17	155.4	1.18
12.	*Lithoglyphus naticoides* Pfeiffer, 1828	7280	1.51	12	48	291.2	606.66	8.51	1457.8	2.49	8	42.10	76.72	182.225	10.24
13.	*Acroloxus lacustris* Linnaeus, 1758	112	0.02	2	8	4.48	56	0.43	0	0	0	0	0	0	0
14.	*Theodoxus danubialis*	448	0.09	4	16	17.92	112	1.22	1087.8	1.86	5	26.31	57.25	217.56	6.99
15.	*Esperiana* sp. Bourguignat, 1877	0	0	0	0	0	0	0	340.4	0.58	5	26.31	17.915	68.08	3.91
16.	*Viviparus viviparus* Linnaeus, 1758	448	0.09	3	12	17.92	149.33	1.05	66.6	0.11	3	15.78	3.50	22.2	1.34
17.	*Viviparus viviparus* juv. Linnaeus, 1758	0	0	0	0	0	0	0	22.2	0.037	2	10.52	1.16	11.1	0.63
18.	*Anodonata cygnea* Linnaeus, 1758	336	0.069	5	20	13.44	67.2	1.18	0	0	0	0	0	0	0
19.	*Stagnicola palustris* juv. Jeffreys, 1830	0	0	0	0	0	0	0	488.4	0.83	4	21.05	25.70	122.1	4.19
20.	*Lymnea stagnalis* juv. Lamarck, 1799	0	0	0	0	0	0	0	81.4	0.13	1	5.26	4.28	81.4	0.85
21.	*Corbicula fluminea* O. F. Müller, 1774	1344	0.27	5	20	53.76	268.8	2.36	14.8	0.0	1	5.26	0.7	14.8	0.36
22.	*Corbicula fluminea* juv. O. F. Müller, 1774	12544	2.60	5	20	501.76	2508.8	7.21	7.4	0.0	1	5.268	0.34	7.4	0.25
23.	*Dreissena polymorpha* Pallas, 1771	392	0.08	1	4	15.68	392	0.57	377.4	0.64	4	21.05	19.86	94.35	3.68
24.	*Dreissena polymorpha* juv. Pallas, 1771	896	0.18	6	24	35.84	149.33	2.11	22.2	0.03	1	5.26	1.16	22.2	0.44
25.	*Dreissena bugensis*	56	0.01	1	4	2.24	56	0.21	37	0.06	1	5.26	1.94	37	0.57
26.	*Sphaerium corneum*	156	0.03	1	4	6.24	156	0.36	0	0	0	0	0	0	0
27.	*Unio pictorum* Linnæus, 1758	168	0.03	2	8	6.72	84	0.52	7.4	0.012	1	5.26	0.39	7.4	0.25
28.	*Darwinula stevensoni*	56	0.01	1	4	2.24	56	0.21	0	0	0	0	0	0	0
29.	*Cypria ophtalmica* Jurine, 1820	112	0.02	1	4	4.48	112	0.30	0	0	0	0	0	0	0

Table 2 (continued)

		2016							2017						
Crt. no.	**Species**	**A**	**D %**	**Noc**	**F%**	**Davg**	**Deco**	**W**	**A**	**D %**	**Noc**	**F%**	**Davg**	**Deco**	**W**
30.	*Ilyocypris* sp.	224	0.05	2	8	8.96	112	0.61	118.4	0.20	1	5.26	6.23	118.4	1.03
31.	*Cypridopsis vidua*	56	0.01	1	4	2.24	56	0.21	0	0	0	0	0	0	0
32.	*Fabaeformiscandona fabaeformis*	56	0.01	1	4	2.24	56	0.21	0	0	0	0	0	0	0
33.	*Cypria ophtalmica*	56	0.01	1	4	2.24	56	0.21	0	0	0	0	0	0	0
34.	*Pseudocandona albicans*	8344	1.73	4	16	333.76	2086	5.26	0	0	0	0	0	0	0
35.	*Gammaridae* Leach, 1813	26264	5.45	13	52	1050.56	2020.31	16.83	12180.4	20.83	19	100	641.07	641.07	45.64
36.	*Corophium* Latreille, 1806	23632	4.9	11	44	945.28	2148.36	14.68	11684.6	19.98	16	84.21	614.97	730.28	41.02
37.	*Jaera istri* Valkanov, 1936	336	0.07	3	12	13.44	112	0.91	503.2	0.86	2	10.52	26.48	251.6	3.00
38.	*Pseudocuma cercarioides* Sars, 1894	560	0.12	3	12	22.4	186.66	1.18	22.2	0.03	2	10.52	1.16	11.1	0.63
39.	*Mysidae*	504	0.10	4	16	20.16	126	1.29	303.4	0.51	4	21.05	15.96	75.85	3.30
40.	*Mysidae* juv.	0	0	0	0	0	0	0	1346.8	2.3	4	21.05	70.88	336.7	6.96
41.	*Arachnida* Cuvier, 1812	56	0.01	1	4	2.24	56	0.21	22.2	0.03	1	5.26	1.168	22.2	0.44
42.	*Baetis* sp. Leach, 1815	112	0.02	1	4	4.48	112	0.30	0	0	0	0	0	0	0
43.	*Caenidae* Stephens, 1835	1344	0.27	1	4	53.76	1344	1.05	259	0.4	4	21.05	13.63	64.75	3.0
44.	*Hydropsiche* sp.Curtis, 1835	3080	0.63	5	20	123.2	616	3.57	991.6	1.695	4	21.05	52.18	247.9	5.97
45.	*Polycentropodidae* Ulmer, 1903	5264	1.09	5	20	210.56	1052.8	4.67	310.8	0.53	5	26.31	16.35	62.16	3.74
46.	*Leptoceridae* McLachlan, 1865	280	0.05	1	4	11.2	280	0.48	96.2	0.16	2	10.52	5.06	48.1	1.31
47.	*Hydroptilidae* Dalman, 1819	952	0.19	1	4	38.08	952	0.88	392.2	0.67	1	5.26	20.64	392.2	1.87
48.	*Zygoptera* Sélys, 1854	1120	0.23	1	4	44.8	1120	0.96	222	0.37	5	26.31	11.68	44.4	3.16
49.	*Chironomidae* Larvae	38416	7.97	16	64	1536.64	2401	22.58	10885.4	18.61	11	57.89	572.91	989.58	32.83
50.	*Chironomidae* pupa	0	0	0	0	0	0	0	873.2	1.49	3	15.78	45.95	291.06	4.85
51.	*Lepidoptera*	0	0	0	0	0	0	0	673.4	1.15	5	26.31	35.44	134.68	5.50
52.	*Corixa dentipes* Geoffroy, 1762	0	0	0	0	0	0	0	88.8	0.15188	2	10.5	4.67	44.4	1.26
53.	*Paracoxia concinna* Fieber, 1848	0	0	0	0	0	0	0	7.4	0.01	1	5.26	0.389	7.4	0.25
54.	*Heteroptera*	0	0	0	0	0	0	0	96.2	0.16	1	5.263	5.06	96.2	0.93
55.	*Bezzia* sp.	336	0.0	3	12	13.44	112	0.91	0	0	0	0	0	0	0
56.	*Chaoborus* sp.	448	0.0	7	28	17.92	64	1.613	0	0	0	0	0	0	0

A - Abundence (ind/m^2), **D%** - dominance, **Noc** - number of occurences, **F%** - frequency, **Davg** - average density, **Deco**- ecological density, **W**- ecological significance index "small M from Dunavat" meander, where crustaceans, gastropods and chironomidae larvae dominated.

Overall, taking into consideration the relatively high diversity of 56 species, comparable with that reported by other authors in the area (Stoica *et al.*, 2012, 2013) and the high abundances of groups such as crustaceans, gastropods and bivalves, the dynamic of the benthic populations both in September 2016 and June 2017 in the study area can be considered in accordance with the positive tendency recorded by several studies in the recent period that attest a slightly recovery process (IGCPR, 2008, 2015). However, attention should be drawn on the dominance of halophilous crustaceans *D. haemobaphes, D. villosus, Obesogammarus obesus, Echinogammarus trichiatus, E. ischnus, Chelicorophium curvispinum,* of polychaete *Hypania invalida,* the Ponto-Caspian species that have become highly invasive in other basins in the last decades, especially due to ship traffic. Anyway, the Danube and its reaches are also exposed to non-native species, 34 non-native aquatic macroinvertebrates being recorded in 2015 (Joint Danube Survey 3 report, 2015). Species like *C. fluminea,* for the first time reported in the Romanian Danube part in 1999 (Bij de Vaate and Hulea, 2000) and in the Romanian sector of the Danube Delta in the winter of 1997 (Skolka and Gomoiu, 2001), was rarely present in the study area, but it is still very abundant in the main Danube stream and its tributaries as well as in the delta, where can reach hundreds to thousands of individuals per square meter (Hubenov *et al.*, 2013).

ACKNOWLEDGEMENTS

The authors thank the project PN16.45.05.03 "The complex qualitative and quantitative assessment of the ecological changes caused by the rectification of the Sfantu Gheorghe meanders and the elaboration of a program of environmental rehabilitation measures" carried out by the NIRD GeoEcoMar, for the financial support. I thank my colleagues Adrian Teaca for helping me in identifying crustacean species and Adrian Popa for the map. The authors also thank the anonymous reviewers for all suggestions provided for improving the manuscript.

REFRENCES

Atanackovič, A.D., Špoka, F., Csányi, B., Vasiljević, B.M., Tomović, J.M., Paunivić, M.M, 2013. Oligochaeta of the Danube River-a faunistical review, *Biologia*, **68**(*2*):269-377.

Bij de Vaate, A., Hulea O., 2000. Range extension of the Asiatic clam *Corbicula fluminea* (Müller 1774) in the River Danube: first record from Romania, *Lauterbornia* **38**:23-26, Dinkelscherben.

Clarke, K., R., and Gorley, R., N., 2006. PRIMER V6: user manual-tutorial, *Plymouth Marine Laboratory*, 190 p.

Coops, H., Doef, R.W., 1996. Submerged vegetation development in two shallow, eutrophic lakes. *Hydrobiologia* **340**:115–120.

Covaliov, S., Van Geest, G., Hanganu, J., Hulea, O., Török, L., Coops, H., 2003. Seasonality of macrophyte dominance in flood-pulsed lakes of the Danube Delta". *Hydrobiologia* **506-509**:651-656*, The Netherlands*.

Dobrin, I., Săndulescu, E.B., Stavrescu-Bedivan, M-M., 2013. Summer field trip to Sfântu Gheorghe Branch at Ilganii de Jos (Tulcea County, Romania): a naturalistic approach, *AgroLife Scientific Journal*, **2**(*2*):79-82.

Florescu, L. I., Parpală, L., Dumitrache, A., Moldoveanu, M., 2013. Spatial and temporal distribution of the zooplankton biomass in Sfântu Gheorghe branch (the Danube Delta, Romania) in relation to environmental factors, *Travaux du Muséum National d'Histoire Naturelle «Grigore Antipa»*, **LVI** (*1*): 109-124.

Gheorghe, A., Roberts, T. E., Ives, J. C., Fletcher, B. R., Calvert, M., 2013. Centre Selection for Clinical Trials and the Generalisability of Results: A Mixed Methods Study, *PLoS ONE* 8(2): e56560. https://doi.org/10.1371/journal.pone.0056560.Giosan, L., Coolen, M., J. L., Kaplan, O.J., 2012. Early anthropogenic transformation of the Danube-Black Sea System, *Scientific Reports*, **2**:582.

Godeanu, S. (2002). Continental waters, overview, In: S. P. Godeanu (ed.) The diversity of the living world. Illustrated Identification Manual of the Flora and Fauna of Romania, pp. 1-24, Bucura Mond Publishing, ISBN 973-98248-5-4, Bucharest (in Romanian).

Hammer, Ø., Harper, D.A.T., Ryan, P.D., 2001. Past: Paleontological Statistics Software Package for Education and Data Analysis, *Palaeontologia Electronica*, vol. **4**, issue *1*, art. 4: 9, 178kb. http://palaeo-electronica.org/2001_1/past/issue1_01.htm.

Hubenov, Z., Trichkova, T., Kenderov, L., Kozuharov, D., 2013. Distribution of *Corbicula fluminea* (Mollusca: Corbiculidae) over an Eleven-Year Period of its Invasion in Bulgaria, *Acta Zoologica Bulgarica*, **65**(*3*): 315-326.

Humborg, C., Ittekot, V., Cosiascu, A. and Bodungen, B.V., 1997. Effect of Danube River dam on Black Sea biogeochemistry and ecosystem structure, *Nature*, 386, 385–388.

ICPDR, 2008. Joint Danube Survey 2, Final Scientific Report, 242 p.

ICPDR, 2015. Joint Danube Survey 3, A Comprehensive Analysis of Danube Water Quality, 369 p.

Ignat, G., Cristofor, S., Angheluță, V., Rîşnoveanu, G., Nafornița, G., Florescu, C., 1997. Structure and dynamics of benthic fauna in Danube Danube and Danube Delta, *Scientific Annals of the Danube Delta Research and Design Institute*, **IV** (*1*): 133-142.

Jugaru Tiron, L., Le Coz, J., Provansal, M., Panin, N., Raccasi, G., Dramais, G., Dussouillez, P., 2009. Flow and sediment processes in a cutoff meander of the Danube Delta during episodic flooding, *Geomorphology*, **106** :186–197.

Martinovic-Vitanovic, V.M, Rakovic, M.J., Popovic, N.Z., Kalafatic, V.I., 2013. Qualitative study of Mollusca communities in the Serbian Danube stretch (river km 1260-863.4), *Biologia*, **68**(*1*):112-130.

Pora, E.A., Oros, I., 1974. Limnology and Oceanology, Hydrobiology, *Didactic and Pedagogical Publishing,* 423 pp.

Rîșnoveanu, G., 1993. The role of benthic oligochetes in aquatic ecosystems in advanced eutrophic phases, *Nature and Environment Protection*, **37**(*1*):19-24.

Schleuter A and Schleuter, M, 1995. *Jaera istri* (Veuille) (Janiridae, Isopoda) erreicht uber den Main – Donau-Kanal den Main, *Lauterbornia*, **33**:125-127.

Sebestyén, O., 1938. Colonization of two new fauna-elements of Pontus origin (*Dreissensia polymorpha* Pall. and *Corophium curvispinum* G. O. Sars forma devium Wundsch) in Lake Balaton. Int. Assoc. Theor. Appl. Limnol. **VIII** (*III*):169-182.

Skolka, M., Gomoiu, M.-T., 2001. Alien invertebrates species in Romanian waters, *Ovidius University, Annals of Natural Sciences, Biology Ecology Series*, **5**: 51-55.

Stanescu, E., Stoica, C., Vasile, G., Petre, J., Gheorghe, S., Paun, I., Lucaciu, I., Nicolau, M., Vosniakos, F., Vosniakos, K., Golumbeanu, M., 2013. Structural changes of biological compartments in Danube Delta systems due to persistent organic pollutants and toxic metals, in: *Environmental Security Assessment and Management of Obsolete Pesticides in South-East Europe*, NATO Science for Peace and Security Series C: Environment Security, L.I. Simeonov, F.Z. Macaev, B.G. Simeonova (Eds), Springer Science+Business Media Dordrecht, **21**:229-248.

Stoica, C., Lucaciu, I., Nicolau, M., Vosniakos, F., 2012. Monitoring the ecological diversity of the aquatic Danube Delta systems in terms of spatial temporal relationship, *Journal of Environmental Protection and Ecology*, **13**(*2*), 476-485.

Stoica, C., Stanescu, E., Lucaciu, I., Gheorghe, S., Nicolau, M., 2013. Influence of global change on biological assemblages in the Danube Delta, *Journal of Environmental Protection and Ecology*, **14**(*2*), 468-479.

Stoica, C., Gheorghe, S., Petre, J., Lucaciu I., Nita-Lazar, M., 2014. Tools for assessing Danube Delta systems with macroinvertebrates*, Environmental Engineering and Management Journal*, **13**(*9*), 2243-2252.

Tittizer, T., (1997). Ausbreitung aquatischer Neozoen (Makrozoobenthos) in den europäischen Wasserstrassen, erläutertam Beispiel des Main-Donau-Kanals. *Schriftenreihe des Bundesamtes für Wasserwirtschaft*, **4**: 113–134.

Tudorancea, C., Tudorancea, M.M., 2006. Danube Delta, Genesis and Biodiversity, Backhuys Publishers, 443 pp.

Vădineanu, A., Cristofor, S., Ignat, G., Ciubuc, C., Rîșnoveanu, G., Bodescu, F., Botnariuc, N., 2000. Structural and Functional Changes within the Benthic Communities of Danube Delta Lakes, *Verh. Internat. Vercin. Limnol.*, **27**(*5*): 251-257.

Van der Velde, G., Rajagopal, S., Kelleher, B., Musko, Bij de Vaate, A., 2000. Ecological impact of crustacean invaders: general considerations and examples from the River Rhine, *Crustacean Issues*, **12**:3-33.

Vosniakos, F., Pascu, L., Petre, J., Cruceru, L., Vasile, G., Iancu, V., Dinu, C., Niculescu, M., Niculae, A., Nicolau, M., Golumbeanu, M., 2012. The temporal and spatial monitoring of water and sediment physical-chemical quality from Sfantu Gheorghe Branch in the period February 2009 - February 2011, *Fresenius Environmental Bulletin*, **21**(*2*), 233-245.

Vosniakos, F., Vasile, G., Petre, J., Cruceru, I., Nicolau, M., Mitrita, M., Iancu, V., Cruceru, L., 2008. The evolution of the physical-chemical quality state of the Danube Delta aquatic ecosystem in the period May-October 2005/2006, *Fresenius Environmental Bulletin*, **17**(*2*):142-153.

http://www.ddbra.ro/en/danube-delta-biosphere-reserve/danube-delta/location

SR EN ISO 5661-1:2008. Water quality. Part 1: General guidelines for establishing sampling programs and techniques.

SR EN ISO 16150:2012. Water quality - Guidance on pro-rata Multi-Habitat sampling of benthic macro-invertebrates from wadeable rivers.

SR EN ISO 8689-1. Water quality. Biological classification of rivers. Part 1: Guidance on the interpretation of biological quality data from surveys of benthic macroinvertebrates.

SR EN ISO 8689-2. Water quality. Biological classification of rivers. Part 2: Guidance on the presentation of biological quality data from surveys of benthic macroinvertebrates.

SR EN ISO 10870:2012. Water quality - Guidelines for the selection of sampling methods and devices for benthic macroinvertebrates in fresh waters.