THE STRUCTURE AND DYNAMICS OF *CLADOCERA* IN THE YUGOSLAVIAN SECTION OF THE RIVER TISZA

R. Ratajac

Ratajac, R. (1992): The structure and dynamics of **Cladocera** *in the Yugoslavian section of the river Tisza. - TISCIA 26,59-61.*

Abstract. The structure of *Cladocera* fauna was investigated in the period 1981-1988 at five localities of Tisza from the Hungarian border up to its mouth into Danube in seasonal intervals. In the investigated period, a total number of 22 *Cladocera* species were ascertained. With regard to qualitative structure and number of species, differences were noticed between seasons and particular years investigated. When seasonal variations are in question, the lowest number of species was found in winter, than in spring and summer, while the highest number was observed in autumn. The number of species was the highest during summer only in the years 1982 and 1988. *Alona quadrangularis, Bosmina longirostris, Chydorus sphaericus* and *Moina micrura* species were present in all seasons. *Diaphanosoma brachyurum* had the highest frequency in the warmer period of the year. Other species appeared in small number of samples and as individual samples. The highest number of species was recorded in the year 1983 (13), and the lowest in the years 1981 and 1985 (7).

Keywords: annual variation, **Cladocera**, *community structure, seasonal variation.*

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Introduction

This paper presents results of the investigation of seasonal and annual changes of *Cladocera* species in the river Tisza. This group was not much investigated (Kalafatic et al., 1982; Pujin et al., 1984), neither much attention was paid to it. For this reason, we considered it as interesting to give a synthesis of our many years' study on the *Cladocera* group in Tisza, which were conducted within the frame of the complex community ecology researches of the river Tisza.

Material and methods

Material was collected along Tisza during eight years (1981-1988) at 5 localities: Martonos, Padej, Novi Becej, Zabalj and Titel. Sampling was done in seasonal intervals in all localities, it was more frequent only in Tisza near Martonos. Total of 200 samples was elaborated. Standard methods were used for sampling and treatment of the material. Investigations were done in Institute of Biology in Novi Sad.

Results and discussion

A total of 22 *Cladocera* species was collected. The highest number of species was found in the year 1983 (13), and the lowest number in the years 1981 and 1985 (7), (Tab 1). Regarding seasonal variations, the highest number of species was in autumn, whereas the lowest number was in winter as a rule. The number of species was the highest during summer only in the years 1982 and 1988 (Fig. 1). The species *Bosmina longirostris, Chydorus sphaericus* and *Moina micrura* were represented in all seasons and each investigated year, while *Alona quadrangularis* was represented in all seasons. The species *Diaphanosoma brachiurum* was frequently present in the warmer period of the year. These species were also most frequent in samples, together with *Daphnia longispina* and *D. cucullata.* Other species appeared in few samples or in certain period of the year and with fewer individuals. We can say that these came into Tisza from surrounding terrains, since they are characteristic for smaller water basins, floody surfaces and more polluted waters.

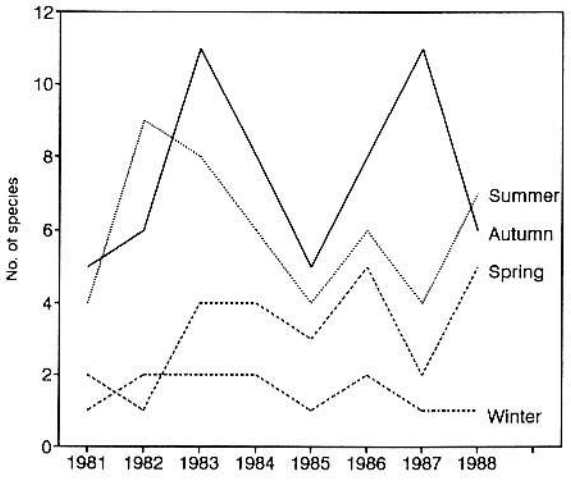

Fig. 1. Number of *Cladocera* species in the river Tisza.

The phytophyllous species *Acroperus harpae* was recorded only in 2 investigated years, as well as *Daphnia pulex* and *Moina brachiata* characteristic for eutrophic waters. The species *Macrothrix laticornis* and the representatives of the genus *Scapholeberis*, characteristic for the littoral zone and benthos, were represented only in few samples and in small number of individuals. All other species (Tab. 1) were found rarely and never as dominant, were found in this investigation of Tisza as individual samples and in small number of samples.

Kalafatic et al. (1982) recorded a very small population density in spring, when the water level of Tisza was high, only for three species of *Cladocera*. Out of these species *B. longirostris* and *D. longispina* were also frequently present in our samples, whereas the species *Alonella nana* Baird was not observed in our investigations.

In the work of Pujin et al. (1984), 7 *Cladocera* species were recorded in the lower flow of Tisza, out of which 6 are recorded also in this present work.

In the investigations of Pujin et al. (1986) in Carska bara which is linked with Tisza, 12 *Cladocera* species were recorded. Out of them, 9 were recorded also in our researches of Tisza.

It is interesting to compare the structure of *Cladocera* in Tisza and in Dead Tisza which is a stagnant tributary of river Tisza and is in connection with the main flow. In their investigation of zooplankton in Dead Tisza, Pujin and Ratajac (1988) registered 14 species of *Cladocera*, out of which 12 were common for both water basins.

Ratajac (1989) investigated *Cladocera* in Dead Tisza registering 19 species, out of which 16 were common for both water basins. All these results show a great dependence of the *Cladocera* fauna on smaller water basins in the region of Tisza. The same species were dominant in Dead Tisza and Tisza, and they also had very similar frequency of appearance in samples and population density. The large number of species in Tisza can be explained by their arrival through confluences at surrounding terrains.

It can be said that *Cladocera* in Tisza represented by the number of species, but not by population density, take an important place in the zooplankton of this water basin.

Conclusion

Within the frame of complex biocenological researches of the river Tisza, special attention was paid to the structure of *Cladocera* fauna in this work.

Period of 1981-1988 was included, and five localities in Tisza starting from the Hungarian border up to the mouth of Tisza into Danube. A total of 22 *Cladocera* species were registered.

Seasonal variations and a different number of species in different investigation years were ascertained. The highest number of species were ascertained in the year 1983 (13), the lowest number in the years 1981 and 1985 (7). The highest number of species was recorded in autumn, than in summer and spring and the minimum during winter.

There were recorded species *Alona quadrangularis, Bosmina longirostris, Chydorus sphaericus* and *Molina micrura* in all seasons, while *Diaphanosoma brachyurum* appeared more frequently in the warmer period of the year. These species were also most frequent in samples, and also species *Daphnia longispina* and *D. cucullata.*

Other species appeared more rarely in a definite period of the year and as individual samples. In this group, there are phytophyllous species *Acroperus harpae, Daphnia pulex* and *Moina brachiata* characteristic for eutrophic waters, as well as species *Macrothrix laticornis* and the representatives of the genus *Scapholeberis*, characteristic for littoral and benthos.

Table 1. Species composition of *Cladocera* in the Tisza

Cladocera	1981	1982	1983	1984	1985	1986	1987	1988
Acroperus harpae (Baird)			x					x
Alona costata Sars		x				x	x	x
A.quadrangularis (O.F.Müll.)	x	x	x	x	x	x		
A.rectangula Sars							x	x
Alonella excisa Fischer				x	x	x		
Bosmina coregoni Baird			x					
B.longirostris (O.F.Müll.)	x	x	x	x	x	x	x	x
Ceriodaphnia quadrangula (O.F.Müll.)		x			x			
Chydorus sphaericus O.F.Müll.	x	x	x	x	x	x	x	x
Daphnia cucullata Sars	x	x	x	x		x	x	x
D.longispina O.F.Müll.	x	x	x	x		x	x	x
D.hyalina Leydig							x	
D.pulex Leydig.em.Scourfield		x	x					
Diaphanosoma brachyurum (Liev.)		x	x	x	x		x	x
Leydigia leydigii (Schoedler)			x	x			x	
Macrothrix laticornis (Jurine)			x	x			x	
Moina micrura Kurz	x	x	x	x	x	x	x	x
M.brachiata (Jur.)			x	x				
Pleuroxus truncatus (O.F.Müll.)							x	
P.uncinatus Baird								x
Scapholeberis kingi sars	x	x				x		
S.mucronata (O.F.Müller)						x		
total:	7	11	13	11	7	10	12	10

The names of all species are given according to the latest key by Margaritora (1985).

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A SECOND DISCOVERY OF *SCENEDESMUS GRAHNEISII* (HEYNIG) FOTT IN HUNGARY

A. Schmidt

Schmidt, A. (1992): A second discovery of ***Scenedesmus grahneisii*** *(Heynig) Fott in Hungary. - TISCIA 26,63-65.*

Abstract. This paper presents environmental and water chemical data from the second Hungarian discovery of the chlorococcal alga, *Scenedesmus grahneisii* (Heynig) Fott. Dimensions and morphological characteristics of the cells and coenobia are the same, as given in the literature.

Keywords: ***Didymocystis****, distribution,* ***Scenedesmus****, taxonomy, water quality.*

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Introduction

The basionym of *Scenedesmus grahneisii* is *Didymocystis grahneisii*, which was described by Heynig (1962). This taxon also includes *Didymocystis comasii* Kom. (Hegewald and Silva, 1988). Previous discoveries identified two celled and four celled coenobia coexisting in the same sample (Fott, 1973; Hindák and Klasová, 1974; Schmidt and Uherkovich, 1976; Uherkovich and Rai, 1977; Tsarenko, 1990). Fott (1973) corrected the name from *Didymocystis grahneisii* to *Scenedesmus grahneisii*. The early data about *Scenedesmus grahneisii* were mainly from Middle Europe: Germany (Heynig, 1962, 1984; Krienitz, 1984, 1988), Switzerland (Fott, 1973), Slovakia (Hindák and Klasová, 1974; Hindák and Holod, 1983), Hungary (Schmidt and Uherkovich, 1976; Schmidt 1978) and Ukraine (Tsarenko, 1990). This alga has also been discovered outside of Europe in both Cuba (Komarek and Fott, 1983) and Africa (Uherkovich and Rai, 1977).

The first Hungarian discovery occurred in a shallow lake (Vadkerti-tó), on the Great Hungarian Plain, between the rivers Danube and Tisza. The characteristic chemical data of this water were: pH 8.5, salt content 785 mg/dm^3, dominant ions Mg^{2+} and HCO_3^-. About half of the coenobia was two celled, while the other half was four celled (Schmidt and Uherkovich, 1976).

Two other, very similar taxa have been found in Hungary. They were described as *Scenedesmus berczikii* Hortob. from the Danube river at Budapest (Hortobágyi, 1975) and *Scenedesmus grahneisii f. crassicostatus* A. Schmidt (instead of "*crassicostata*", see Schmidt, 1978; Hegewald and Silva, 1988) from the shallow lake Vadkerti-tó. Both of which may be synonyms of *Scenedesmus grahneisii*, because these new taxa differ only by their shield-like, scabrous thickening (Hegewald and Silva, 1988).

However, Uherkovich (1992) in a recent manuscript has published that these three taxa are valid.

Methods

Water samples were collected for chemical and microscopic studies from the backwaters of the river Tisza at the village Tiszadob (504 river km). These backwaters are located in an environmental protection area, called "Tiszadob Nature Reserve" (Lakatos, 1991).

The samples were collected twice on the 17th and 29th October, 1992. These samples were drawn from each end of the Malom-Tisza (Fig. 1.). We followed the Hungarian Standards for determining the chemical parameters. Conductivity, pH, dominant ions, nutrient ions and chemical oxygen demand (COD) were measured.

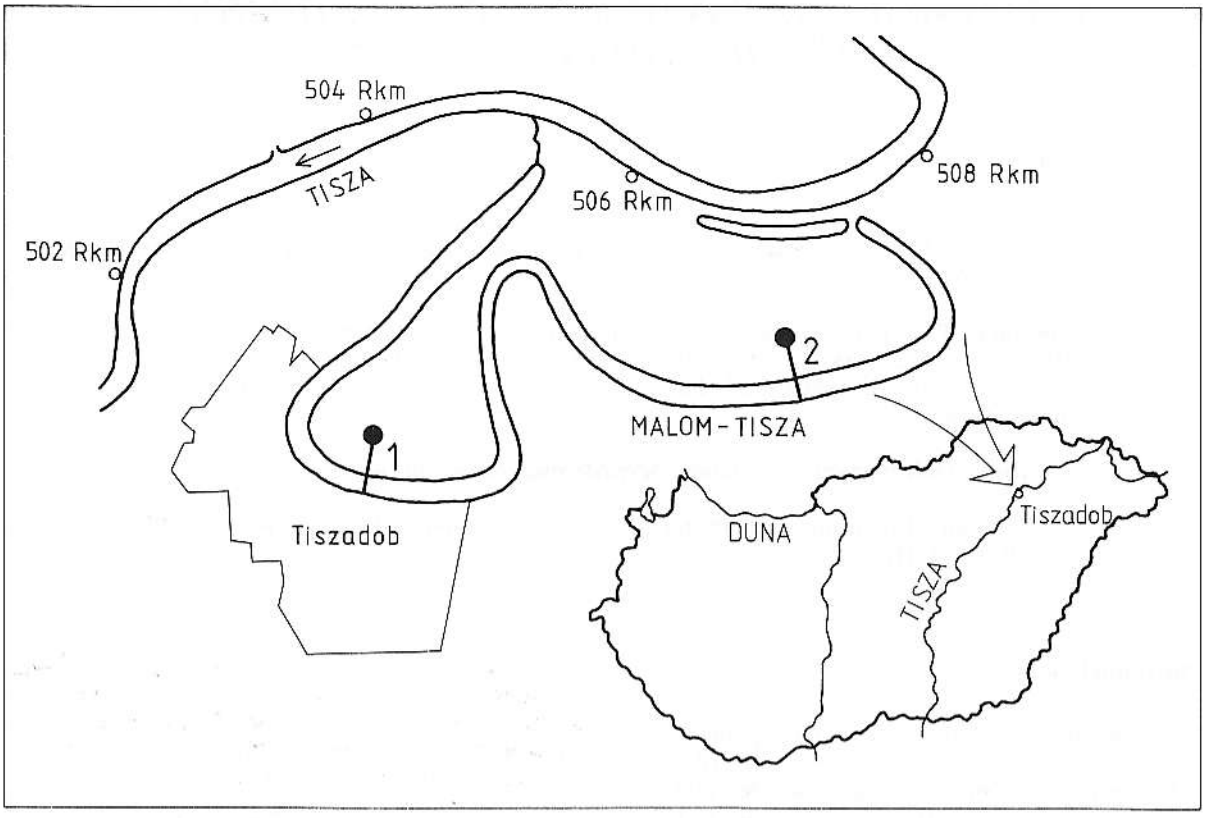

Fig. 1. Map of the backwaters at Tiszadob

Discussion

The results of the chemical data analysis show, that the water quality is similar at both ends of the Malom-Tisza. Based on the conductivity data (Table 1.) it is a middle sort fresh water (beta-alfa oligohalobic class, see Felföldy, 1987 p. 25). The dominant ions are Ca^{2+}, Mg^{2+} and HCO_3^-. The level of the nutrient material for plant organisms (NH_4^+, NO_3^-, PO_4^{3-}) is very low (Table 1.) The inorganic data show that this water is of medium quality.

The organic materials, based on COD-$K_2Cr_2O_7$ data show a higher level, in spite of the fact that waste water is not discharged into this backwater. The relationship between COD-$K_2Cr_2O_7$ and COD-$KMnO_4$ may indicate humin materials in the water.

The phytoplankton assemblage shows a high diversity with many thriving taxons. *Chlorococcales* greenalgae and the bluegreen species *Oscillatoria limnetica* Lemm. and *Lyngbya limnetica* Lemm. are of the highest cell number in the community.

Scenedesmus grahneisii was found in our samples with both two and four celled coenobia (cca. 50-50 %). Cell dimensions: 6-9 x 2.5-3.5 μm. Coenobium dimensions two celled: 6-9 x 5-7.5 μm, four celled: 8-11 x 12-13 μm. These cell dimensions are the same, as given in the literature, also there were no morphological aberrations observed.

Acknowledgment

The author thanks Miss Anikó Huszti for collecting the samples and Mr Xavier Morales for helping with the translation.

Table 1. Water chemical characteristics at two sample sites of Malom-Tisza (29th October, 1992)

		1.	2.
Ca^{2+}	mg/dm^3	37	35
Mg^{2+}	"	21	21.5
Na^{+}	"	30	30
K^{+}	"	15	16
CO_3^{2-}	"	0	0
HCO_3^{-}	"	200	200
Cl^{-}	"	60	60
SO_4^{2-}	"	11	10
NH_4^{+}	"	0.6	0.65
NO_3^{-}	"	0.4	0.35
PO_4^{3-}	"	0.01	0.01
pH		7.8	7.8
Conductivity	μS	494	463
COD-$KMnO_4$	mg/dm^3	9.7	11
COD-$K_2Cr_2O_7$	"	48	47

Fig. 2. *Scenedesmus grahneisii* (Heynig) Fott from the backwater at Tiszadob

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FOOD ANALYSIS OF SOME *RANA* SPECIES IN THE HABITAT OF CARSKA BARA (YU)

E. Popovic, S. Simic and B. Tallósi

*Popovic, E., Simic, S. and Tallósi, B. (1992): Food analysis of some **Rana** species in the habitat of Carska Bara (YU). - TISCIA 26,1-3.*

Abstract. The analysis of stomach content was done for following species: *Rana kl. esculenta* L., *R. lessonae* Camerano and *R. ridibunda* Pallas. It was found that these species feed on different groups of invertebrates (*Crustacea*, *Arachnida, Insecta, Myriapoda, Gastropoda* and *Bivalvia*). Quantitative and qualitative composition of food shows that insects are predominant.

*Keywords: Carska bara (YU), feeding, **Rana** species*

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Introduction

Frogs are significant members of food webs in aquatic habitats. *Rana ridibunda* inhabits the whole territory of the former Yugoslavian countries, while species *R. kl. esculenta* and *R. lessonae* are characteristic only for northern parts of the Balkan peninsula (Radovanovic, 1951; Engelmann et al. 1985). They live in all types of aquatic habitats (ponds, lakes, fish ponds, backwaters, rivers), or in their vicinity. They are representatives of lowland species except of *R. ridibunda* which is quite often found on hills and mountains up to 2500m altitude. They rise from hibernation at the beginning of March and April, and their reproduction season is during the first half of April and May (Radovanovic, 1951; Engelmann et al, 1985). They are voracious species, active both during daylight and night. Edible and marsh frogs hibernate in the mud of aquatic habitats; while the pool frog hibernates in land (Arnold and Burton, 1978; Engelmann et al, 1985).

Concerning the feeding of *Rana* species, the formerly Yugoslavian literature contains only preliminary reports (Popovic and Mikes, 1989) related to Koviljski meadow. Having in mind the importance of this problem and the insufficient studies, we have tried to contribute for its better understanding.

Methods

The quantitative analysis of frogs feeding was carried out in a sample of 32 individuals (*R. kl. esculenta*: 23 specimens; *R. lessonae*: 7 specimens and *R. ridibunda*: 2 specimens). Although the sample was small, obtained results were relevant because they represented the first data of this kind not only for Carska bara, but for whole area of formerly Yugoslavia. Beside that, all kinds of green frogs are protected as rare species with limiting catch permission. Accidental sample points to natural relations in representation of certain types, showing both fauna conditions of given habitat and its other ecological characteristics. They were collected in the region of Carska bara (near the Tisza) during July, 1990 at the forest edge dominated by flotant vegetation. Frogs were caught by nets and fish hooks during the period of their greater activity, from 9 a.m. to 4 p.m. Collected specimens were determined to the level of species (Engelmann et al. 1985). Sex and age were also defined. Biometrics data were also taken. After dissection, stomach contents were put into test tubes containing 70% alcohol. Stomach content determination was made according to the classification of Schmidt (1970) and Kerovec (1986).

Certain characteristics of investigated area

Carska bara presents an inundated area of the river Tisza around the mouth of the river Begej. On the right side of Carska bara, there is a fish pond surrounded by agrobiocenoses. It is situated behind the protection embankment. Around it, there is a marshy forest association *Saliceto-Populetum nigrae*; a swampy association of *Scirpo-Phragmitetum* is spreading in front of it. Floating association of *Nymphaeetum albo-luteae* and submersed *Myriophyllo-Potametum* are predominant along the shore of the pond. This kind of area offers suitable conditions for survival and development of heterogeneous fauna.

Results and discussion

Rana species are abundant and widely spread group of amphibians in Vojvodina. That is the reason generally they have an important role in the nature and especially in the population regulation of other animals they feed on. Performed under the international project "Exploration of the River Tisza", a new study about the feeding of these species has been initiated.

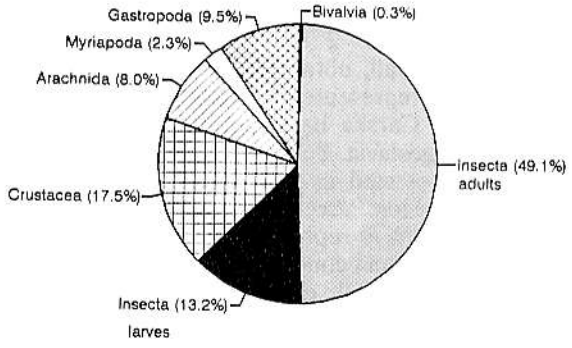

Fig. 1. Food contents of analyzed frog species.

Quantitative and qualitative composition of food shows that insects are predominant in the food of Rana species. The insects were represented with 171 (49.1%) adult forms (Fig. 1.). Beside adults, insect larvae with 46 specimens (13.2%) were also found, making a total of 62.3% food quantity. The species of the family *Formicidae (Hymenoptera)* were the most represented among insects. This is partly conditioned by a selective preference for the prey in question. At the same time it points out also the specificity of biocenotic components of the analyzed biotop. Other classes of invertebrates had a following share in food contents: *Crustacea* 17.5%; *Arachnida* 8%; *Myriapoda* 2.3%; *Gastropoda* 9,5% and *Bivalvia* 0.3%. From analyzed area, data of *Gastropoda* participation in food is in accordance with those from Kminiak (1978), and Popovic and Mikes (1989), (9.2% and 10.6%, respectively). But opposite Kminiak (1978), we did not record *Oligochaeta* presence in stomach contents.

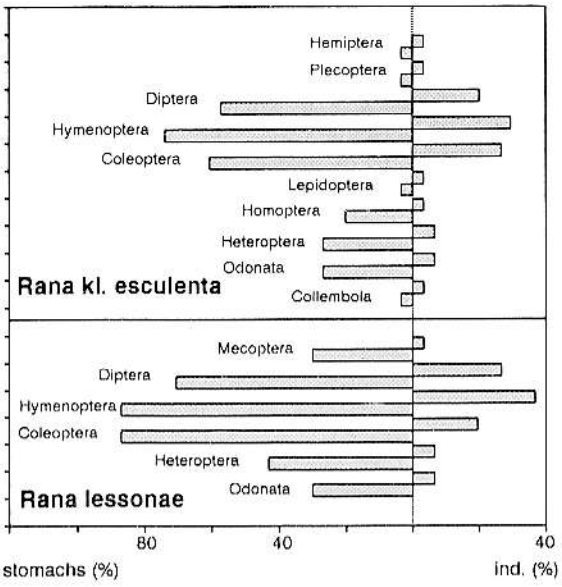

Fig. 2. Quantitative and qualitative presence of some insect orders in the stomachs of analyzed frog species.

Although the sample was not standardized in regard to the number of analyzed specimens, it was possible to recognize certain relations in feeding, on the basis of obtained results. With species *R. kl. esculenta*, beside insects and their larvae, the class of *Crustacea* (22.6%) was quite noticeable. This was not the case with pool frog (3.5%; Fig. 2.). One specimen of the edible frog had 42 individuals in its stomach content, and therefore there is such a high percentage of *Crustacea* in food. Then, there were the representatives of the class *Arachnida*, *Gastropoda* and *Myriapoda*. Only one individual of class *Bivalvia* was found in a stomach content. *Hymenoptera* (74% - 35 sp.) predominated among insects (Fig. 3.) because of the large individual number of *Formicidae* species. *Coleoptera* (60,9% - 31 sp.) and *Diptera* (56.5% - 24 sp.) had also an important role in feeding of edible frog, while it is not the case wit other insect groups. According to Kminiac (1978) and Popovic and Mikes (1989), *Coleoptera* takes part with 44.5% and 54.1%, and *Diptera* with 7.6% and 13% in edible frog food.

Such differences of food contents were the result of differences in habitat conditions.

With species *R. lessonae*, the percentage of food composition was almost the same. It was the case both in other groups of invertebrates, as well as for some species of insects (Fig. 2. and 3.). The only obvious difference was in relation to the presence of *Crustacea* species.

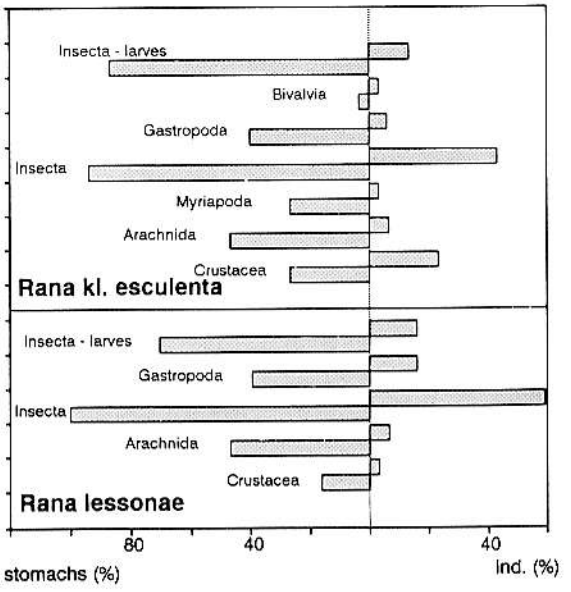

Fig. 3. Quantitative and qualitative presence of some invertebrate classes and their larvae in stomachs of analyzed frog species.

The analysis of stomach contents of only two marsh frog specimens provided us with insufficient result for comparison with data obtained for other two species. The insects were represented with only 4 specimens in the stomach contents (*Hymenoptera* - 2, *Coleoptera* - 1 and *Orthoptera* - 1) and the class *Gastropoda* with one specimen.

We have especially to underline the data relating to the insufficient role of aquatic insects in feeding of genus *Rana*.

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SEASONAL CHANGES IN FEEDING OF *RANA RIDIBUNDA* PALLAS *(AMPHIBIA: ANURA)* FROM BACKWATER TISZA

S. Simic, B. Tallósi and E. Popovic

Simic, S., Tallósi, B. and Popovic, E. (1992): Seasonal changes in feeding of ***Rana ridibunda*** *Pallas* ***(Amphibia: Anura)*** *from Backwater Tisza. - TISCIA 26,5-7.*

Abstract. *Rana ridibunda* Pallas is dominant frog species in the area of Biser island. Qualitative and quantitative composition of food of this species was investigated during 1990. Insects far outreached other present groups (*Gastropoda*, *Crustacea*, *Aranea* and *Chilopoda*) with 74.9%. Among insects, dominate species were from orders *Diptera* and *Coleoptera*.

Keywords: Backwater Tisza (Yugoslavia), food, ***Rana ridibunda***

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Introduction

It is known that the food of *Anura* includes large number of invertebrates and sometimes also smaller vertebrate species. This fact points to importance of frogs in food chains - as regulators of density of species which they eat, as well as hosts and carriers of different worms. Namely, molluscs and insects are second intermediate hosts in the growth cycle of flukes. Because of that, data about food of *Anura* have exceptional importance for explanation of invasion ways. Also, investigation of *Anura* food gives insight in condition and characteristics of habitat, species living there, seasonal changes and other important components of particular biocenoses.

This paper presents results of quantitative and qualitative investigations of *Rana ridibunda* Pallas feeding on Biser island. Paper presents details of complex investigations, which are part of international Tisza research program.

Methods

Material was collected in the Biser island area in 1990. Total of 62 specimens of *Rana ridibunda* (27 individuals in spring, 25 in summer and 10 individuals in autumn) was collected. Determination was made according to keys by Engelmann (1985), and Arnold and Burton (1978). Collected material was used for parasitological and food composition investigations of this species. Stomach content was found in 40 individuals (12 in spring, 18 in summer and 10 in autumn). Contents were fixed in 70% ethanol, and afterwards analyzed and determined to class, order and in some cases to family or even species (Kerovec, 1986; Schmidt, 1970).

Description of study sites

Biser island is situated in middle part of eastern Backa, between settlements of Novi Becej, Becej, Backo Gradiste and Curug. It is an island, surrounded on north, west and south by Backwater Tisza or Old Tisza. Total area is 2678 ha, with altitude of approximately 75 m. Since there are dams along new and old River Tiszaflow, possibility of larger influences on further relief formations is excluded.

Biser island is characterized by high temperature amplitudes (10-15 °C during the same day), strong northeast wind ("kosava") and annual average precipitation under 600 mm. Backwater Tisza is partly channelled (in northern part), partly morassed (closer to river Tisza), and mostly consist of an oxbow lake (Bukurov, 1948).

These habitat conditions caused presence of characteristic plant and animal life forms. Although part of this area is used in agriculture, autochthonous flora and fauna still exists closer to dams, and somewhere even deeper. Narrow zone of silky willow *(Salix alba)* is spread along the riverbank, and marsh vegetation is represented by

associations *Scirpo-Phragmitetum communis* and *Hydrochari-Nymphoidetum peltatae* (Slavnic, 1956). *R. ridibunda* dominates this area from *Rana* genus. Though not typically plain species, Marsh frog prefers stagnant waters, backwaters and fishponds, which is major cause of its frequency and individual number in this area.

Results and discussion

Marsh frog is wide-spread species, often seen on fields near stagnant and flow waters, overgrown by dense vegetation. It is very voracious, and apart from insects and other invertebrates consumes young fish, frogs, birds and mammals (Arnold and Burton, 1978; Engelmann et al., 1985). It has been found in all investigated localities in Tisza valley, but had fewer individuals in samples than other *Rana* species *(R. kl. esculenta, R. lessonae)*.

Nevertheless, it is dominant species in Biser island area, which certainly is the result of favourable survival conditions.

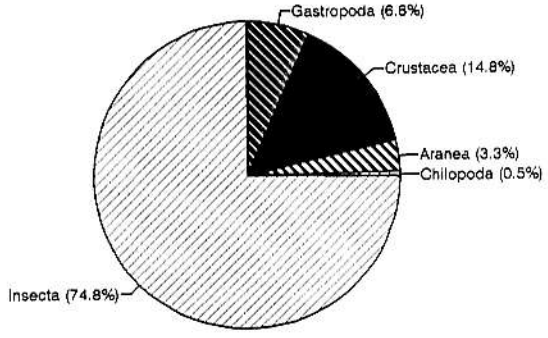

Fig. 1. Food contents of *Rana ridibunda* Pallas from Backwater Tisza - Biser island.

According to literature (Angelov and Bacvarov, 1972; Popovic and Mikes, 1989) the species group composition of food were the same in all studied area, but their proportion varied. It shows as a rule that insects are the basic food (in number of species and specimens), and other invertebrate groups are subordinate. Similar relations were established in samples from Biser island (Fig. 1) - *Insecta* 74.9%, *Crustacea* 14.8%, *Gastropoda* 6.6%, *Aranea* 3.3% and *Chilopoda* 0.5%. (Tab. 1) Dominant insect species were from order *Diptera* (total number of adults and larvae), then followed *Coleoptera, Hymenoptera, Odonata, Lepidoptera, Heteroptera, Homoptera* and *Orthoptera.* Qualitative analysis showed that order *Coleoptera* was represented in nutriment with the highest number of families - *Scarabeidae, Carabidae, Cantharidae, Elateridae, Chrysomelidae, Hydrophillidae, Curculionidae, Silphidae, Coccinellidae*. Members of only three families were established from *Diptera* order which dominated in food during summer, (*Syrphidae*, and only one specimen from both *Tipulidae* and *Culicidae*). Other *Diptera*, because of poor condition of material, could not be determined more precisely, though presence of larger heterogeneity was expected. Ants were most dominant among *Hymenoptera* also in this case. According to our results and those obtained by Angelov and Bacvarov (1972), it could be expected that food composition would be similar to the other *Rana* species *(R. kl. esculenta, R. lessonae)*. The above mentioned authors also reported the presence of *Cyprinidae (Pisces)* - 12 specimens in 10 stomach. The most frequent insect species were from *Coleoptera* order. It is quite probable that such differences in food contents of the same species are the results of differences in habitat conditions.

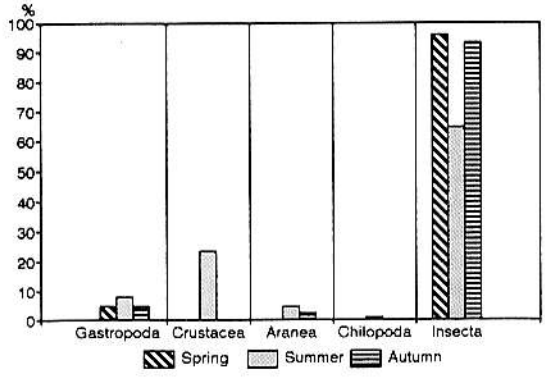

Fig. 2. Seasonal variations in feeding of *Rana ridibunda* Pallas from Backwater Tisza.

Differences in nutriment of *R. ridibunda* are expressed also during seasonal activities (Fig. 2). It is the fact that insects dominated in all seasons. However, basic food were *Coleoptera* and *Hymenoptera* in spring, *Diptera* in summer, and *Coleoptera* in autumn (Tab. 1). Other invertebrate groups were considerable part in food, such as snails in spring and autumn, and some crustacean species in summer. Largest diversity in food was found during summer. This was caused by favourable conditions for development of large number of invertebrate species which prefer these types of habitat. Members of *Cantharidae* and *Hymenoptera* were most frequent in spring sample, while members of *Carabidae* and *Formicidae* families dominated in autumn sample.

Investigations on Carska bara established (Popovic et al., 1992) that frogs from genus *Rana* feed mostly with land insects, much less with water ones. Same result was found in area of Backwater Tisza as well. Because of relatively good state of material, species were found in stomach contents from genera *Harpalus* and *Zabrus (Carabidae), Otiorrhynchus (Curculionidae), Agriotes (Elateridae)* and other pests in plant production.

At last, having in mind all presented results gives insight in presence and number of species which are frog's food, changes of nutriment in different seasons, species which dominate in feeding, which leads to data on habitat and species for which man is interested in positive or negative sense ("Harmful" and "useful" species).

Tab. 1. Percentage proportion of insect individuals in the stomach contents of *Rana ridibunda* Pallas according to different seasons (Backwater Tisza area)

INSECTS	SPRING	SUMMER	AUTUMN	Σ
COLEOPTERA	**41.2**	12.7	**46.3**	**27.1**
HOMOPTERA	5.9	8.4		5.4
HETEROPTERA	11.8	4.2	4.9	5.4
HYMENOPTERA	35.3	7.0	29.3	**17.8**
LEPIDOPTERA		5.6		3.1
DIPTERA		**33.8**	12.2	**22.5**
ODONATA		11.3		6.2
ORTHOPTERA		2.8		1.5
LEPIDOPTERA - larvae	5.9		7.3	3.1
DIPTERA - larvae		11.3		**6.2**
ODONATA - larvae		2.8		1.5
Σ	13.2	55.0	31.8	100.0

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CHANGES IN THE GROWTH OF PIKE PERCH *(STIZOSTEDION LUCIOPERCA)* IN THE AREA OF LAKE-TISZA

Á. Harka

Harka, Á. (1992): Changes in the growth of pike perch ***(Stizostedion lucioperca)*** *in the area of Lake-Tisza. - TISCIA 26,9-12.*

Abstract. The storage lake of the river Tisza was established in 1978 near Kisköre. From the growth analysis of pike perch living in the lake it is concluded that the growth rate of body weight decreased after swelling up the water. Longitudinal growth of pike perch, however, increased in time, and as a consequence, average body length of individuals over 3 years is greater than was earlier. Longitudinal growth is more important than the growth rate of weight, that is why the growth of pike perch is recently a little more favourable, than was before the establishment of storage lake, but it can be qualified as moderate compared with other rivers and ponds.

Keywords: age, body length, body weight, Bertalanffy-model

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Introduction

The reservoir that was established by swelling up the water of river Tisza between Kisköre and Tiszafüred in 1978, is called Lake-Tisza. Its total area is 120 km^2, and its depth is about 1-1.5 m. The water of the reservoir is drained every autumn, and the fish species hide themselves in winter partly in the riverbed, and partly in the deeper water of backwaters that can be found at this area.

Annual harvest of pike perch was about 7-8 tones before the development of the reservoir. It increased after swelling up the water - it reached 50 tones in 1982 - but later decreased gradually, and the quantity changed between 14 and 19 tones from 1986.

The aim of this study is to find the changes in the growth rate of pike perch as a consequence of establishment of the storage lake. The basis of the comparison is the result of an investigation on the growth of pike perch that was carried out in the reach of Tisza in question before building the reservoir (Harka, 1975, 1977).

Material and Methods

Data of 82 pike perch individuals were used for growth analysis. Fish were caught in the north-eastern basin of Lake-Tisza near Tiszafüred and Poroszló, between 1987 and 1990. Standard body length of specimens varied between 290 and 710 mm, and their weight between 270 and 4400 g.

Relationship between body length (L) and weight (W) was calculated with the formula ($W = aL^b$) suggested by Tesch (1971), and with its logarithmic form, respectively. Linear regression analysis of measured data was performed (Sváb, 1973).

Age determination was made with scalimetry. Total oral radius (S) of scales and distance of annual rings developed in winter, from the focus of scales (S_n) were measured. Measurements were made by using a microfilm reader equipment and applying 21.5x magnification.

Body length of fish in the time of development of a new annual ring (L_n) was calculated by Lea (1910) method, because the correlation between body length and scale radius was no close enough.

Growth dynamics was estimated with Bertalanffy-type growth model that was suggested by Dickie (1971). Parameters of Bertalanffy-function were determined with Gulland (1963) method.

Results and Discussion

Relationship of body length and weight

The relationship between standard body length (L_c) and weight (W) of pike perch from Lake-Tisza is as follows:

$$\lg W = -4.9388 + 3.0132 \lg L_c$$

Body length is given in mm, and weight in g (Fig. 1).

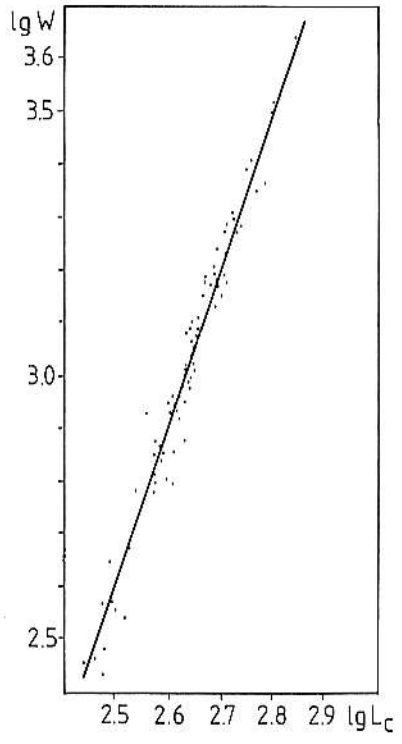

Fig. 1. Relationship between body length (L_c) and weight (W) of pike-perch in Lake-Tisza ($\lg W = -4.9388 + 3.0132 \lg L_c$; $r=0.987$).

The parameters of this function were the following in the period before swelling up.

$$\lg W = -5.6303 + 3.2837 \lg L_c$$

It can be seen from the comparison of the functions that pike perch starts recently with larger weight than earlier, but the growth rate decreased. The more favourable start gives some advantage up to 360 mm body length, but the smaller growth rate of body weight results in a greater and greater lag of larger individuals. Since just the individuals old enough for catching are in worse condition, this change is evaluated as negative one in general.

Growth of body length in time

It could be established on the basis of pattern of scales that the age of studied individuals varied between 2 and 9 years. The two oldest age classes, however, were represented only by 1-1 individuals, therefore the growth was analyzed up to the age of 7 years.

Table 1. shows the calculated standard body length in the age classes. Body weights are given on the basis of the function mentioned above.

Saturation curve was fitted to body length data which were calculated from the annual rings of scales. Parameters of Bertalanffy-function describing above curve are as follows:
asymptotic body length $L_\infty = 1020.6$ mm; growth rate $k = 0.1234$; hypothetical age at 0 body length $t_0 = -0.356$ year. Expected standard body length (L_t) of pike perch living in the north-eastern basin of Lake-Tisza is:

$$L_t = 1026.6\,[1 - e^{-0.1234(t+0.356)}]$$

in the age of t years.

Fig. 2. shows the growth curve with averages and extreme values calculated from scale data.

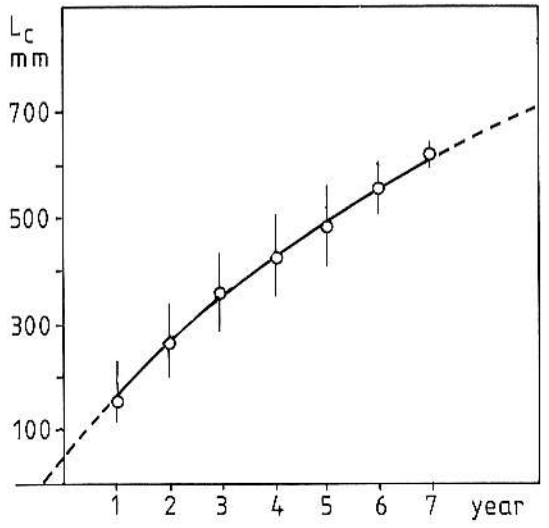

Fig. 2. Growth of pike-perch in Lake-Tisza according to Bertalanffy-model. Dots are averages calculated from scale data, vertical lines represent extremes.
($L_t = 1026.6\,[1 - e^{-0.1234(t+0.356)}]$).

The relationship concerning the period before development of storage lake is:

$$L_t = 790\,[1 - e^{-0.1676(t+0.42)}]$$

Table 1.Body lengths of pike perch in different age classes calculated from scale data, and the corresponding calculated body weights.

Age year	Data n	Body length in mm min.	max.	mean	Body weight in g min.	max.	mean
1	82	110	233	153	16	157	44
2	82	195	325	261	92	427	220
3	72	284	438	358	284	1048	571
4	48	347	500	422	520	1562	937
5	21	401	560	484	804	2198	1416
6	7	506	598	549	1619	2679	2071
7	3	608	631	616	2816	3150	2929

Table 2. Growth of body length and weight of pike-perch before (1977) and after (1990) filling up the storage lake.

Age year	Body length in mm 1977	1990	Body weight in g 1977	1990
1	167	157	47	48
2	263	257	207	210
3	344	346	500	515
4	413	424	911	951
5	471	494	1403	1506
6	520	555	1942	2139
7	562	609	2506	2830

Table 2. shows the body lengths calculated with above two functions and the related body weights. Data clearly show that longitudinal growth of pike perch increased, their body length is greater from the 3rd year than was in the past. Also this change - similarly to the deterioration of condition mentioned above - manifested itself in the age class which is ripen for catching, but the effect is opposing.

Data of body weight in the Table 2. also show that the later of opposite changes is more important. The overweight coming from the quicker longitudinal growth compensates the drawback originating from the weaker condition. Recently the pike perch is "slimmer" than its ancestor was, but its weight is larger at a given age because of the increased longitudinal growth.

This quicker growth can, however, be qualified as moderate compared with that of pike perch from other waters (Fig. 3.) because it is quicker than in the Yugoslavian reach of Tisza (Maletin and Budakov, 1984), but slower than in river Száva, and than that observed by Maletin and Kostic (1989) in one of backwaters of Tisza near Curug in Yugoslavia.

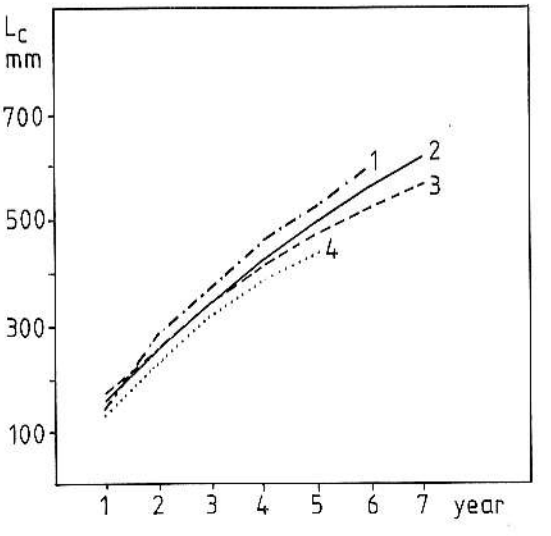

Fig. 3. Growth of standard body length of pike perch in some closer rivers. 1. river Száva, Yugoslavia (Maletin and Budakov, 1984); 2. Lake-Tisza (present study); 3. river Tisza, Hungary (Harka, 1977); 4. river Tisza, Yugoslavia (Maletin and Budakov, 1984).

The advantageous change of pike perch in Lake-Tisza was really probable, since a rich food supply developed inthe newly flooded area. But the reality is more complicated, because the surplus food should have taken positive effect also on the condition i.e. on body weight related to body length. It is not proved with data, but according to the observations by fishermen, it occurred in the first period. Pike perch individuals were thicker in the first years after swelling up the storage lake, and they became slim only in the last years. Probably the first cause of deterioration of condition is that larger areas of the bottom is covered with sediment that results the decrease of food supply. Also the decrease of longitudinal growth can be expected on this basis. The unfavourable environment has a negative effect on the reproduction, that is why we can find in the future, that the proportion of less demanding Volga-zander (*Stizostedion volgensis* Gmelin) will increase against pike perch.

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FECUNDITY OF PHYTOPHIL FISH SPECIES IN "BACKWATER TISZA" (BISER ISLAND)

S. Maletin, N. Djukic and D. Kostic

Maletin, S., Djukic, N. and Kostic, D. (1992): Fecundity of phytophil fish species in "Backwater Tisza" (Biser island). - TISCIA 26,13-24.

Abstract. Potential fecundity was investigated in three typical phytophil fish species (*Scadinius erythophthalmus, Carassius carassius* and *Carassius auratus*) and in a phytolithophil one (*Rutilus rutilus*) in Backwater Tisza during 1985-1987 period. The relationship between gonadal weight, absolute and relative fecundity in comparison to body weight, standard length and age were examined by linear regression $y=ax+b$, and were estimated by coefficient of correlation r, significance of which was tested at $p<0.01$ and $p<0.05$. It is noted that absolute fecundity and gonadal weight intensively enlarge with increase of basic biological parameters, and level of this relationship was confirmed by highly significant correlation. Relative fecundity shows weaker dependency on parameters analyzed, and stronger connection usually occurs in comparison to standard length. Absolute and relative fecundity values are within optimal range in all examined species.

Keywords: crucian and prussian carp, roach, rudd, Tisza backwater

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Introduction

Several years ichthyological investigations of this backwater in Tisza valley cover a wide range of taxonomic and ecological analysis of populations. These studies include mostly all dominant species with more or less economical value, which are - in wide biological sense - an important biotic factor in overall hydrobiocenosis. Other than a number of faunistic - taxonomic investigations (Grgincevic et al., 1987; Kostic and Maletin, 1989), the majority of examinations was mostly ecological, analyzing firstly the rate of growth and length and body weight, and secondly the fecundity and diet of the most numerous fish species in this locality (Maletin et al., 1985; Maletin and Budakov, 1986; Jovanovic et al. 1988; Maletin, 1989; Maletin and Kostic, 1989a; Maletin et al., 1989; Maletin et al., 1990.).

Fecundity analysis of certain fish species was relatively neglected until recently in Backwater Tisza. Most authors today are convinced that this problem is best approached by correlation-regression analyses of basic parameters on absolute fecundity, weight, length and age of examined specimens in certain group distances (Bastl, 1980; Petrovski and Sidorovski, 1980; Zivkov, 1983, 1984, 1985; Soric and Ilic, 1986) thus interpreted results give more real insight into the reproduction potential of certain fish population than discussing this phenomenon in comparison with gonadal and body weight only.

From the point of view of these investigations, there are very interesting data given by Triapicina, (1975), Bastl, (1977), Zivkov, (1980) and Volodin, (1981), concerning fish population in still water, reservoirs and river backwaters with hydrological regime and trophic level similar to those of our localities.

Investigations of fecundity dynamics were carried out with roach (*Rutilus rutilus*) which is strictly phytolithophylic species, as well as with rudd (*Scardinius erythrophthalmus*), crucian carp (*Carassius carassius*), and prussian carp (*Carassius auratus*), which are typical phytophylic species. All four species are dominant or subdominant in fish community of Backwater Tisza (Kostic and Maletin, 1992). Moreover, they reach very good growth in weight and length under optimal nutrient conditions and stable hydrological and oxygen regime (Maletin and Kostic, 1989b).

Material and methods

Material for these investigations was collected before spawning period during 1985-1987, with standing nets, fishing traps and electrofishing apparatus. Absolute fecundity and gonadal weight were analyzed in *R. rutilus* (26 females), *S. erythrophtalmus* (50), *C. carassius* (41) and *C. auratus* (50), in comparison to certain weight, length and age categories. For determination of age and potential fecundity, standard methods were use (Chugunova, 1959; Pravdin, 1966). Relationship between examined parameters was estimated by linear equation $y=ax+b$, and the correlation coefficient r was tested at $p<0.01$ and $p<0.05$ significance levels.

Results and discussion

The analyzed specimens of *R. rutilus* belonged to age categories of 2 to 5 years, with average body weight 8-83 g and standard length 76.5-157 mm, and were grouped to nine categories. Gonadal weight categories ranged from 0.5 to 20.7 g. Increase of average ovary weight in comparison to body weight, standard length and age (basic biological parameters) is very evident. Its rate is relatively slow, especially in comparison to the growth of length. In specimens larger than 35 g (i.e. 115 mm), gonadal weight increases rapidly. This tendency is especially obvious analysing the whole sample in correlationson to age (Fig. 1). Absolute fecundity in some weight, length and age categories ranged between 1.400 and 30.000 with steady increasing tendency, and with some deviations in small-sized specimens (up to 50 g, i.e. 90 mm). In larger individuals, this increase is more expressed and correlated with gonadal increase. In contrast to these two parameters, the relative fecundity shows different tendency. Values are ranging between 175 and 355, with obvious variability. Some decrease of this parameter is noted in specimens around the center of increasing body weight, length and age. This is especially visually apparent to body weight and age. In some length categories, decrease of relative fecundity in comparison to increase of length growth can be observed.

This tendency of increase or decrease of fecundity parameters was noted in roach by Zivkov (1983 and 1985) in reservoir Batak, Bulgaria. Average absolute fecundity of roach from this Bulgarian water basin is very similar to those of specimens from Backwater Tisza. Analyzing of fecundity and sexual maturity in *R. rutilus* from Lake Dojransko jezero, Petrovski and Sidorovski (1980) also noted an increasing tendency of absolute fecundity, and the values of relative fecundity are within the same limits established in our investigations.

Analyzing the correlation of gonadal weight, absolute and relative fecundity with the basic biological parameters, highly significant coefficients were obtained for the ovary weight and the absolute fecundity ($p< 0.01$, Fig. 2), but different relationship was established in relative fecundity. In comparison to body weight and age, correlation was positive but not significant, and in comparison to the growth in length it was negative and significant ($p< 0.05$). High level of significance was described between the absolute fecundity and the basic biological parameters in roach, as well as weaker one between the relative fecundity and the same parameters by the quoted authors.

Caught specimens of *S. erythrophthalmus* were 2, 3 and 4 years old. The whole sample was grouped to eleven weight and length categories ranging from 9.5 to 58 g and 78 to 129 mm respectively. Average ovary weight was 0.3 - 4.6 g. Their increase in comparison to basic biological parameters (age, body weight and standard length), has different rate for different weight and length categories. In smaller specimens (15-20 g and 85-90 mm), this growth is stepwise. A bit less relative gonadal weight appears in the categories of 20-25 g and 90-95 mm. In medium size specimens and the biggest ones, rate of ovarian weight growth is intensive, with a minor decrease in 45-50 g and 115-120 mm categories. Enlargement of gonads with age (2-4 years) is extremely intensive. Absolute fecundity of rudd ranges between 2.880 and 13.625 and increases permanently with increase of age. Intensive growth of this parameter values is noted also in comparison to increase of body length and weight, except for some minor deviations in smallest and biggest categories. Average relative fecundity ranges between 177 and 303, with more or less oscillations. The biggest values are noted in smallest and youngest categories, and relative fecundity varies with increasing body weight and length, but slightly relative fecundity is noted by Triapicina (1975) in ecological studies of rudd from Volga delta.

Level of relationship of gonadal weight and absolute fecundity in comparison to body weight, standard length and age is positive, highly significant, which can be seen from the values of correlation coefficient r (Fig. 4). Relative fecundity, however, shows different correlation between these parameters and growth rate. This relationship is negative and slow with non-significant coefficients. The same analysis has been

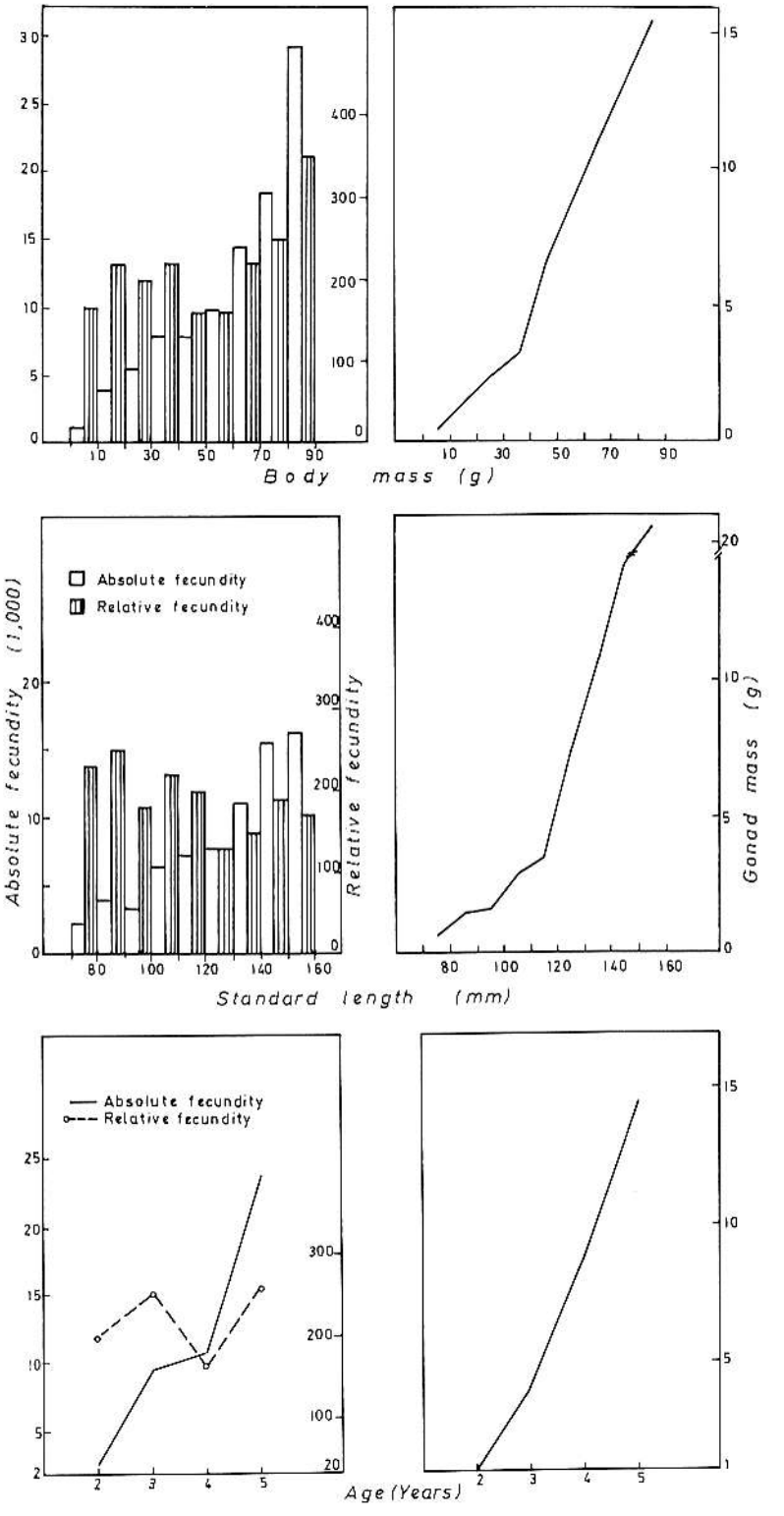

Fig. 1. Fecundity and gonad weight of roach *(R. rutilus)* related to body weight, standard length and age

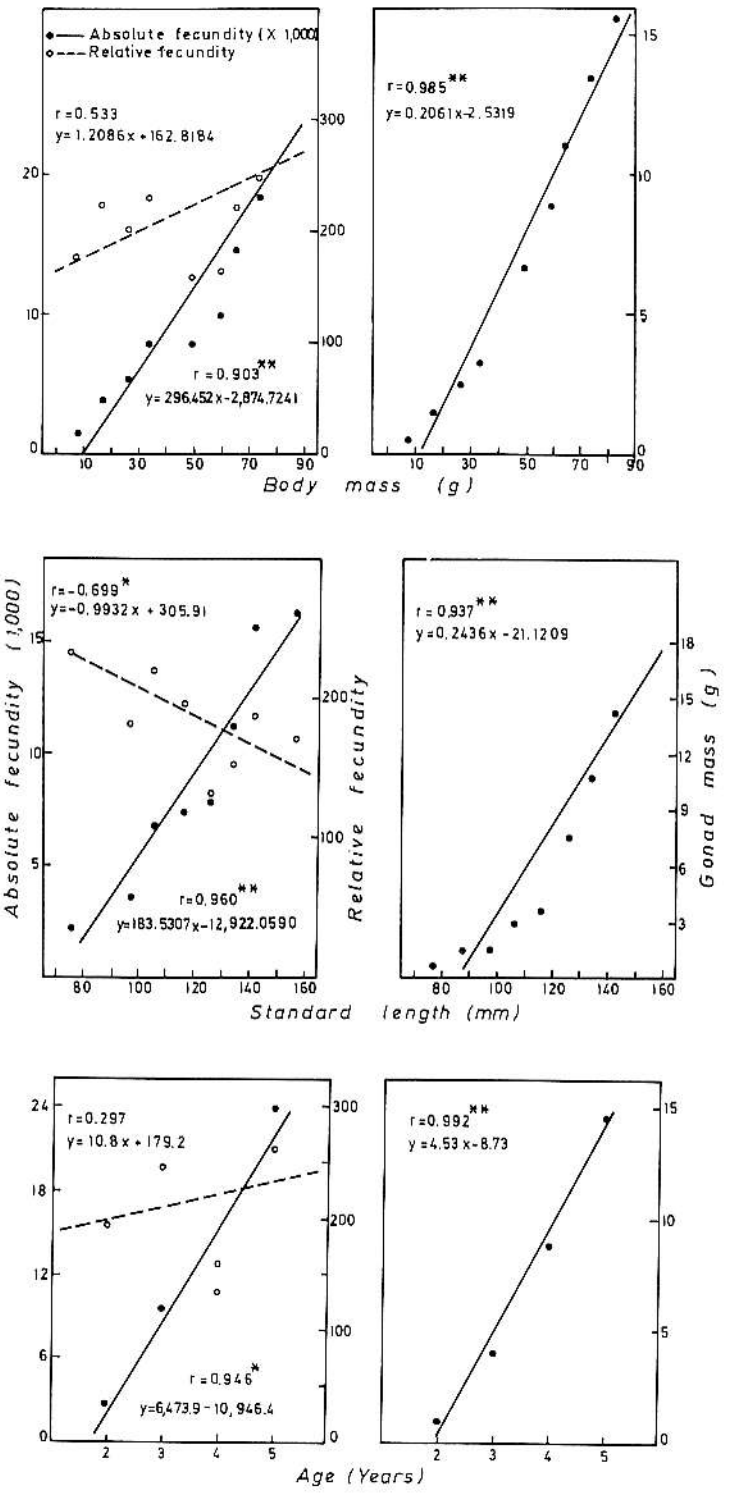

Fig. 2. The correlation of fecundity and gonad weight of roach *(R. rutilus)* in relation to body weight, standard length and age

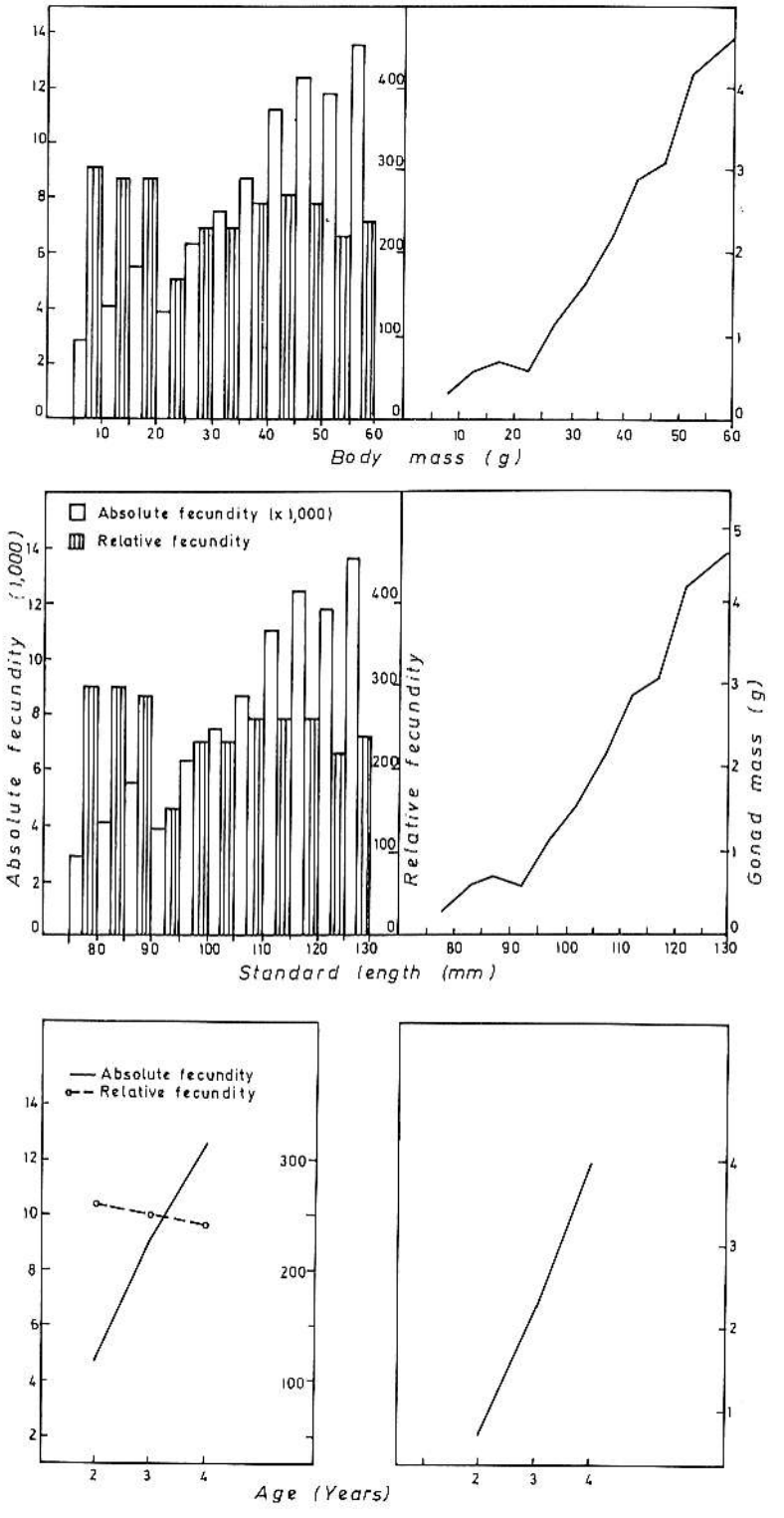

Fig. 3. Fecundity and gonad weight of rudd *(S. erythrophthalmus)* related to body weight, standard length and age

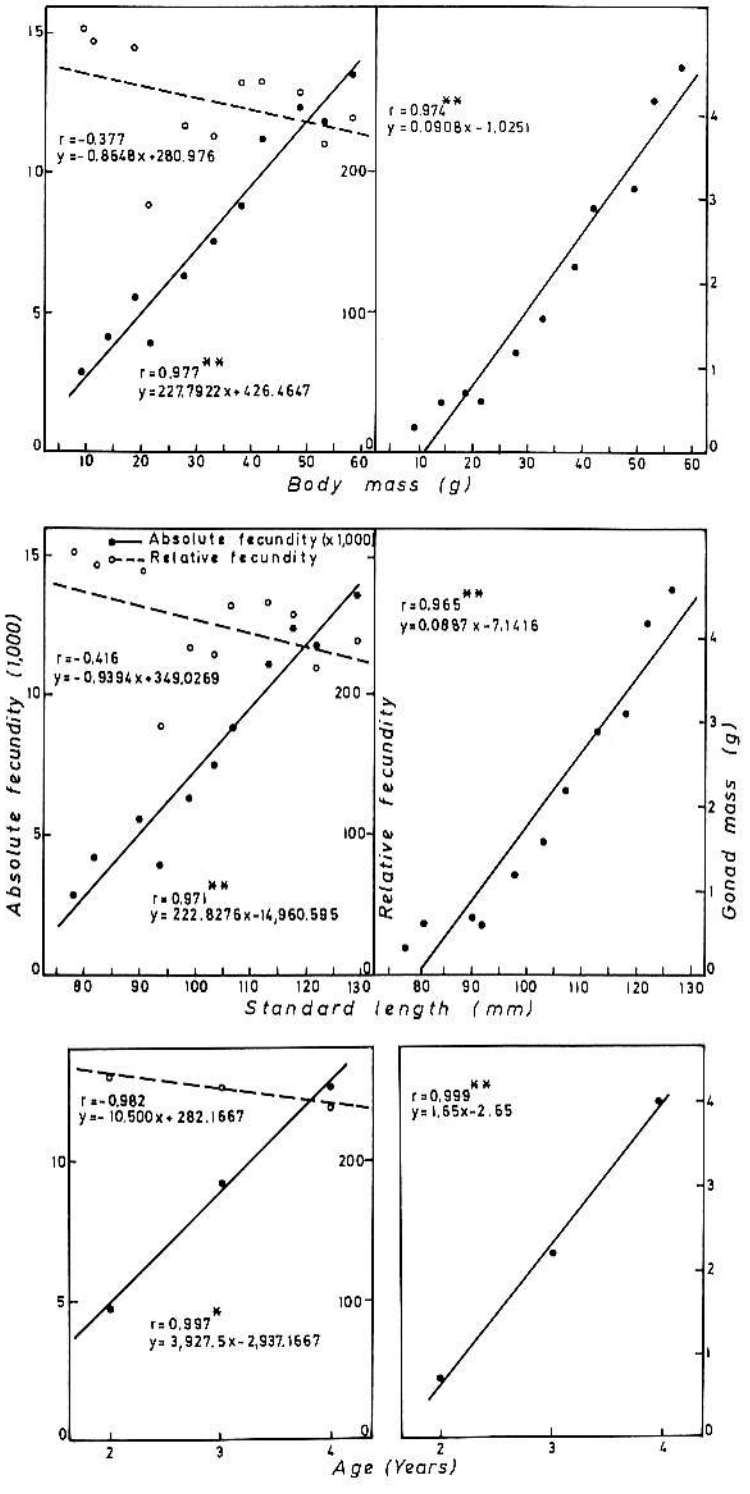

Fig. 4. Correlation of fecundity and gonad weight of rudd *(S. erythrophthalmus)* in relation to body weight, standard length and age

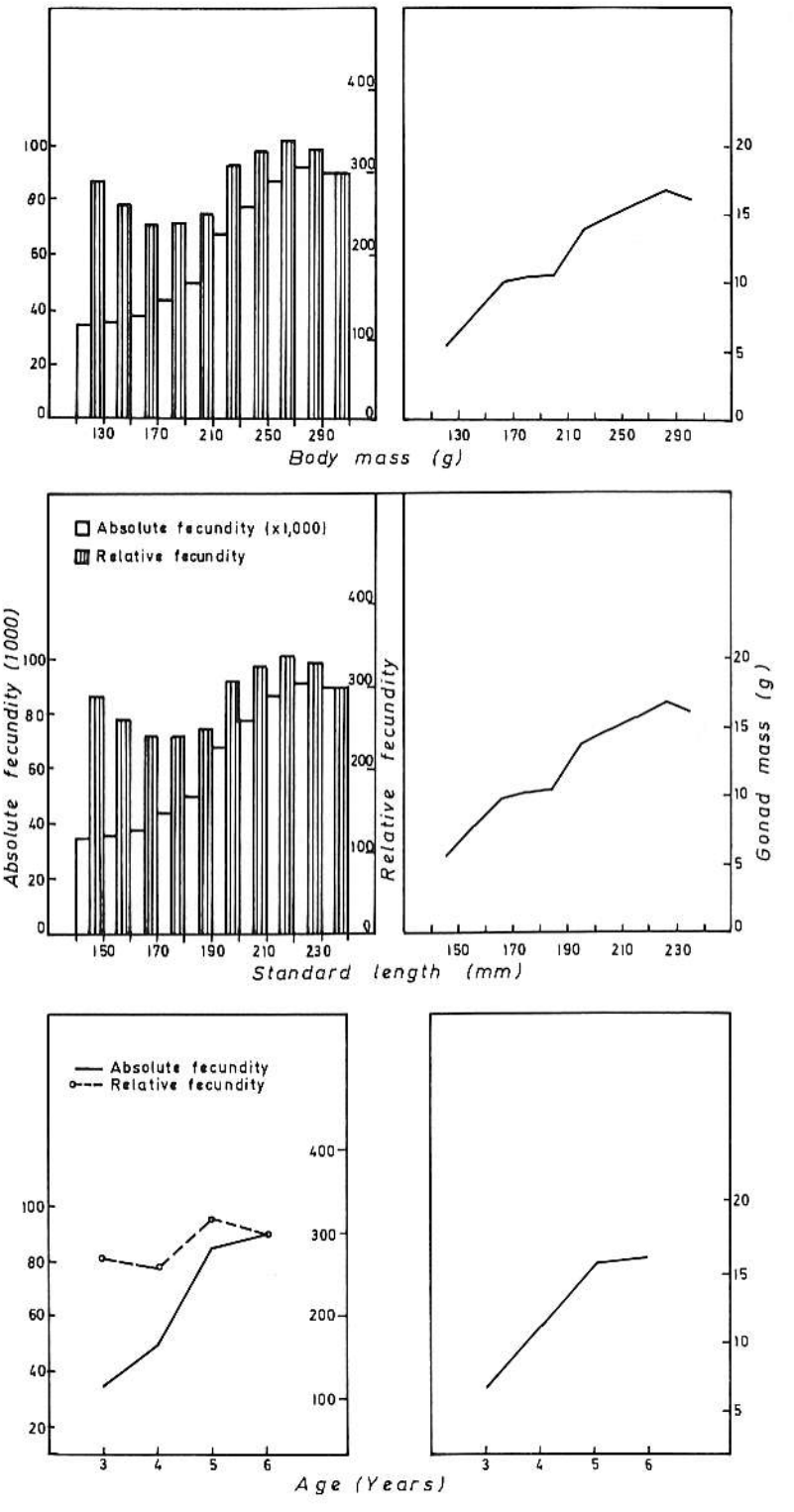

Fig. 5. Fecundity and gonad weight of crucian carp *(C. carassius)* related to body weight, standard length and age

presented by Triapicina (1975) with high level of correlation between the absolute fecundity and the biological parameters indicating the absence of connection between the relative fecundity and the above parameters, especially age.

Individual age of *C. carassius* in the examined samples ranged between 3 and 6 years. Average values of body weight ranged between 123 and 310 g in different groups, and those of standard length were between 148 and 238 mm (total of ten weight and length groups). Average ovary weight varied from 5.6 to 16.1 g and an increasing tendency of this parameter in comparison to the body weight, length and age can be established (except the last categories). Some stagnation has been noted in gonadal weight in specimens with body weight 150-190 g and length 160-190 mm (Fig. 5). Absolute fecundity was calculated on the basis of average values of each weight, length and age categories, and ranged from about 35.000 to over 92.000 with a distinct increasing tendency, except for the last categories, showing a typical sigmoid curve.

Relative fecundity ranged between 236 and 338 and, in contrast to the previous two parameters, showed lower dependency on the basic biological parameters. The highest values were noted in medium weight and length categories, whereas in comparison to the age there was a very slow irregular increase.

Correlation between the ovary weight (and absolute fecundity) and the biological parameters is positive in all cases, with high and significant coefficients. It is interesting that the relationship of the relative fecundity and the body weight, as well as the standard length and the age were also positive and significant ($p < 0.05$, Fig. 6). Analyzing the correlation between the absolute fecundity and the body weight in crucian carp, Astatin and Podgorny (1968) has stated a positive correlation of these parameters and underlined that total fecundity in *C. carassius* in lower than that of *C. auratus*. Relationship of absolute fecundity and body weight is also less distinct in crucian carp than in prussian carp.

Sample of *C. auratus* was grouped into six weight and five length and age categories, and individual age ranged from 2 to 6 years. Average body weight within the categories was 260-870 g, and length 200-292 mm. Average gonadal weight was 41.2 - 141.7 g. In comparison to basic ecological parameters, a very intensive growth of ovaries could be observed (Fig. 7), especially in comparison to growth in weight and length. Absolute fecundity of examined individuals ranged from 28.210 to over 152.000 with a distinct increasing tendency in dependence on age, body weight and standard length. High values and the same tendency were also noted in our previous analyses of prussian carp fecundity in this water basin (Maletin and Budakov 1986), and similar results were obtained also on the basis of potential fecundity of this fish in lake Palic and Obedska bara (flood zone of river Száva, Maletin et al. 1987). In comparison to same categories relative fecundity of *C. auratus* is more similar, ranging between 123 and 171, which values are similar to those observed in our investigation on population from Obedska bara. Values were especially similar when observing the age.

Very strong relationships were established according to the correlation analyses between the absolute fecundity and all the basic biological parameters. Connection was positive, strong and highly significant (Fig. 8). The same has been stated by Zivkov (1983, 1984) for this parameter in comparison to body weight, length and age of prussian carp fecundity in reservoir Batak. Dependency of gonadal weight and another two parameters is also positive, highly significant when r ranged up to 0.999. These results were also obtained in the population from Batak (Zivkov, 1985).

Relative fecundity was somewhat different. In all three cases, connections were also positive and stronger only in length categories ($p<0.05$), while this relationship for the weight and age categories proved to be non-significant.

Absolute and relative fecundity of examined fish during the last period of investigation point out the potential power of the reproductive activity of analyzed populations. Reproductive potential of dominant species has been influenced by total favourable abiotic and biotic factors (hydrological regime, temperature, pH, oxygen regime, food resources, competitive relationships) which were analyzed in details in our previous investigations (Maletin, 1989).

Conclusion

Analyses of fecundity dynamics of phytophyl fish species (*R. rutilus, S. erythrophthalmus, C. carassius* and *C. auratus*) from Backwater Tisza - Biser island showed a very intensive increase of gonadal weight and absolute fecundity in comparison to the increase of body weight, standard length and age in 1985-1987 period. Level of this dependency has been confirmed by high values of the correlation coefficients, which were positive and highly significant ($p<0.01$). Relative fecundity showed a weaker dependency on the

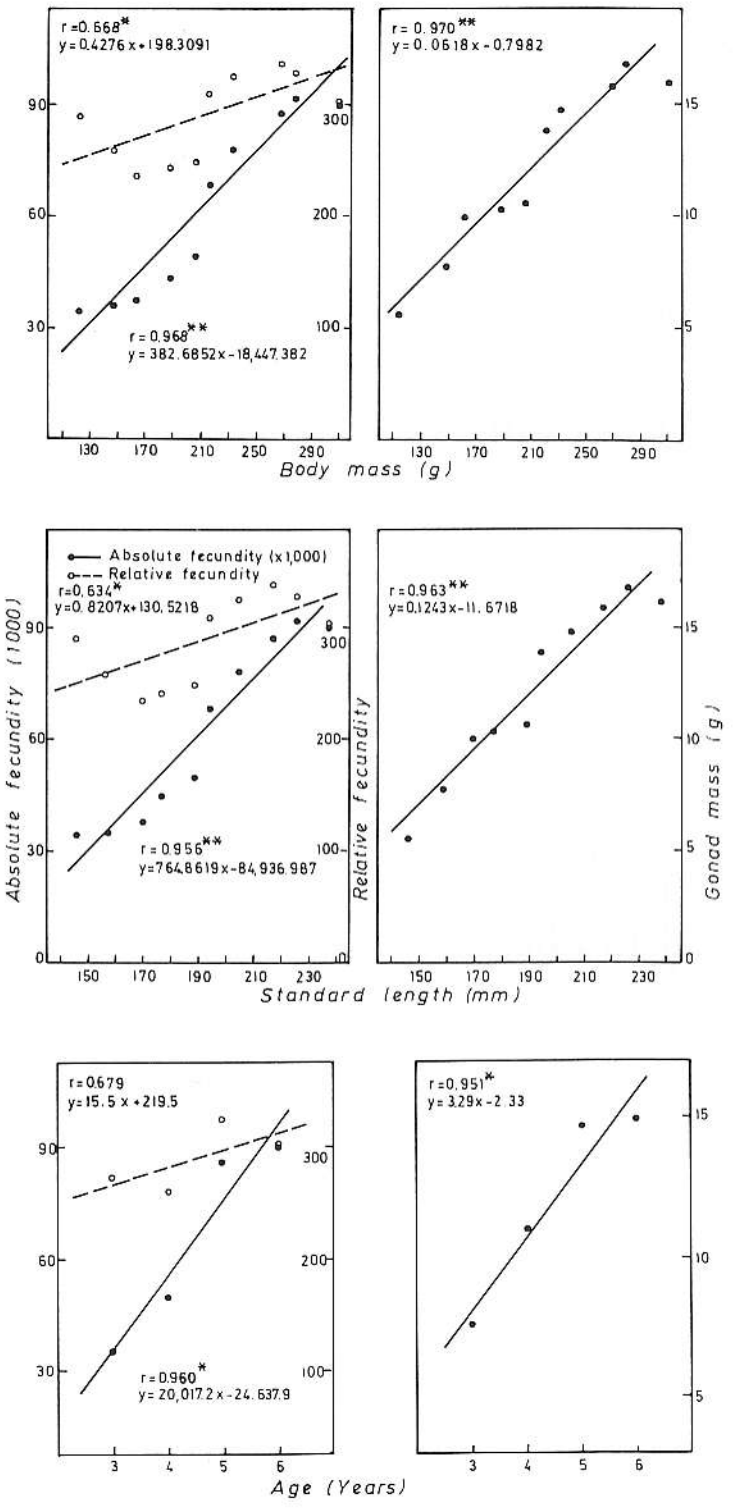

Fig. 6. Correlation of fecundity and gonad weight of crucian carp *(C. carassius)* in relation to body weight, standard length and age

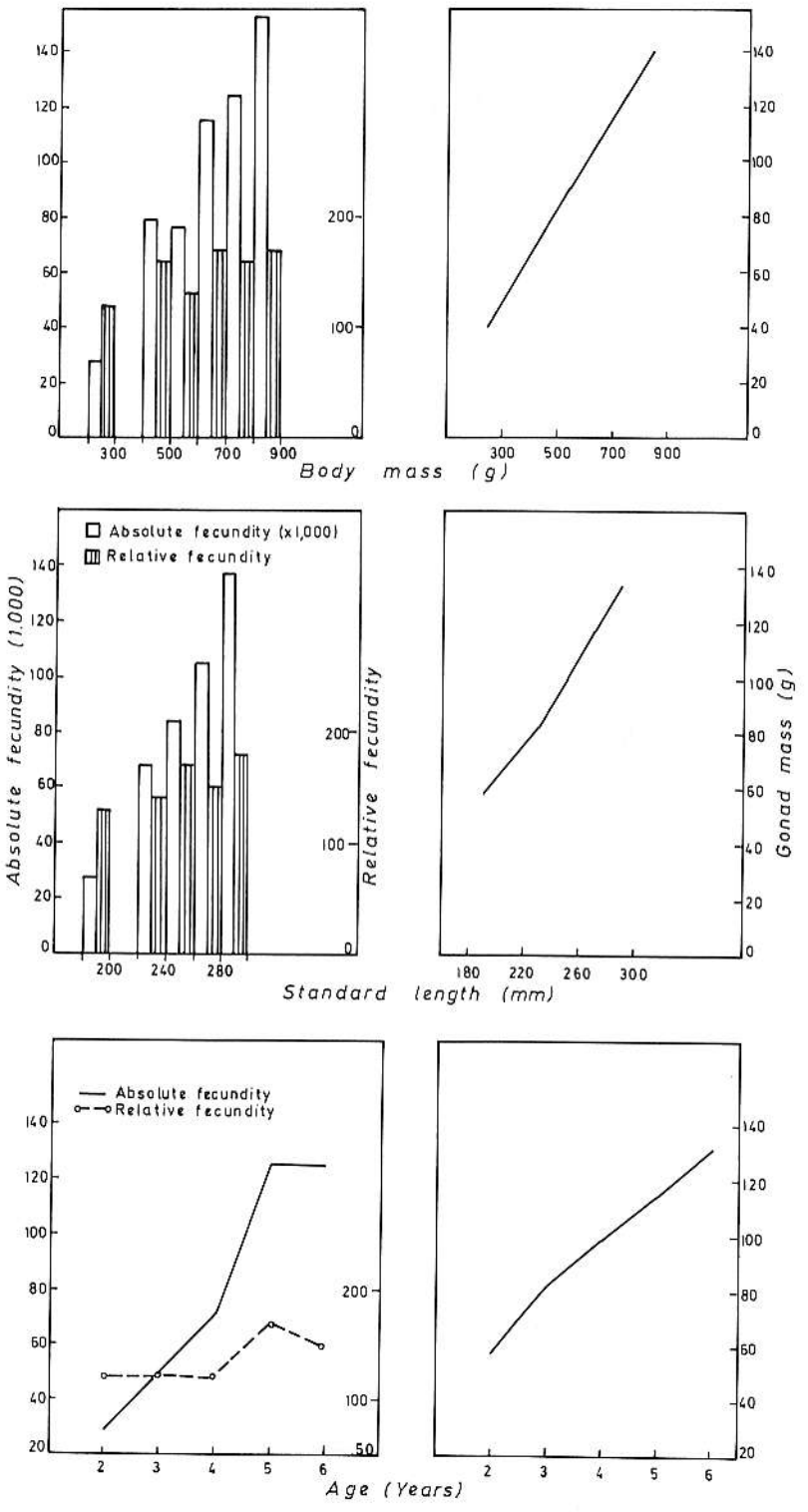

Fig. 7. Fecundity and gonad weight of prussian carp *(C. auratus)* related to body weight, standard length and age

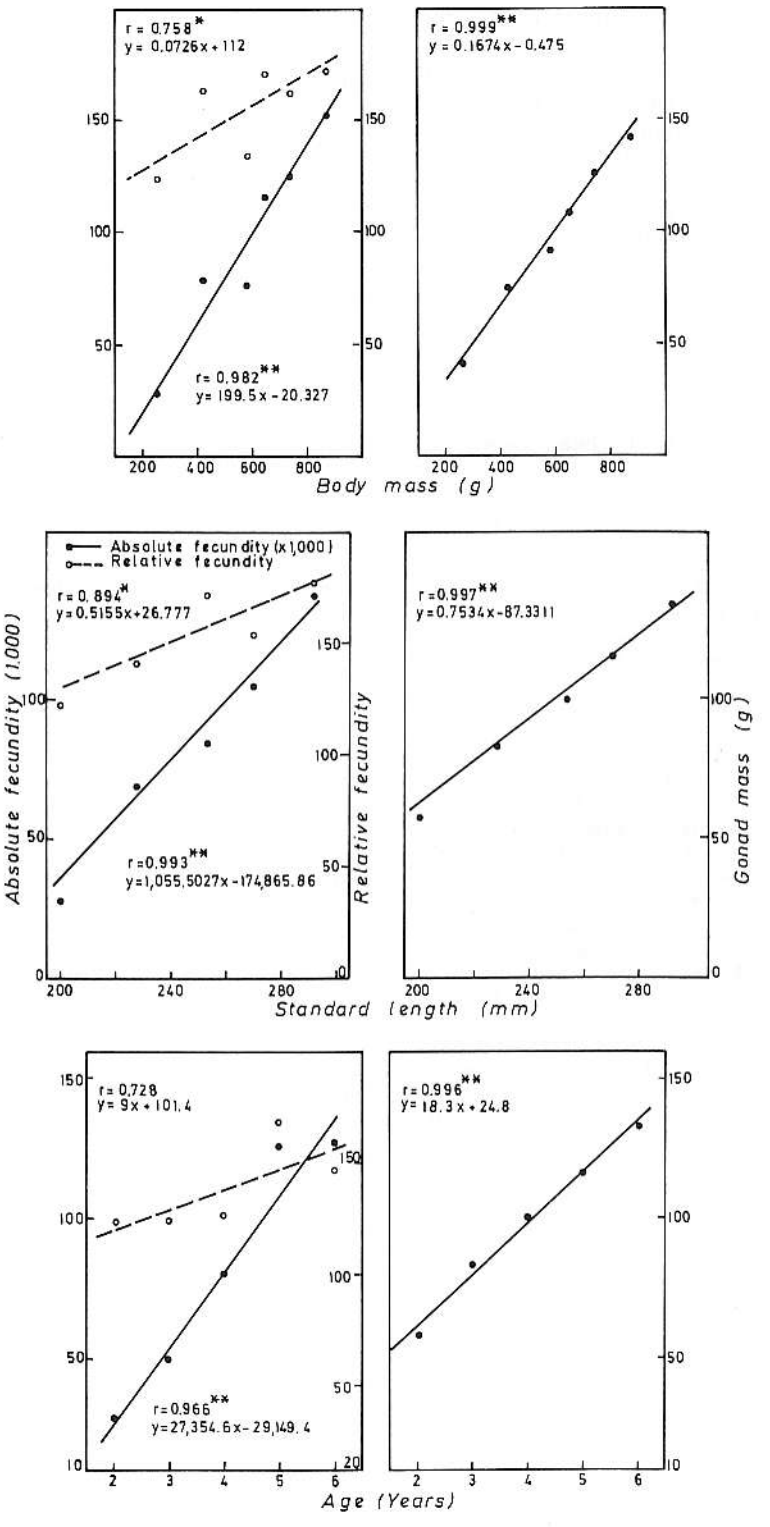

Fig. 8. The correlation of fecundity and gonad weight of prussian carp *(C. auratus)* in relation to body weight, standard length and age

basic biological parameters, however a stronger, but negative one was shown for the standard length (*R. rutilus*), or a positive for the body weight and standard length (*C. carassius*), or for the standard length only (*C. auratus*).

Values for absolute and relative fecundity of examined fish species lie between the limits stated by other authors for similar investigations. Highly expressed potential fecundity in the analyzed populations points out the good living conditions and water quality of this ecosystem.

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HEAVY METAL CONTENT IN FISH FROM "BACKWATER TISZA" (BISER ISLAND)

S.Maletin, N. Djukic and B.Miljanovic

Maletin, S., Djukic, N. and Miljanovic, B. (1992): Heavy metal content in fish from Backwater Tisza (Biser island). - TISCIA 26,25-28.

Abstract. Concentration of 8 heavy metals (Zn, Fe, Mn, Cd, Cu, Ni, Co, Pb) and that of Al were analyzed in certain tissues and organs (gills, liver, spleen, kidney, gonads and muscles) in 7 fish species with different habitats and nutrition types *(Cyprinus carpio, Carassius auratus, Abramis brama, Lepomis gibosus, Stizostedion lucioperca, Esox lucius* and *Silurus glanis)* caught by electroagregate during 1991. High bioaccumulation of Zn was found in gills and anex glands of benthivores, while in predators high amount of Al was found in gonads. Concentration of Fe is constantly high in most organs in fish investigated. Other heavy metals were found in considerably lower amounts.

Keywords: accumulation, benthivores, freshwater, piscivores.

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Introduction

Increase of concentration of heavy metal ions in hydroecosystems is caused by influence of not properly treated waste waters, or as a consequence of disperse pollutants. These elements can, in higher concentrations, act on hydrobionts as direct intoxicants, or, more often, be carried through food chains and accumulate in organs and tissues of fish. Their presence in water habitat is a special problem, different from other pollutants which can be decomposed or otherwise eliminated from water.

Heavy metal content in water and sediments of river Tisza and its backwaters was investigated during last decade, especially in Hungary. Extreme load of these pollutants was found at some parts of river, being under influence of industrial waste waters (Fügedi and Fekete, 1980; László and Berta, 1981; Fekete, 1984). At the same time, high content of these intoxicants was found in invertebrates and certain organs and muscles of the fish in Danube and its affluents by Wachs (1982, 1983, 1985), Gaál et al. (1985), Yevtusenko et al. (1990) and Pujin et al. (1990), but no selectivity in accumulation and level of concentration in hydrobionts, depending on amount of these agents in environment.

Material and methods

Material was caught during 1991, using electroagregate. Concentration of 8 heavy metals (Zn, Fe, Mn, Cd, Cu, Ni, Co, Pb) and of Al was analyzed in muscles, gills, liver, spleen, kidneys and gonads of 7 fish species from different habitats and with different types of feeding. Two ecological groups were investigated: benthivores *(Cyprinus carpio, Carassius auratus gibelio* and *Abramis brama)* and predators *(Lepomis gibbosus, Stizostedion lucioperca, Esox lucius* and *Silurus glanis)* five specimens of each. Samples were prepared by standard methods and measured on flame AAS Perkin Elmer. Heavy metal content was shown as mean values in mg/kg fresh weight.

Results and discussion

Total amount of heavy metals bioaccumulation was different in tissues and organs of investigated fish species (Fig. 1). It was 3.33-fold higher in muscles of predators than in those of benthivores, which is connected with state of analyzed species in food chains. At the same time, concentration of heavy metals (and of Al) was 3.34-fold higher in gills of benthivores than in those of predators. This

result can be explained by different conditions of heavy metals amount in water and in mud.

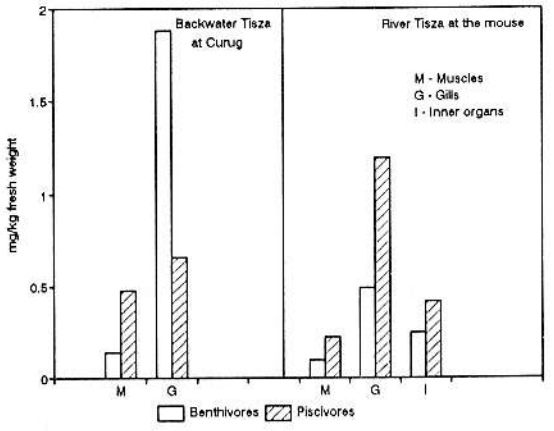

Fig. 1. Total heavy metal content in some fish groups according to feeding type. Sequence of total selectivity: I>G>M (Backwater Tisza); G>I>M (river Tisza). See text for abbreviations.

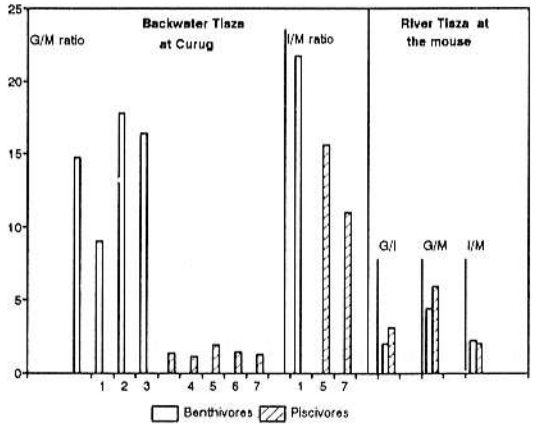

Fig. 2. Relationships between total heavy metal content of organs in some fish groups and species. Bars without number are averages of groups.

The total heavy metal content in gills and muscles, as well as internal organs and muscles, is different, depending on the investigated group, as well as species. Namely, concentration of heavy metals was 15-fold higher in gills of benthivores than in muscles, whereas in predators this relationship is only 1.34. In certain benthivore species, this ratio ranges between approximately 9 and 18, and in predators between 1.25 and 1.88. Significantly higher differences were obtained between two examined groups in relationship between total heavy metal amount of internal organs and that of muscles. In *C. carpio*, which is benthivore, this value was 21.77, whereas in predators it ranged between 11.13 *(S. glanis)* and 15.73 *(S. lucioperca)*, Fig. 2.

Selectivity of certain tissues and organs in bioaccumulation of heavy metals is very similar for both ecological groups. Sequence was in benthivores *(C. carpio)* as follows: S > Gi > H > Go > M, and in piscivores: S > Go > H > Gi > M *(S. lucioperca)* and K > Go > S > Gi > M *(S. glanis)*. (Abbreviations: S = spleen, Gi = gills, H = liver, Go = gonads, M = muscles, K = kidney.) Generally, it can be concluded that highest accumulation of heavy metals occurred in internal organs (mostly spleen and kidney), then following gills and at last muscles.

When comparing heavy metal content of fish caught in Tisza mouth, somewhat different situation can be noted. Benthivores have lower concentration of total heavy metals amount than predators. Least difference was established in internal organs (1.68), then in muscles (1.90), and highest in gills (2. 58), (Figs. 1 and 2).

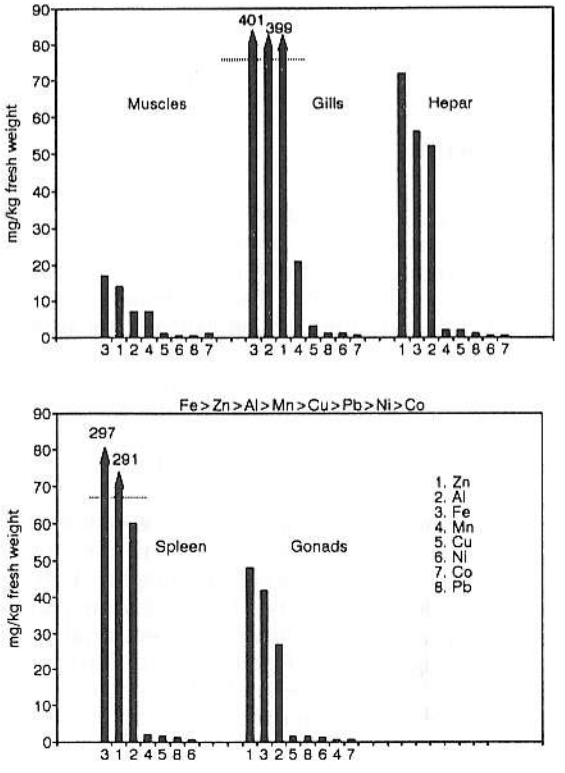

Fig. 3. Accumulation of heavy metals in benthivore fish species

Ratio between total heavy metals concentration in certain organs of groups examined varies from approx. 2 to 6. Smallest

values were found for ratio between gills and internal organs in benthivores, as well as between internal organs and muscles in predators, and higher between gills and muscles in both groups.

The same sequence was established in both groups: Gi > I > M, (I = intestinum) in selectivity of investigated organs to bioaccumulation of heavy metals.

Sequence of certain heavy metal bioaccumulation in organs of investigated fish from Backwater Tisza was very similar for both ecological groups. According to these investigations, following sequence would be formed for benthivores: Fe > Zn > Al > Mn > Cu > Pb > Ni > Co, while Cd was not found (Fig. 3). At the same time, the same sequence was found in piscivores, with minor differences for certain species and organs, and with Cd at the end, stored in liver and kidneys. High concentrations of Fe, Zn and Al were found in gills and anex glands of benthivores, as well as in internal organs of predators (Fig. 4).

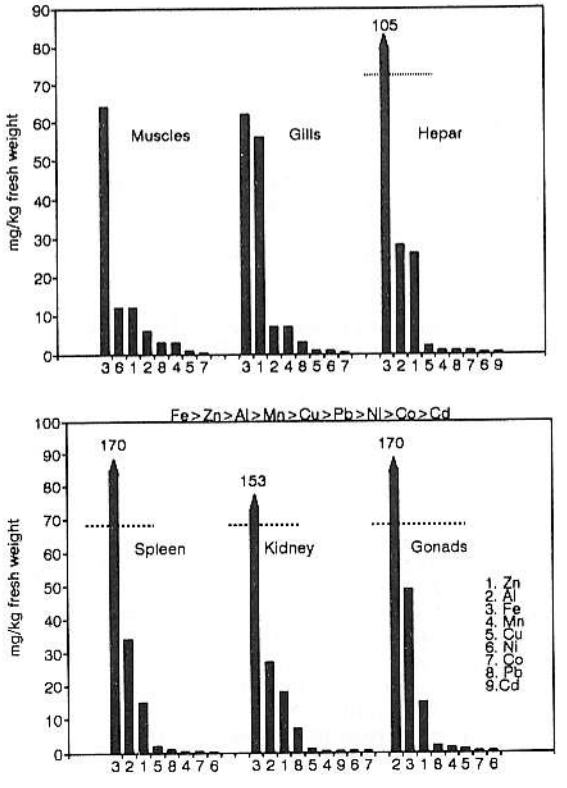

Fig. 4. Accumulation of heavy metals in predators.

Concentration of other metals was significantly lower. In this group, Mn was prominent in benthivores gills, and Ni in piscivores muscles *(E. lucius)*.

In order to do detailed analysis of heavy metals concentration in certain tissues of fish, relationship was established between internal organs and muscles, gills and muscles, as well as between internal organs and gills. Higher concentration of all 9 elements was found in internal organs than in muscles of examined benthivores and some piscivores *(S. lucioperca* and *S. glanis)*. These values ranged from several to even 103.21-fold (Al in *C. carpio*). On the contrary, 5 times more Pb was found in muscles of *E. lucius* than in internal organs. Similar situation was in examined benthivores, where level of certain metals was 1.19 to 33.73-fold higher than in breathing organs.

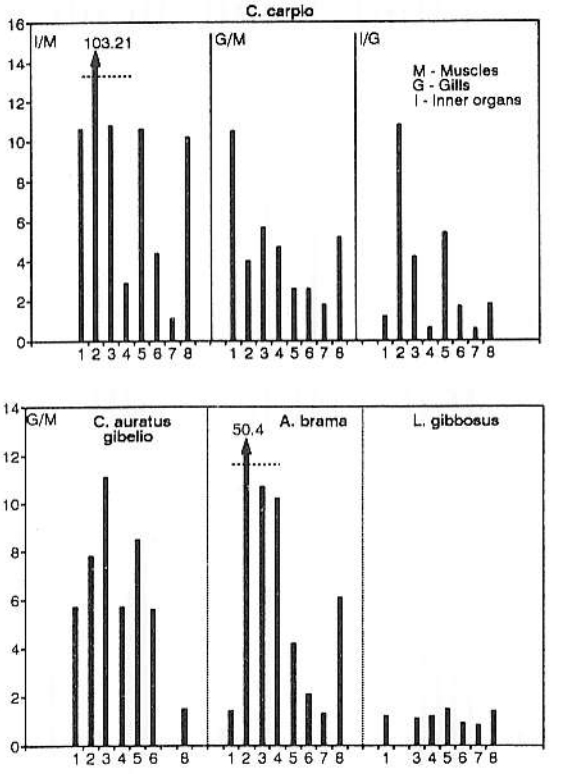

Fig. 5. Ratio of some heavy metals between organs in fish species (mostly benthivores).

However, somewhat different sequence was found in predators, so some intoxicants were more accumulated in muscles. Highest values were found for Ni (40.6-fold), while for others - Al, Fe, Cu and Pb - this relationship was up to 5-fold. Accumulation of certain metals was also found in higher concentration in internal organs compared to gills, with highest values for Al in predators (60.63-fold in *S. lucioperca* and 41.33-fold in *S. glanis*). Reversed relationship was established for

all predators and *C. carpio*, but with lower values for Pb, Co and Zn (4 to 6-fold), (Figs. 5 and 6).

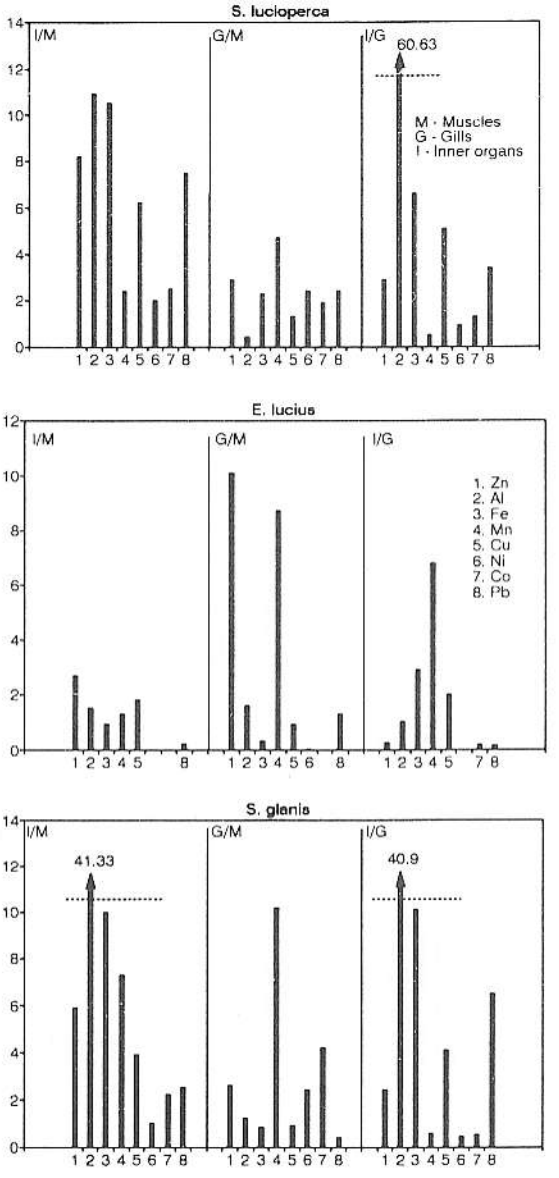

Fig. 6. Ratio of some heavy metals between organs in predatory fish.

By investigating heavy metals concentration in similar backwaters Alpár and Lakitelek, Fekete (1984) also found highest values for Cu, Zn, Fe and Mn in water. Fügedi and Fekete (1980) examined content of heavy metals in water and mud in Hungarian part of Tisza, also finding highest values for Cu and Zn, mostly at mouths of affluents, while László and Berta (1981) found also high concentrations of Fe on the same area.

Conclusion

By the analysis of ways and final locations of certain heavy metals deposition in tissues and organs of fish from Backwater Tisza, it can be concluded that most of them are accumulated in high concentrations in internal organs (spleen, liver, kidneys, gonads). Lower concentrations was found in gills, and the end of this sequence are muscles, where most of heavy metals are least deposited. Predators are exception, especially *E. lucius*, where in muscles and gills higher concentration was found for Ni, Pb, Co and Zn.

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THE RESULTS OF PRELIMINARY INVESTIGATIONS OF AQUATIC VEGETATION IN THE REGIONAL PARK "STARI BEGEJ"

B. Butorac and V. Stojsic

Butorac, B. and Stojsic. V. (1992): The results of preliminary investigations of aquatic vegetation in the Regional Park "Stari Begej". - TISCIA 26,29-36.

Abstract. Complex data about the flora and vegetation of the Regional park "Stari Begej" are not existing in botanical literature. Fragmentary elaborations are only on vegetation of Carska bara, Vojtina mlaka and Mala bara (Gigov and Djerfi, 1960). According to these authors, aquatic macrophytes form three communities of the alliance *Potamion (Potamogetonion)* W. Koch 26 emend. Oberd. 57 of the order *Potametalia* W. Koch 26 and class *Potametea* Tx. et Prag. 42 in these marshes. The latest investigations of Carska bara, Vojtina mlaka including the riverbed of Stari Begej and the low parts of zone flooded by it indicate, that in the Regional park "Stari Begej" developed are also formations of smallest flowering plants: *Wolffia arrhiza, Lemna minor, Lemna trisulca, Spirodela polyrrhiza* and others. Formations of association alliance *Lemnion minoris* W. Koch et Tx. ex. Oberd. 57 of the order *Lemnetalia* W. Koch et Tx. ex Oberd 57 and class *Lemnetea* W. Koch et Tx. ex Oberd. 57 are in question.

Keywords: backwater, community composition, duckweed.

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Introduction

The area of Regional park "Stari Begej" is located in Banat (Eastern Vojvodina), comprising a complex of marches, swamps and willow grooves at the river mouth of Begej into Tisza. According to Ham (1975), low terrains are in question (72.00-74.00 m altitude) which were regularly flooded in the past during high waters. A partial regulation, by erecting embankments and some other hydrotechnical objects, was made at the beginning of this century.

However, basic changes in the ecosystem arose after serious works in the period 1971-1974. At that time, the river Begej was partitioned at its 15th kilometer, a new embankment was erected east of the old riverbed and the flow of Begej was directed through the new riverbed (resp. canal), so that a part of Stari Begej was completely cut-off for about 10 km from Tisza and Begej.

The components of this mosaic marshy biotope are Carska bara, Vojtina mlaka, Tiganjica, Zagnjenica, Perleska bara and Stari Begej itself.

This area, (especially Carska bara and Vojtina mlaka) is mostly known by its birds, however its vegetation also deserves full attention.

The complex features of the micro- and mezorelief (shallow and deeper depressions, separated by elevations - so called "beams") and in connection with this the regime of underground and flood waters, were contributed to the presence of almost all types of vegetation: aquatic, marshy, swampy meadow and forest vegetation. Depending on actual synecological conditions, each of the mentioned types is divided into particular communities. Up till now, only the vegetation of Carska bara, Vojtina mlaka and Mala bara (Gigov and Djerfi, 1960) were fragmentarily elaborated in botanical literature for aquatic and swampy habitats, including phytocenological analyses of willow grooves. With regard to the above mentioned newly created water regime in the lower flow of Begej, and the fact that the two mentioned authors did their researches 30 years ago (prior to the newest hydro-regulation), it was expected to notice many changes of the vegetation in these three marshes.

Material and methods

The investigations of the vegetation were carried out in the years 1989 and 1990, so the results should be considered as preliminary.

The phytocenological samples were taken with Swiss-French method (Braun-Blanquet, 1921).

The collected plant material was determined according to Flora of Serbia (1970-1986) and Jávorka (1934), while in disputable cases on the basis of Soó's (1964-1980) diagnoses. The nomenclature was taken from the above mentioned Flora of Serbia. The floral elements were quoted according to Gajic (1980). Ecological indexes were given according to Landolt (1977) and corrected according to Soó (1964-1980). Life forms for all ascertained species were interpreted according to the above author.

Results and discussions

On this occasion, we shall describe only the macrophytic vegetation, being the first in the ecological line. According to Gigova and Djerfi (1960) in Carska bara, Vojtina mlaka and Mala bara, aquatic plants form three phytocenoses of the alliance *Potamion (Potamogetonion)* W. Koch 1926 emend. Oberd. 1957 (order *Potametalia* W. Koch 1926 and class *Potametea* Tx. et Prsg. 1942). However, the latest investigations of Carska bara, Vojtina mlaka, including the riverbed of Stari Begej and the low parts flooded by it when the water from fish pond is let out for cleaning purposes, show that in the Regional Park "Stari Begej", also formations of the association alliance *Lemnion minoris* W. Koch et Tx. ex Oberd 1957 of the order *Lemnetalia* W. Koch et Tx. ex Oberd 1957 and class *Lemnetea* W. Koch et Tx. ex Oberd 1957 developed. Formations of smallest flowering plants are in question, in which the following species could be found as regular elements: *Lemna minor, Lemna trisulca, Spirodela polyrrhiza* and especially *Wolffia arrhiza*. The later herbaceous species is a newcomer in our flora. This was one of the reasons why we present the results of preliminary investigations of the aquatic vegetation in the Regional Park Stari Begej, in order to draw attention to formations of a community edificator of which is *Wolffia arrhiza*.

Data given here represent first findings of this species not only in the investigated protected area, but also in this part of Banat in general. For this reason, we wish to emphasize data about the spread of this species in Vojvodina.

a) Chorologic data for the species *Wolffia arrhiza* (L.) Wimm

In the shallow, stagnant, warm waters of the Regional park "Stari Begej", which are getting completely dry from time to time, we have found a tiny floating plant, which at first glance looked like scattered seeds. It was covering the water like a greenish carpet. We have noticed that its upper part is slightly convex and that at the back side there is a small pit. There was duck weed *(Wolffia arrhiza)* in question, a plant of tropical parts of Asia and Africa, spread also in Philippines, Jawa, Australia, Western and Southern Europe (Blecic, 1976).

First data about the arrival of this species to Vojvodina were given by Degen (1910) for Pancevo, based on plant material collected by Simonkai. In Mostonga, near Bac, it was discovered by Unger (1916) and in Deliblato sand by Kosanin (1930) - (Becarevic, 1953). The first two localities were mentioned by Jávorka (1925). Botanists who performed detailed floristic investigations in the area of todays Vojvodina, at the beginning of this century, did not mention the presence of this rare plant in swampy and aquatic flora (Kupcsok, 1915; Prodán, 1916; Kovács, 1929). The year 1951 can be considered as that when duck weed appeared in the vegetation of this part of the Pannonian plain, however, it should be concluded that the findings of this species were very rare at that time. Becarevic (1951) recorded it in a swamp at Sremski Karlovci (opposite the Railway station) and in 1953 in one canal in Novi Sad-Kac swampy area. Three years later, Slavnic confirms these two findings and gives three new localities: Petrovaradin-Karlovci marshy area, Gajica bara (filled-in canal), Obrovac and "Galad" between Kikinda and Basaid.

In his work "Contribution to the flora of Backa" Atanackovic (1958) does not mention the species *Wolffia arrhiza*. The same relates also to the works of Canak and Dokic (1969, 1970) and Parabucski (1972, 1973). The flora of Petrovaradin-Karlovci marshy area is elaborated by Obradovic and Butorac (1975) and Vukoje (1979), but they do not confirm the findings of Slavnic. This is in accordance with the opinion of Obradovic (1966, 1978) that this smallest flowering plant is in retreat in some habitats in Vojvodina.

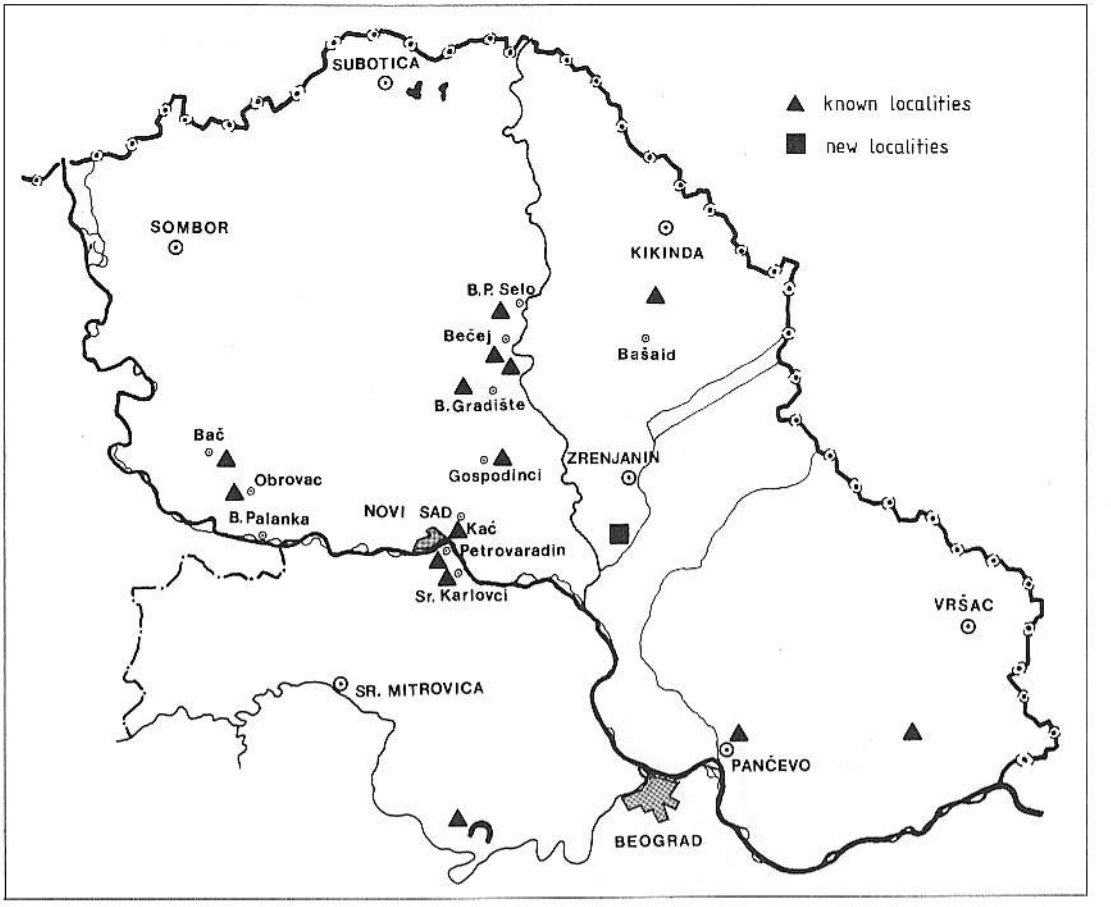

Fig. 1. Distribution of the species *Wolffia arrhiza* (L.) Wimm. in Vojvodina province

Soó (1973) mentions the species *Wolffia arrhiza* for some parts of Hungary, where it is massively spread, since it reproduces vegetatively. In Europe it has an Atlantic-Mediterranean character, while in Hungary it is a neophyte. This coincides with the understanding of Obradovic regarding some newly recorded habitats in the Vojvodina part of the plain. Our opinion is that while it retreats in the southern part of the Pannonian plain, it appears massively on newly recorded places in Vojvodina and Serbia. Canak and Dokic (1968) have ascertained it in a swamp at Mala Krsna in Serbia, Blecic (1976) records it near Belgrade, Babic and Parabucski (1971) in Jegricka at Gospodjinci.

These data are interesting, since they show that *Wolffia arrhiza* (according to some authors even a relict plant) is successful in gaining new habitats. So, Vukoje (oral report in 1980) ascertains this species in Backa, at the following localities: branch of dead Tisza-"Medenjaca" at Stari Becej, a canal on "Medenjaca", "Ilidza" swamp at Backo Gradiste and its canal towards the canal "Becej-Bogojevo" and in the canal Backo Petrovo Selo-Becej. The spread of *Wolffia arrhiza* is possible only on such places where the slow waterflow, low water level, water eutrophication and others, are dominant factors, for the development of duck weed.

This is supported by our newest findings of this species in the area of "Stari Begej" at the following places: Vojtina mlaka in shallow depressions; several separated places in the Stari Begej floody areas (between the riverbed and old embankment, opposite Zagnjenica); between the riverbed of Stari Begej and the old embankment (opposite Palenita Greda); (see Fig. 2.).

These data indicate that duckweed is not such a rare plant of stagnant waters supplementing the areal of *Wolffia arrhiza* in Banat, Vojvodina and the Pannonian plain in general being of scattered

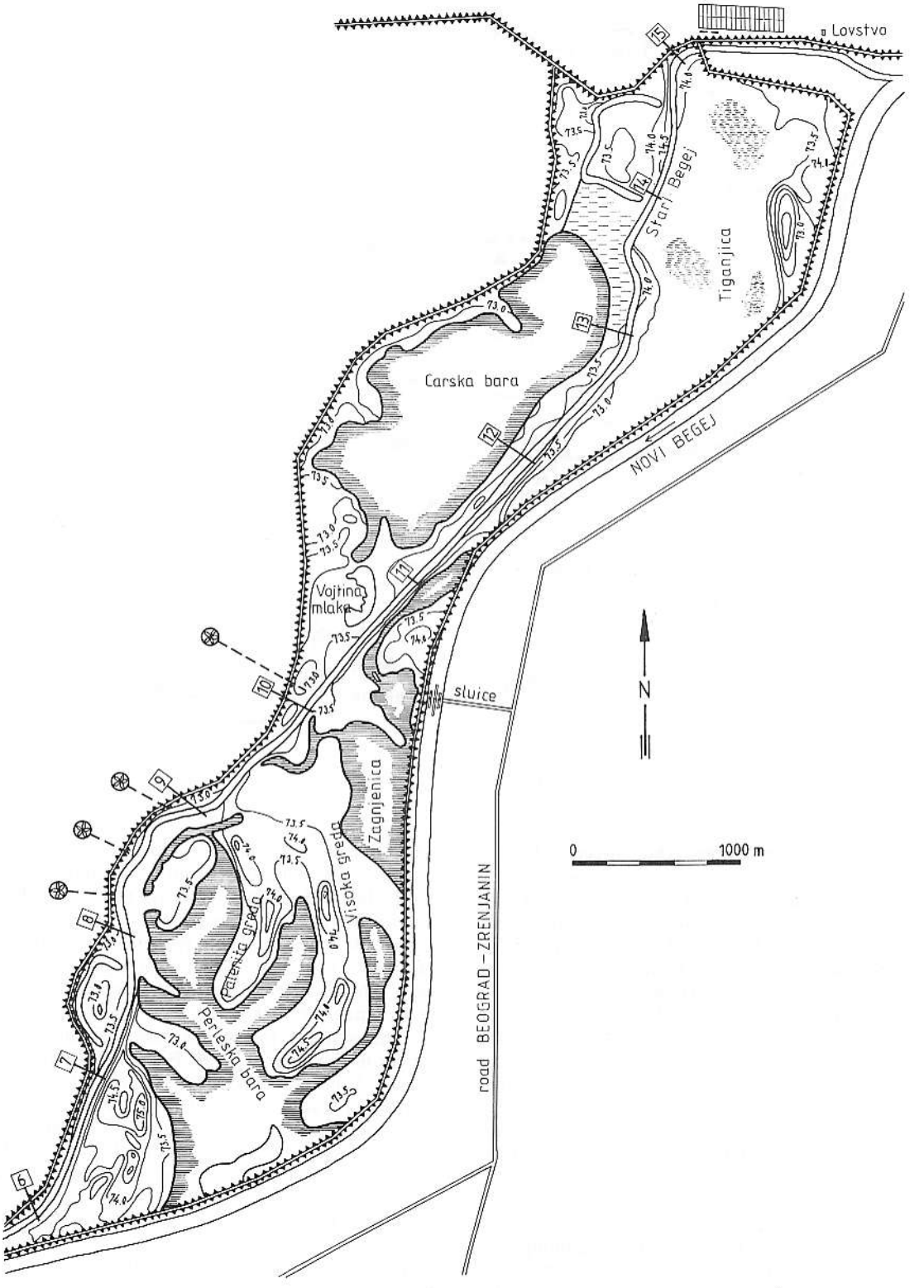

Fig. 2. Distribution of the community *Wolffietum arrhizae* in Regional Park "Stari Begej".

character. In the Flora of Serbia (1976 and 1986) except the findings in Vojvodina, near Belgrade, duckweed is mentioned by Domac (1973) for the areas of Serbia and Croatia, but no localities are mentioned. Data about the introduction of the species *Wolffia arrhiza* in the flora and vegetation of Croatia are given also by Jávorka (1925) for the vicinity of Rijeka; Hulina (1973, 1989) for the vegetation of Turopolje; Trinajstic and Trinajstic (1988) for Krapje Djol on the left bank of Sava, west of Jasenovac; Persin (1988) for marshes in Ilovac (region of Karlovac); Topic (1989) for the vegetation of Kopács meadow.

This smallest flowering plant was also ascertained in the aquatic vegetation of Slovenija (Seliskar, 1983) in stagnant tributaries near Petanjci in Pomurje (Jez and Skoberne, 1986).

The mentioned chorologic data are interesting. Becarevic (1953) for instance classifies the species *Wolffia arrhiza* as a Mediterranean plant in a wider sense, although the majority of authors here and all over the world treat it as cosmopolitan. Obradovic (1966, 1978) stresses that this taxon is of relict character in the Pannonian plain, i.e. it is a rare plant in retreat, but that it belongs to the Atlantic-Mediterranean floral elements. We are inclined to accept the opinion of Soó, that a neophyte species is in question, because from 1953 to 1980 a great number of new habitats were recorded (on Fig. 1. marked as ▲).

However, investigations in the last ten years have shown that in accordance with changed synecological circumstances of the habitat on some of these localities, *Wolffia arrhiza* is not developing any more, but that it succeeded on some new localities on the same reasons (Fig. 1., marked as ■).

b) Vegetation data with the dominant role of species *Wolffia arrhiza*

On the investigated area of the Regional park "Stari Begej", duckweed appears in combination with species from the family *Lemnaceae: Lemna minor, L. trisulca* and *Spirodela polyrrhiza*.

The number and coverage of particular herbaceous species are the consequence of newly created circumstances in the habitat. Formerly a typical marshy-swampy biotope, later it was artificially changed by channeling a part of Begej, by cutting-off part of Begej from Tisza and Begej, and by erecting a dam. Due to this changes wetting and flooding was reduced. The changed and regulated nature of flooding, low terrains have caused the appearance of formations which floristically fits mostly the ass. *Wolffietum arrhizae* Myawaki et J. Tx. 1960 during the last years by alternation of the intensity of drought and a warm season. Since this community is separated in Mid Europe and as Slavnic (1956) states in Vojvodina, in the most shallow warm waters are developing formations which in Holland are described under the name *Wolffio-Lemnetum gibbae* Bennema 1943, this statement looks discussible at first glance. Adding to this, the fact that in their survey of aquatic macrophyte phytocenoses, formations in which *Wolffia arrhiza* has an edificatory role are mentioned under this last name by Otti (1973), Soó (1973), Parabucski et al. (1986) and others. However, Runge (1980) records them as two completely independent associations in the syntaxonomic location of plant communities in Mid Europe: *Wolffietum arrhizae* and *Lemnetum gibbae* (W. Koch, 1954) Myawaki et J. Tx. 1960. The later phytocenosis was proved also in Soviet Union (Mirkin 1986). Seliskar (1983) has a third approach to this problem, who shows formations with *Wolffia arrhiza* within the association *Lemno-Spirodeletum polyrrhizae* W. Koch 1954, and its sub-association *wolffietosum arrhizae* Segal 1965, respectively, stressing that it is perhaps more logical to classify formations with the domination of duckweed as independent associations *Wolffio-Lemnetum gibbae*, and *Wolffietum arrhizae*, respectively. This is confirmed by the viewpoint of authors who have separated the mentioned communities, and would justify our opinion based on field data and on phytocenologic separation of macrophytes of the alliance *Lemnion minoris* according to Runge and Mirkin, respectively. However, Soó (1973) gives the name *Wolffietum arrhizae* as a synonym for the ass. *Wolffio-Lemnetum gibbae* in the syntaxonomic survey of vegetation units for Hungary, that points to some new moments. Evidently, in the sense of classification, there are still some problems to be solved. The latest data for the Hungarian part of Tisza (Szalma and Bodrogközy, 1985) indicate that the community *Wolffietum arrhizae* was found in a backwater in the area of the village Bokros, as well.

Regardless to all above stated, to the adequacy of nomenclature, or giving some other names the community, the question belonging to an alliance is still pending. Namely, viewpoints differ in the phytocenological separation of the order *Lemnetelia* (*Lemnetea* class). The majority of authors classify phytocenoses with duckweed into the alliance *Lemnion minoris* (Hulina, 1973; Runge, 1980; Mirkin, 1986; Parabucski et al., 1986; Topic, 1989; and others). To the contrary, Slavnic (1956) describes the ass. *Wolffio-Lemnetum gibbae* within the newly separated alliance *Lemnio-Salvinion natantis* Slavnic 1956, which he gives a synonym: *Hydrocharition* (Rubel) Vierch p.p. This is not in accordance with the classification of Soó

(1973), who differentiates the communities of alliance *Lemnion* and the communities of the alliance *Hydrocharition* in the order *Lemnetalia*, adding also a new alliance *Ceratophyllion*.

In the Regional park "Stari Begej" (Fig. 2.), in Vojtina mlaka and on three other localities in the floody area between the embankment and Stari Begej, formations of the smallest flowering plants developed: *Wolffia arrhiza, Lemna minor, L. trisulca* and *Spirodela polyrrhiza*. Considering this, it can be said that communities are in question from the alliance *Lemnion minoris* W. Koch et Tx. ex. Oberd 1957.

Comparative analyses of these formations with those of communities *Wolffio-Lemnetum gibbae, Lemno-Spirodeletum polyrrhizae wolffietosum arrhizae* and *Wolffietum arrhizae* made in Yugoslavia, Hungary and Mid Europe within the same alliance, has shown that they are nearest to the last phytocenosis. This suggests in a way all the above stated and that some species found by Slavnic (1956) in the ass. *Wolffio-Lemnetum gibbae*, in the area of Vojvodina are now missing. Although Slavnic has recorded the mentioned phytocenosis in shallow, warm swamps in Vojvodina, getting dried-off in the most part of the year, being similar to those in the floody region of Stari Begej, after the regulation of the water regime, certain differences were nevertheless ascertained.

These differences were getting bigger due to high air temperatures in the recent years.

The formations of ass. *Wolffietum arrhizae* recorded in the vegetation of Regional park "Stari Begej", were of a poorer floristic composition (total of 4 species). As their edificator, we distinguished *Wolffia arrhiza* (duckweed), present in all formations with a maximum abundance and coverage. A sub-edificatory role belongs to *Lemna trisulca*, a species having cosmopolitan spread. It is at the same time a characteristic species of the alliance *Lemnion minoris*. Of the same importance are *Lemna minor*, and only in some formations *Spirodela polyrrhiza*. The mentioned duckweed *(L. trisulca)* in a specific way lives in a place, which by Jankovic (1974) was marked as a phenomenon of pseudo-floating. As a submersive plant, completely submerged in water below its very surface, it looks like a floating plant. By its mass and density, it is influencing the physiological processes in the deeper layers of water. Such a layerwise arrangement is the result of specific ecological features of these sciophyllous, and floating above them, heliophyllous species. *Lemna gibba* is completely absent also from these formations as well as from ass. *Wolffietum arrhizae* from Mid Europe (Runge 1980). This relates also to the aquatic vegetation of stagnant tributary around the river Mura (Seliskar 1983). It is interesting that these relatively distant formations from Slovenija (Pomurje) are identical with the investigated formations in Banat.

Comparison with the formation of ass. *Wolffio-Lemnetum gibbae* (Slavnic 1956) indicates considerable differences. Slavnic records a total of 13 species in phytocenelogical table, among which there are all the four plants ascertained by us in the ass. *Wolffietum arrhizae*. However, their importance and coverage values indicate some specificities. In contrast to the analyzed, almost homogenous formations in the community *Wolffio-Lemnetum gibbae* (Obrovac, Kacki rit, Petrovaradin-Karlovci marsh, Galad between Kikinda and Basaid - according to Slavnic) dominant species is *Lemna minor*, while co-dominants are: *L. gibba* (connected only with this ass.) and *L. trisulca*. The first one was ascertained with a IVth grade constacy (1-5).

All three duckweeds are very important both floristically and physiognomically.

Characteristic species for the community is also *Wolffia arrhiza* (III_{3-4}), however Slavnic mentions this cosmopolitan only as inclined to this phytocenosis.

The species of the alliance *Lemnion minoris* are well represented. Beside already mentioned species of the genus *Lemna*, both characteristic species of the association appear as well.

Salvinia natans, and taxons of special importance for the order *Lemnetalia minoris* as well *(Ceratophyllum demersum, Myriophyllum spicatum* and *Hydrocharis morsus-ranae)*, are of differential character in relation to the formations ascertained in the investigated Regional park "Stari Begej". There are in this sense accompanying plants of high size: *Phragmites communis, Polygonum amphibium, Glyceria aquatica* and *Rumex limosus*.

Slavnic (1956) ascertains these mentioned formations of small aquatic flowering plants always near places covered with reeds or inside them. On floody terrains around Stari Begej, we rarely met duckweed near reeds. It mostly lives on places of spread shallow waters, under lonely willows, most frequently next to formations of ass. *Sparganio-Glycerietum fluitantis*.

Comparative analyses of ecological indexes (Tab. 1) according to Landolt (1977), between the analyzed phytocenosis and ass. *Wolffio-Lemnetum gibbae* Slavnic 1956, indicate some differences. They are not significant and refer to the presence of organic matters and light factor index. The formations in Stari Begej, compared with the habitat of floating flowering plants recorded by Slavnic, have less nutritive material, especially

nitrogen (N= 2.75:3.46), while the influence of light is more expressive (L= 4.20:3.76) so that these formations are rich with heliophytes. No species living in sodic habitats were recorded either in the communities of Regional park "Stari Begej". Halophytes are poorly represented in the formations by Slavnic, since he in fact describes the vegetation of shallow salt marshes. In the investigated area of Stari Begej and Carska bara, the analyzed formations were formed by tiny floating flowering plants, for which Landolt does not give indexes for the quantity of humus in the substrate and data about the dispersion of ground, what is understandable considering their eco-morph. For that reason, these rows are empty in the 1st column of table. To the contrary, also plants of high size are present (*Phragmites communis, Glyceria maxima* and others) in the vegetation of shallow warm marshes in Vojvodina (according to Slavnic), that is why the humus content index is 3,00. Question about plants living on waterproof, very compact soil (particles smaller than 0.0002 mm) is very proved by the dispersion value of 4.85. It is evident that this abiotic factor has no importance on the appearance and survival of floating macrophytes in the waters of Regional park "Stari Begej".

Tab. 1. Comparative survey of ecological indexes according to Landolt (1977).

Index	Ass.Wolffietum arrhizae (Stari Begej Carska bara)	Ass.Wolffio-Lemnetum gibbae (Vojvodina)
F	5	4.92
R	3	3.30
N	2.75	3.46
H	-	3.00
D	-	4.85
S	-	11 (-), 2 (+)
L	4.20	3.76
T	4.20	4.23
K	2.50	2.54

Regarding life forms, there are some differences which are in correlation with the floristic structure. All the species of the analyzed phytocenosis belong to the aquatic floating and pseudofloating plants, while also heliophytes appear in the formations of ass. *Wolffio-Lemnetum gibbae*. This has an essential reflection on the values of ecological indexes.

The similarity index according to Sørensen between the analyzed communities in the Regional park "Stari Begej" and: - Wolffio-Lemnetum gibbae (Vojvodina: Slavnic) = 47.05%; - Wolffietum arrhizae (Kopács meadow: Topic) = 61.53%; - Wolffietum arrhizae (Hungary: Szalma) = 66.66%; - Wolffietum arrhizae (Mid Europe: Runge) = 66.66%

These percentages confirm the accuracy of the above stated assertions.

Conclusion

The latest investigations of Carska bara, Vojtina mlaka, including the riverbed of Stari Begej and low parts flooded by it, show that also the formations of smallest flowering plants: *Wolffia arrhiza, Lemna minor, Lemna trisulca, Spirodella polyrrhiza* and others are developed in the Regional park "Stari Begej". Formations of association alliance *Lemnion minoris* W. Koch et Tx. ex Oberd 1957, of the order *Lemnetalia* W. Koch et Tx. ex Oberd 1957, from the class *Lemnetea* W. Koch et Tx. ex Oberd 1957 are in question.

The comparative analyses of these formations with the formations of *Wolffio-Lemnetum gibbae* Bennema 1943, *Lemno-Spirodeletum polyrrhizae* W. Koch 1954 *wolffietosum arrhizae* Segal 1965 and *Wolffietum arrhizae* Myawaki et J. Tx. 1960, ascertained in Yugoslavia and Mid Europe within the same alliance, has shown that they are closest to the last phytocenosis. However, according to phytocenological literature, the characteristic aquatic vegetation in Vojvodina are the formations of *Wolffio-Lemnetum gibbae* Bennema 1943 (Slavnic, 1956; Parabucski et al., 1986 and others).

Having in mind absence of some species, which were discovered by Slavnic in this phytocenosis of shallow warm marshes in Vojvodina, getting dry for the most part of the year, and the specific ecology of formations in the investigated area (due to reduced intensity of flooding because of regulated water regime of Stari Begej and on the other hand due to exceptionally high temperatures in the recent years), it is evident that the aquatic habitats of Regional park "Stari Begej" are covered by floating formations of the community of smallest flowering plants, which Myawaki and Tüxen described in 1960 under the name *Wolffietum arrhizae*.

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SPECIFICITIES IN THE VEGETATION OF UNPROTECTED BAND OF RIVER TISZA

B. Butorac , S. Stojanovic and V. Stojsic

Butorac, B., Stojanovic, S. and Stojsic, V. (1992): Specificities in the vegetation of unprotected band of river Tisza. - TISCIA 26,37-41.

Abstract. This paper contains data obtained by following the changes in floristic composition of the association *Thymo-Chrysopogonetum grylli* Stojanovic (1981) 1983 (subass. *stipetosum capillatae*) on the slopes and the clefts of Titel plateau, near river Tisza. Five new species were found in the structure of this steppe phytocenosis. Two of them were found for the first time on Titel plateau: *Prunus tenella*, which exists only on a few localities in Vojvodina and east Serbia, and *Ornithogalum refractum*, which is spread in Serbia, but was recorded in Vojvodina only in three localities. In this paper, new data are given about two forms of low iris: *Iris pumila* .
Our examinations point out to wider spreading of *Adonis vernalis*, *Vinca herbacea*, *Iris pumila f. pumila* and *f. lutea* in the flora of Titel plateau and their high density within the alleged association. These results complete the review of floristic composition of the association *Thymo-Chrysopogonetum grylli*, indicate the habitat's synecological conditions and are important because all species, except of *Ornithogalum refractum*, are protected as natural rarities and are on the list for Red data book of the flora in Serbia.

Keywords: flora, Red book, Titel plateau, vegetation

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Introduction

The steppe vegetation is represented with the alliance *Festucion rupicolae* Soó 1940 developing on the steep slopes and in the clefts of Titel plateau and is a specificity of the unprotected Tisza band. Titel plateau is a loess plateau in southern Backa. Bukurov (1953) divides it into two altitude entities: the western lower part (110-120 m) and the eastern one, closer to River Tisza, with the approximate altitude of 130 m. The eastern and the northeastern parts of Titel plateau near Tisza have more or less deep chernozem soil, where influence of basic rock is more expressed. Because of the high $CaCO_3$ content inthe soil, deep underground waters, periodical torrents and permanent foundation sapping by Tisza water, the process of loess erosion is expressed, producing different geomorphological forms: the slopes and the cliffs of a height 30-50 m, the loess pyramids, the "shelves" and the clefts.

Very steep, sometimes even vertical cliffs and clefts, descending to River Tisza, are the most unaccessible parts of Titel plateau and because of that they are mostly out of human and zoogenic influence, which made possible the survival of the original vegetation. On these terrains, there were followed the changes in floristic composition of the subassociation *Thymo-Chrysopogonetum grylli stipetosum capillatae* which, as well as the association itself, was distinguished and described by Stojanovic (1981; 1983).

The association *Thymo-Chrysopogonetum grylli* is the basic steppe community of Titel plateau. It develops on more or less level or more inclining slopes, at the altitude of 111 to 130 m, mostly on the sites close to the plateau itself, on chernozem soil. Compared with other steppe communities, it is characterized by the following species: *Euphorbia glareosa var.lasiocarpa, Thymus marshallianus, Festuca rupicola, Allium rotundum ssp. waldsteinii, Falcaria vulgaris,* and *Convolvulus cantabricus*. Furthermore, it is characterized by a complex stratified structure, high density, and pronounced seasonal dynamics. It incorporates highly variable floral elements. The dominant species are the representatives of the Pontic-

Central Asian group, including the Pannonian endems *Centaurea scabiosa ssp. sadleriana* and *Dianthus pontederae*, as well as the representatives of the Pontic-Pannonian group including character species of the association (*Euphorbia glareosa var. lasiocarpa, Thymus marshallianus, Allium rotundum ssp. waldsteinii, Convolvulus cantabricus*) which give the community the Pannonian appearance (Stojanovic, 1983).

The association includes two subassociations: *Thymo-Chrysopogonetum grylli typicum* and *Thymo-Crysopogonetum stipetosum capillatae*. The elements of the former subassociation develop in favourable condition on the horizontal or slightly inclining hillsides, at the altitude of 111 to 125 m, in the western, northwestern, and southwestern parts of Titel plateau. The soil is a deep and well-developed chernozem soil.

The later subassociation develops on the sharply inclined, in some cases almost vertical, slopes exposed to the sun, at the altitude of 117 to 130 m, on a shallow or eroded chernozem. It is then not surprising that these sites host a number of pronouncedly xerothermic plant species: *Stipa capillata, Festuca valesiaca, Potentilla arenaria, Xeranthemum annuum, Petrorhagia saxifraga, Verbascum lychnitis, Erysium diffusum* and *Echium italicum*. These are also the differential species of the subassociation (Stojanovic, 1983).

Material and methods

The phytocenological analyses took place during 1990 and 1991 on Titel plateau, after Swiss-french methods of Braun-Blanquet (1921).

Collected plants were determined after Flora SR Srbije (1970-1986) and Jávorka (1925, 1934) and, in controversal cases, on the basis of the diagnosis after Soó (1964-1980). Syntaxonomic status of the species, as well as some ecological indices, are given after Soó (1964-1980). The majority of the ecological demands were taken from Landolt (1977). The nomenclature was quoted after Flora SR Srbije (1970-1986).

Results and discussion

Our investigation shows that in the stands of the subassociation *Thymo-Chrysopogonetum grylli* Stojanovic (1981) 1983 *stipetosum capillatae* Stojanovic (1981) 1983 there are even five new species: *Adonis vernalis, Vinca herbacea, Iris pumila, Prunus tenella,* and *Ornithogalum refractum*.

Adonis vernalis L.

This species is a Pontic-Central Asian floral element. It is a remnant of the steppe vegetation from the xerothermic period of the Postglacial (Boreal). The transformation of the steppe soil (chernozem) into the cultivated soil, the erosion of the loess clefts near River Tisza (and also Danube), the spreading of the human settlements reduced the habitats of this plant on fragments. Although this species appears on several localities in Serbia and Vojvodina with a disperse areal, it is vulnerable because its habitats are endangered. This species is protected in Serbia and is on the list for Red data book of the flora of Serbia.

First report about the appearance of *Adonis vernalis* into the flora of this plateau, on the unaccessible loess slope near Titel settlement, was given by Stanojev and Boza (1984). These authors reported a limited dispersal of this species. Today, *Adonis vernalis* appears north from Titel to Perkovcov cleft near River Tisza and around the clefts Zmijnjak, Dukatar, Makaricev cleft and Keljin cleft with a density of about twenty stems per locality. Exceptionally dense populations, with about a hundred stems were discovered between Keljin cleft and Dukatar cleft (see the map on which the size of the circle is adequate to the size of the population).

Vinca herbacea W. et K.

First report about the presence of *Vinca herbacea* in Titel plateau was given by Stanojev and Boza (1984). They found this plant in the surroundings of Titel. Our investigations confirm those data (see Fig. 1.). The additional data about spreading of this species are related to the stands of the gentle slopes of Titel plateau, between Makaricev cleft and Demljakov cleft, Lacov and Rogulicev clefts and around the cleft Dukatar. This species is a Pontic-Pannonian floral element and is a Boreal relict. This species is protected by law in Serbia as a natural rarity and is on the list for the Red data book of the flora in Serbia as a relict. This plant is a distinctive species of the steppe vegetation of the alliance *Festucion rupicolae* on the sand and the loess. In Vojvodina this species appears in a dispersed areal (Subotica-Horgos sandy plain, high eastern loess bank of Ludas, Rimski sanac, Titel plateau, Sajkas-Kovilj, Fruska gora and Deliblat sandy plain). This species was found in the surroundings of Beograd (Kosutnjak, Visnjicka kosa) and Kragujevac, on Rujan mountain (southern Serbia) and on a few localities in southern Serbia.

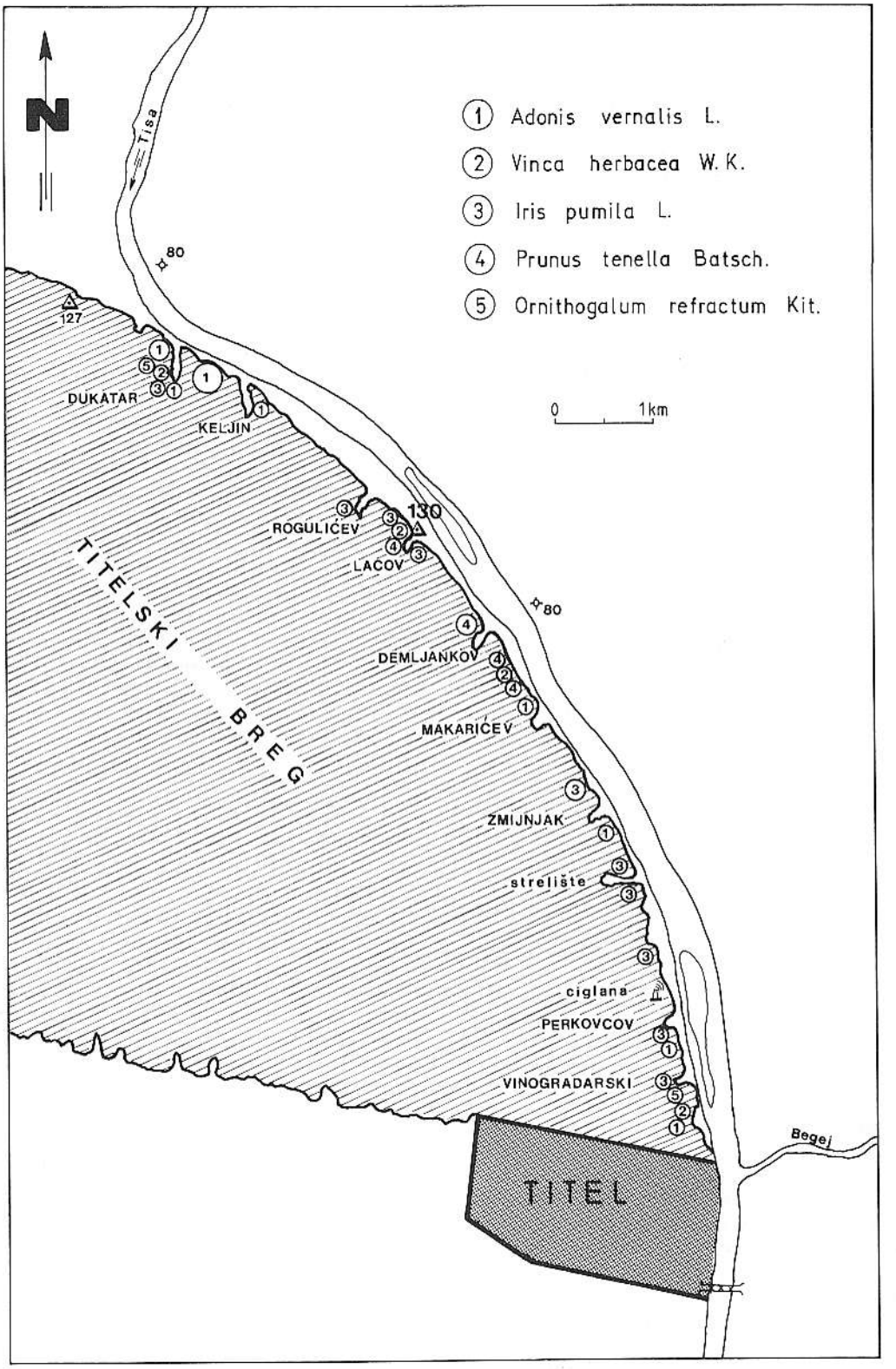

Fig. 1. Research area along river Tisza.

Iris pumila L.

Only a typical subspecies of *Iris pumila* appears in our country, the *ssp. pumila*. Appearance of this species in the vegetation of Titel plateau was observed by Obradovic and Budak (1980) on only one locality near Titel. These authors recorded the matter about *Iris pumila ssp. pumila* and *var. pumila* with its forms: *pumila* which characterized by the violet flowers, and *lutea* which characterized by the bright-yellow to cream-yellow flowers. The appearance of only these subspecies was confirmed by Igic (1988). The result of our investigations is the discovery of two new forms in the flora of Titel plateau: *f. flaviflora*, with dark-yellow flowers, and *f. atroviolacea*, with dark-violet to almost black flowers. All forms appeared in relatively dense populations. Except of the plateau, the forms of this species appear on the almost vertical cliffs descending to River Tisza and on the sides of the clefts faced toward the South. The forms of this species were present in the plant cover of all clefts descending to River Tisza, except Makaricev, Demljankov and Keljin cleft.

Like the previous two species, this one is also protected as a nature rarity and listed for Red data book of the flora in Serbia, as vulnerable.

In Serbia, *Iris pumila* appears on Suva mountain and in the surrounding of Aleksinac (Leskovik), whereas in Vojvodina its areal is disjunctive. In comparison with *Vinca herbacea* this species is wider spread. It appears on adequate sites of Fruska gora, Deliblat sandy plain, Subotica sandy plain, Titel plateau, Vrsac mountain, Telecka but also on the poor sodic soil of the lowland. This species is, in the phytogeographic sense, the Pontic-Central Asian floral element, belongs to the group of the steppe and meadow-steppe plants. It is indicator of the dry continental climate and the xerophylic character of the vegetation.

Ornithogalum refractum Kit.

This newly found species grows on pastures, in forest clearing and on uncultivated soil of hills. *Ornithogalum refractum* is wider spread in Serbia and because of this it is not a natural rarity for this territory, but in Vojvodina this species is listed as rare. On the basis of the literary data (Obradovic, 1966) this species was found toward the last century in the surroundings of Zemun, and in the middle of this century on only one locality in Fruska gora (Cerevic). The data of this author point out, that it is a Balkan-Caucasian species according to Soó and Jávorka (1951). According to Gajic (1980), this species is a Pontic floral element, but according to Soó (1973) it is a Southeastern European floral element.

Our findings of this species in the vegetation of Vinogradar cleft are first data about the appearance of *Ornithogalum refractum* in the flora of Titel plateau and first description of this species in the structure of the subassociation *Thymo-Chrysopogonetum grylli stipetosum capillatae*.

Prunus tenella Batsch.
(P. nana Stockes, Amygdalus nana L.)

This species was not known in the flora of Titel plateau till our discovery. The low bushes of Russian almond cover almost completely the sides of Demjankov cleft painting them pink when they are in bloom, in spring. This species was found on the plateau between Demjankov cleft and Makaricev cleft as well as in Lacov cleft.

In Vojvodina this species has a dispersed areal (a few localities on Deliblat sandy plain, on Fruska gora only near Beska, on Rimski sanac and now on Titel plateau). *Prunus tenella* is a Pontic-Central Asian floral element. In Serbia except the mentioned localities in Vojvodina, it appears in thew shrubberies with steppe elements (ass. *Artemisio-Prunetum* Jov.) on limestone massifs of eastern Serbia. Like other species, survival of which is endangered, the species is on the list for Red data book of the flora in Serbia, in the category of the vulnerable species. It is protected as a natural rarity which spontaneously vanishes.

Ecological characteristics of species

Common for all five species is that they are indicators of the very dry and the dry grounds. Namely, the humidity index (F - after Landolt, 1977) is from 1 to 2. These species are the bioindicators of oligotrophyc soils (N 1-2) with a strong basic reaction (R 5). Regarding the temperature regime, these species are the indicators of moderately thermophilic (T3) and thermophilic (4) habitats. This is in accordance with the expressive climatic extremes on the steppe loess cliffs facing the River Tisza and in the moderated micro- and mesoclimatic conditions in the clefts of Titel plateau. The syntaxonomic and the phytogeographic relations belonging to the analyzed species point to the character of *Thymo-Chrysopogonetum grylli stipetosum capillatae* stands. The species of the alliance *Festucion rupicolae* are: *Ornithogalum refractum* and *Vinca herbacea*. *Ornithogalum refractum* is a Pontic floral element whereas *Vinca herbacea* is a Pontic-Pannonian floral element. The species: *Adonis*

vernalis, Iris pumila and *Prunus tenella* are Pontic-Central Asian floral elements. *Adonis vernalis* and *Iris pumila* are the characteristic species of the ordo *Festucetalia valesiacae* but *Prunus tenella* is the species of the shrubbery (the ordo *Prunetalia*) and, in the same time, the species of the authentic forest vegetation of the alliance *Aceri tatarico-Quercion*. Beside this nanophanerophytes, the characteristic species of this alliance are the herbaceous plants: *Adonis vernalis* and *Vinca herbacea*.

All these data are important elements for the recognition of the structure of analyzed Titel plateau steppe associations, the addition to flora of Titel plateau, Vojvodina and Serbia and basic data for Red data book of the flora in Serbia.

Conclusion

In the vegetation of Titel plateau, the meadow steppe flora is especially important as a witness of historical florogenesis process. It was maintained in a more or less original form at the most unaccessible spots of this loess plateau near River Tisza. These isolated loess cliffs, the loess pyramids and the clefts are geomorphological products where the steppe vegetation is represented by the association *Thymo-Chrysopogonetum grylli* Stojanovic (1981) 1983 of the alliance *Festucion rupicolae*. The stands of the same subassociation *stipetosum capillatae* described by the same author, are indicators of the synecological conditions on the mentioned geomorphological forms. Our investigations point out to a more complex floristic composition, because we found five new species: *Prunus tenella, Ornithogalum refractum, Adonis vernalis, Vinca herbacea* and *Iris pumila (subsp.* and *var. pumila* with four forms: *pumila, atroviolacea, lutea* and *flaviflora*). Our discovery of *Prunus tenella* and *Ornithogalum refractum* are first data about appearance of these species in the flora of Titel plateau. For the other three species, a wider spreading was noted on Titel sandy plain (on the unprotected band of River Tisza) and denser populations than those recorded in the literature.

The fact that it is the matter about the species with a dispersed areal, not only in Vojvoidina but also in all Serbia (except *Ornithogalum refractum*) confirms that these discoveries have not a local character. All mentioned species, except *Ornithogalum refractum*, are protected by the law as natural rarities and are on the list of Red data book of the Serbian flora. They are categorized as endangered species by the classification of IUCN. In such a way *Vinca herbacea* is characterized as rare species (R). The species *Adonis vernalis, Iris pumila* and *Prunus tenella* are classified as vulnerable species (V), but it is considered that in the near future these species will be classified as endangered species, because of the fact that their still numerous populations and sites are exposed to negative influences in all their area.

It can be concluded that this paper is a support for the species habitat protection because protection of a single species and its genofond is not possible without the protection of its habitats.

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MICROBIOLOGICAL INDICATORS OF THE WATER QUALITY OF BACKWATER TISZA WITH SPECIAL REFERENCE TO THE OLIGOTROFIC MICROFLORA

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Gajin, S., Gantar, M., Matavulj, M., Petrovic, O., Obreht, Z., Radnovic, D. and Budakov, Lj. (1992): Microbiological indicators of the water quality of Backwater Tisza with special reference to the oligotrofic microflora. - TISCIA 26,43-48.

Abstract. Samples for microbiological water analysis of the Mrtva Tisza (the backwater of the river Tisza) were taken every two months during the period from November 1987 to September 1990.

During these investigations we estimated the total number of bacterioplankton, number of heterotrophic and facultatively oligotrophic bacteria, and enzymatic (phosphatase) activity of water. The classification of waters was carried out on the basis of number of heterotrophs, T/H index and enzyme activity of water. In addition, the morphology of oligotrophic bacteria were investigated by electron microscopy.

The obtained results revealed that water quality of the Backwater Tisza ranges from moderately polluted to fully polluted waters (II-III class). The dominant part of bacterioflora was the population of oligotrophic bacteria. Electron microscopy showed that the morphology of bacteria was effected by the concentration of nutrients in the media.

Keywords: facultative oligotrophs, microbial indicators, organic load, water.

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Introduction

Microbiological investigations of surface waters are mostly confined to sanitary aspect in the water state estimation, which are carried out by institutes of Public Health. Also, the level of the microbiological parameters are prescribed by law and regulations. These investigations are, certainly, of significance, but recent results indicate that the dominant microflora of surface water is represented by oligotrophic microorganisms. This group of microorganisms (which represents 50-90% of the total bacterioflora in surface waters) is not included by standard microbiological investigations, although, thanks to their multienzymatic nature, they participate significantly in self-purification processes of surface waters.

The study of ecological conditions in water habitats has led to the conclusion of irregularity in access to quantitative studies of water bacterioplankton by cultivation methods. Even nowadays, nutrient agar is used in routine way for cultivation of heterotrophic bacteria from water, although the results obtained by many authors: Ishida and Katoda (1977, 1979, 1981), Kuznecov et al. (1979), Ishida et al. (1980-a, 1980-b, 1982), Olsen and Bakken (1987), Stilinovic and Futac (1990), Gajin et al. (1990), and others indicate that at such investigations it is necessary to apply media poorer in nutrients than the nutrient agar.

For these facts, we decided to draw our particular attention to oligotrophs in these investigations of autochthonous microflora of surface waters. The results of classical microbiological investigations of water have been used in this paper for standard estimation of water condition.

Methods

Samples for microbiological water analysis of the Backwater Tisza were taken every two months in the period from November 1987 to September 1990, and were analyzed in the Microbiological Laboratory of the Institute of Biology in Novi Sad.

The total number of bacterioplankton was estimated applying the direct method of bacteriological filtration (Razumov, 1932) using bacteriological filters "Sartorius No 2". The number of aerobic heterotrophic bacteria was determined by cultivation on nutrient agar, and the number of oligotrophic bacteria by the same method on diluted nutrient agar (1:10, 1:100, 1:1000), as well as on medium F-5 (Ishida and Katoda, 1977).

Besides, enzyme (phosphatase) activity of water was determined on the basis of p-Nitrophenylphosphate hydrolysis (Matavulj et al., 1984).

Estimation of the condition of the investigated waters and categorization into classes were carried out according to the number of aerobic heterotrophic bacteria (Kohl, 1975), according to the level of water phosphate activity (Matavulj et al., 1990) and T/H index (ratio of the total number of bacteria and heterotrophs) values (Matavulj et al., 1989).

Morphologically different bacterial colonies grown on nutrient media were isolated and tested with respect to the requirements concerning the nutrient quantity, by transferring each isolate on the nutrient agar, also on the same but diluted medium (1:10, 1:100, 1:1000), and on the medium F-5. The capability and intensity of growth were recorded on these substrata, while the changes of morphology of bacterial strains in dependence of quantity of nutrients in media were followed by transmission electron microscopy.

Results and Discussion

The results of our three-year investigation of the Backwater Tisza water point to the fluctuation of the water quality during the year. The average values of the microbiological parameters indicate that in the most cases it was a question of the polluted waters. Most of the samples belonged to the II-III class, with the tendency of mild improvement of water quality during the three years of investigation (that should be confirmed by further investigations). We assume that this mild improvement of the water quality could be the result of measures undertaken for the protection of the waters investigated.

It can be seen from Fig. 1. that number of heterotrophic bacteria, taken as an indicator of water quality, fluctuates to a great extent depending on a season but remaining within the limits of II-III and II classes of water according to Kohl (1975). However, the percentage of heterotrophs in the total bacterioplankton, and the ratio of total bacterioplankton to heterotrophs (T/H) certainly gives more real picture. These parameters vary in the summer-autumn period, but on the other hand we obtained clearly expressed winter minimums in the percentage of heterotrophs in the total bacterioplankton, that is maximums in the T/H ratio in winter period.

Phosphatase activity of water, representing the enzyme activity of all microorganisms present in the water, point to summer or spring-summer maximums, that is to the waters which are the most loaded in spring-summer period during a year, but all values are within the limits of III-A category of water (Matavulj et al., 1988).

Values of determination of heterotrophic and oligotrophic bacteria number indicate that bacterioplankton of the Backwater Tisza water had far better conditions for growth on the substrata poorer in quantity of nutrients than on the standard nutrient agar. So, viable bacteria count on nutrient agar diluted ten times was up to 5.1 times greater than on the standard media (yearly averages: 3.2 in 1988, 2.5 in 1989, 3.4 in 1990); (Gajin et al., 1990). It should also be emphasized that from all media applied, in all cases of investigation, the highest number of colonies has been found on the nutrient agar diluted ten times.

The dominance of (facultative) oligotrophic bacteria over the heterotrophic ones, found also in the Backwater Tisza water, point to the incompleteness of such investigation of water quality when only classical methods of determination of number of (heterotrophic) bacteria, corresponding only to one level of trophy are applied, that is, when only standard nutrient agar is being used.

At the investigation of bacterioplankton of waters by cultivation method, the usual period of incubation is 5-7 days. By prolongation of this period, we noticed that at the incubation temperature of 26°C period of 5 days was enough for full growth of heterotrophs, but bacterial colonies on the media poorer in nutrients grew slower. On the basis of these observations we concluded that one of the reasons of exclusion of autochthonous oligotrophic microflora of waters at routine investigations is certainly the insufficient routine period of incubation as well.

From the total number of 412 tested bacteria, isolated from the Backwater Tisza water during three-year investigation, 80.1% of isolates were capable to grow on diluted nutrient agar and 74.5% on the standard nutrient agar (Fig. 2.).

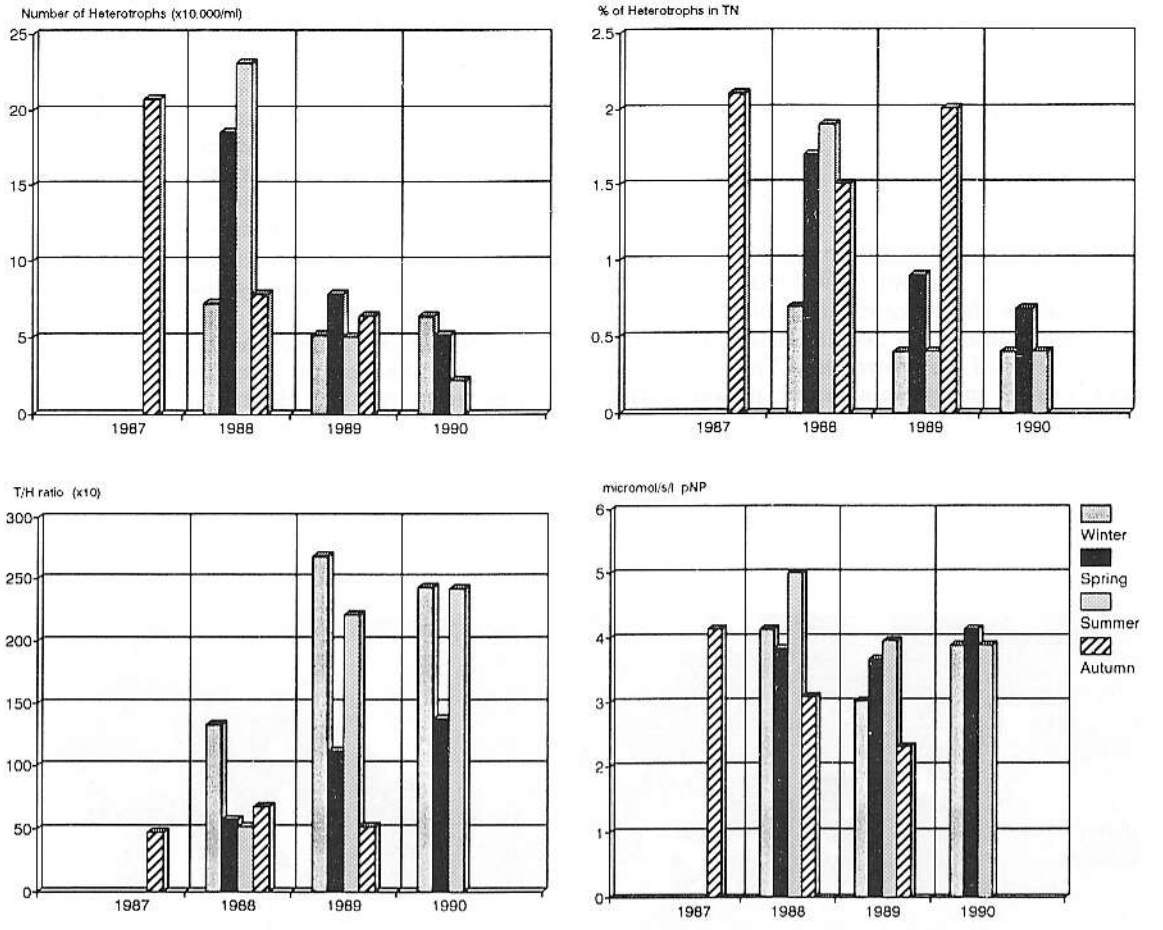

Fig. 1. The water quality of Backwater Tisza according to microbiological and enzymological indicators

These results also point to the abundance of autochthonous oligotrophic microflora in the investigated waters, as well as to a possible methodological error at routine investigation of microflora of surface waters carried out only on one level of trophy, and only on the standard nutrient agar respectively.

Examination of microflora of the investigated water by an electron microscopy revealed, besides the usual bacterioflora, the abundance of forms with noticeable numerous pili. However, by examination of isolates taken from the investigated water such forms could not be noticed. For this reason we assume that the forms observed in the intact sample were strict oligotrophs, or oligonitrophiles. Oligotrophic strains grown on nutrient agar were polymorphic, or with a great number of lysing cells, and typical morphology of cells was noticed only when grown on the medium with reduced quantity of nutrients (Fig. 3.). Morphological

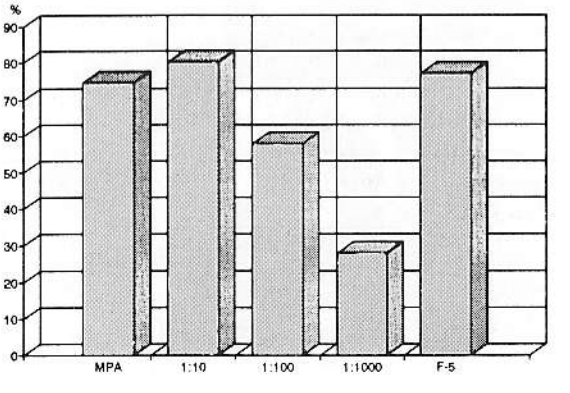

Fig. 2. Percentage of bacterial isolates growing on media with different nutrient concentrations

ambiguity was the most expressive in the isolates of stalked bacteria grown on the nutrient agar, whose typical morphology was noticed only when grown on the media with reduced quantity of nutrients (Fig. 4.).

Conclusion

The results obtained during the three years of investigation of microbiological indicators of water quality allow the categorization of the Backwater Tisza water into II-III and II classes (according to the number of heterotrophs). This is the water most loaded in spring-summer period during a year, but within the limits of III-A category (according to the enzyme activity of water).

The numbers of bacteria obtained by cultivation methods, as well as the capability of growth of bacteria isolated from the Backwater Tisza water on media with different concentrations of nutrients, point to the dominance of oligotrophic microflora in investigated waters. With this respect we point to the incomplete investigation when this important part of microflora is neglected and to the possible methodological error at routine investigation of microflora of surface waters carried out only on one level of trophy, that is on the standard nutrient agar only.

Morphological investigations of oligotrophic bacteria cultivated on standard nutrient agar also point to the fact that the media with reduced concentrations of nutrient are more suitable for investigation of microflora of surface waters .

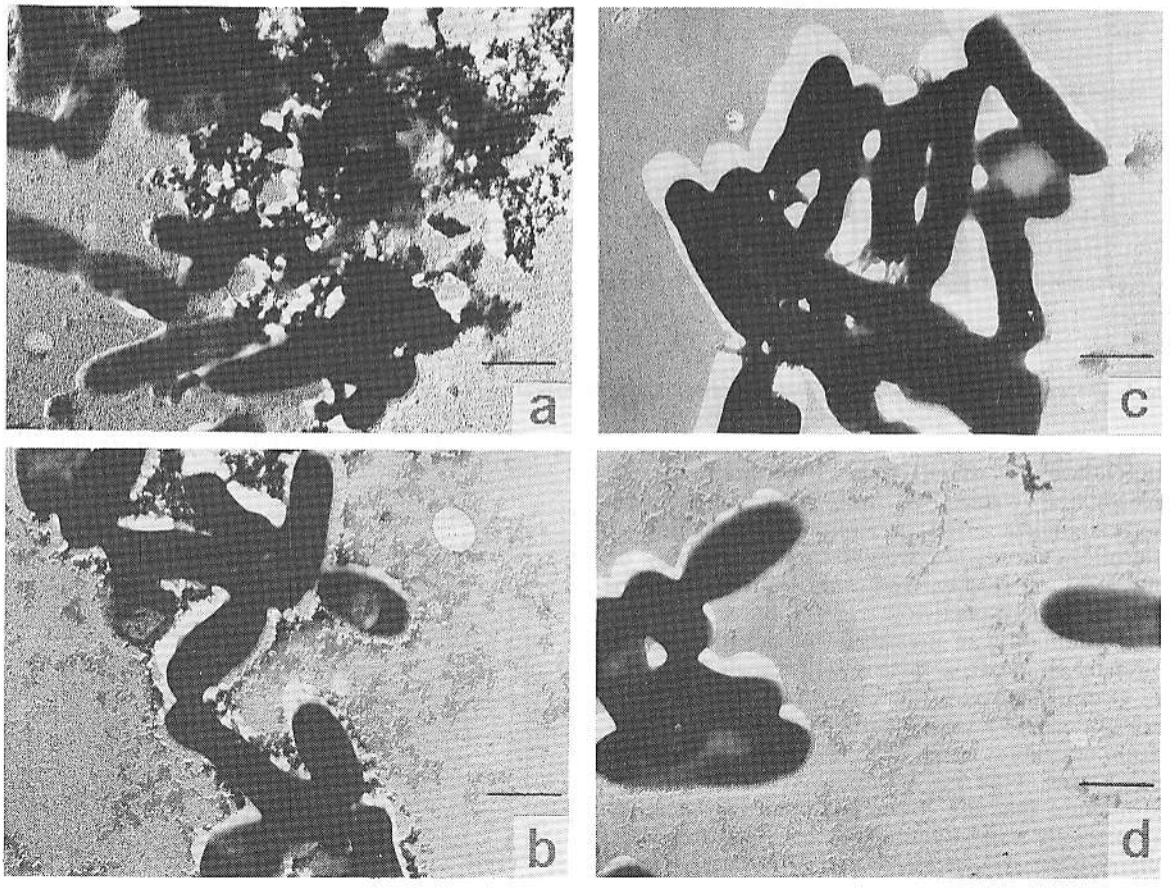

Fig. 3. Electron micrographs of bacterial cells showing morphological changes as affected by different nutrient concentrations. a - standard nutrient agar; b - nutrient agar diluted 1:10; c - nutrient agar diluted 1:100; d - nutrient agar diluted 1:1000.; (index = 1μm)

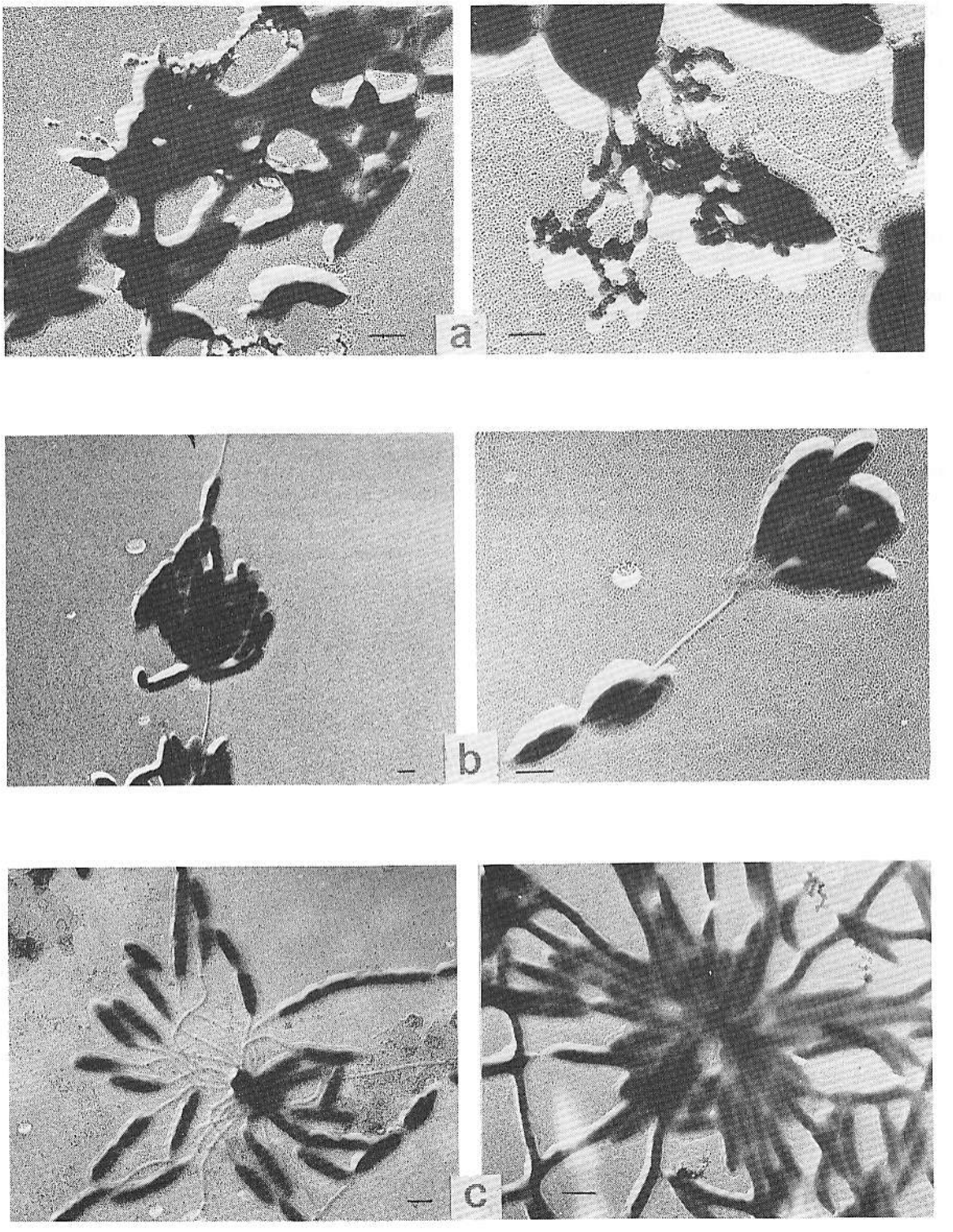

Fig. 4. Electron micrographs of stalked bacteria showing morphological changes as affected by different nutrient concentrations. a - standard nutrient agar; b - nutrient agar diluted 1:10; c - nutrient agar diluted 1:100; (index = 1μm)

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COMPARATIVE DATA ON THE COMPOSITION OF ZOOPLANKTON IN THE PART OF THE RIVER DANUBE AND THE RIVER TISZA IN VOJVODINA (YUGOSLAVIA)

V. Pujin

Pujin, V. (1992): Comparative data on the composition of zooplankton in the part of the river Danube and the river Tisza in Vojvodina (Yugoslavia). - TISCIA 26,49-57.

Abstract. In the period 1987-1989 comparative examinations were conducted on the composition of zooplankton in Danube and Tisza on several localities. In the composition of zooplankton of these two rivers, a total number of 187 species and varieties were ascertained, out of which 31 *Protozoa*, 119 *Rotatoria*, 26 *Cladocera* and 11 *Copepoda*. The number of species in Danube was higher than the number of species ascertained in Tisza and we also observed differences depending on locality, that could be attributed to a great extent to the antropogenic influences. *Rotatoria* represent in both water currents the most diverse group, where most emphasized are genera *Brachionus*, *Keratella*, *Cephalodella*, *Colurella*, *Lecane* and *Trichocera*. On the basis of similarity index according to Sørensen (1948), the dendrograms show two complexes, one in Danube and the other in Tisza, which are linked through a locality downstream from the mouth of Tisza into Danube. The saprobity index according to Pantle and Buck (1955) in Danube, through all three years, indicates a betamesosaprobic pollution stage, while in Tisza in most cases a betaalfamesosaprobity.

Keywords: Antropogenic influence, clustering method, dendrogram, saprobity index, Sørensen similarity index.

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Introduction

Although hydrobiological researches in the Danube and Tisza were conducted for many years, there are not many works relating to comparative data for these two rivers. We recently carried out only a few works (Dobler and Schmidt, 1980; Tevanné Bartalis, 1987; Pujin et al. 1990).

Since these mostly relate to the composition of phytoplankton, the aim of this work is to give a comparative survey of zooplankton composition.

Material and methods

The examinations included the period 1987-1989. Samples were taken in monthly intervals in 6 localities: Bezdan (1), Novi Sad (2), Novi Banovci (3) by the river Danube, and Martonos (4), Novi Becej (5) and Titel (6) by the river Tisza, respectively. The material was collected with a plankton net No. 25 made of mill silk (nylon) and treated partially live, partially in fixed state (in 4% formalin). In order to establish the similarity, the index according to Sørensen (1948) was calculated, while the link is shown on dendrograms. Clustering method was made according to Sneath and Sokal (1973).

Results and discussion

During the examined period, a total number of 187 species and varieties were ascertained in the composition of zooplankton, out of which there were 31 *Protozoa*, 119 *Rotatoria*, 26 *Cladocera* and 11 *Copepoda* (Tab. 1.). Composition of zooplankton was slightly more diverse in Danube (total of 172 species and varieties), although there were differences depending on the locality. The highest number of species were ascertained at Bezdan (158), less at Novi Banovci (120) and the smallest number at Novi Sad (116). A total of 131 species and varieties was ascertained in Tisza, out of which 29 *Protozoa*, 82 *Rotatoria*, 17 *Cladocera* and 10 *Copepoda*. Here, the differences in relation to localities were also evident. So, 101 species were ascertained at Martonos, only 66 at Novi Becej, and 91 at Titel. We explain this by the influence of pollution brought through the canal Becej-Vrbas

at Novi Becej and by Begej which streams in Tisza at Titel.

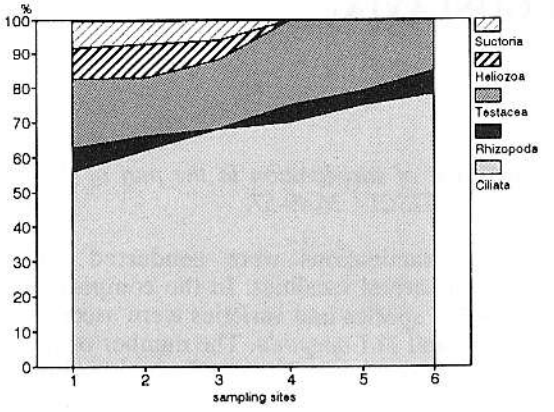

Fig. 1. Average percentage presence values of particular *Protozoa* groups in the Danube and Tisza (1987-1989).

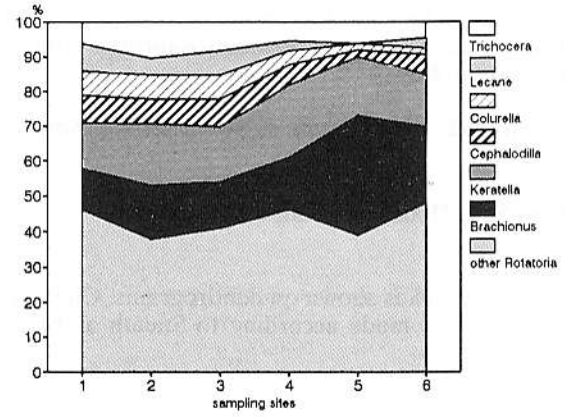

Fig. 2. Average percentage presence values of particular *Rotatoria* genera in the Danube and Tisza (1987-1989).

If we compare the composition of zooplankton in Danube and Tisza with earlier results, we can notice some differences. So for example, the differences in Danube are not so noticeable regarding the number of species as in the represented species. So Zivkovic (1987), on the basis of researches conducted in the period 1947-1963 and 1965-1973, has ascertained a total of 129 species and varieties of *Rotatoria* with 68% of typical plankton species, while the rest was mainly phytophil and met rarely and individually. This relates especially to the genus *Trichocera*, whose species are mainly represented among the macrovegetation in more still waters. According to this author, the same were mainly represented as individual samples, but now they appear more and more in some localities in Danube, and also in larger numbers (Pujin 1988, 1989, 1990; Pujin et al 1987, 1990 a, 1990 b).

These differences in Tisza are even more drastic. Kalafatic et al. (1982) ascertained in Tisza about 60 zooplankton species. This number was mainly maintained until 1979 (Pujin et al. 1984; Pujin and Ratajac 1983), to be of larger later, especially *Rotatoria* which we connect with the construction of a dam at Novi Becej and the influence of the HE Power Project Djerdap, affecting not only the mouth of Tisza into Danube, but also felt in Novi Sad (Pujin 1985; Kojcic et al. 1989; Pujin et al. 1990).

In relation to other groups, for example *Crustacea*, no essential changes were found (Ratajac and Rajkovic, 1985). In relation to the participation of particular groups in the composition of zooplankton, there are also some differences. So in the composition of *Protozoa*, the main components are *Ciliata*, participation of which ranges from 57.3% to 77.8% (Fig. 1), then *Testacea* (16.7%-25%). Only these two groups of *Rhizopoda-Protozoa* were represented in Tisza, while in the Danube we ascertained also *Helizoa* and *Suctoria*. As it was already mentioned, *Rotatoria* represent the most diverse group in the composition of zooplankton in these two rivers. These are the genera *Brachionus, Keratella, Cephalodella, Colurella, Lecane* and *Trichocera*. Their percentage participation varies depending on the locality (Fig. 2).

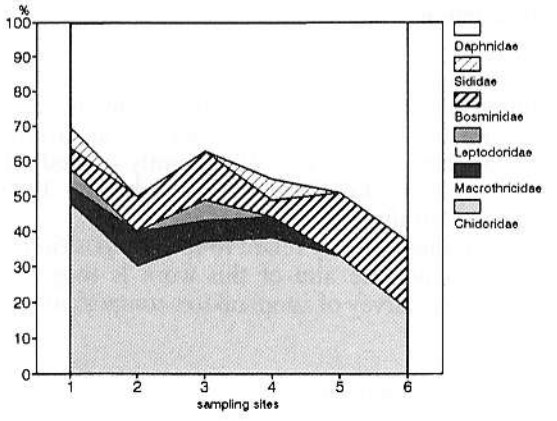

Fig. 3. Average percentage presence values of particular *Cladocera* families in the Danube and Tisza (1987-1989).

According to the earlier researches, the genera *Brachionus* and *Keratella* played an important role in the composition of zooplankton. An important place was taken also by the genera *Polyarthra*, *Synchaeta* (Zivkovic 1987; Pujin 1982, 1988; Pujin et al. 1987) and *Asplanchna*. Concerning the composition of *Cladocera*, the main components

are the families *Daphnidae* and *Chydoridae* (Fig. 3), which vary depending on the locality. The similar composition of *Cladocera* and *Copepoda* was also ascertained in Danube and Tisza by Ratajac (1987) and Ratajac and Rajkovic (1985), which means that up to now antropogenic actions did not considerably influence these groups. Analyzing dendrograms for particular groups, we noticed that for *Protozoa* and *Rotatoria* more mutual similarity was shown on localities in Danube as well as in Tisza (Fig. 4).

The dendrograms of *Cladocera* and *Copepoda* show rather uniform index at all localities in relation to loc. 5 (Novi Becej), where the similarity index is much lower (Fig. 5). This can be attributed to the influence of canal Becej-Vrbas, which affects this group by its pollution. Analyzing the saprobity index according to Pantle and Buck (1955), obtained on the bases of represented zooplankton species and their relative abundance, we can see that in all the three examined years in Danube, the values were lower, indicating betamesosaprobity, while in Tisza the indexes indicated beta-alfamesosaprobity (Fig. 6). Contrary to our data, Dobler and Schmidt (1980) indicate on the basis of represented phytoplankton species that Danube is more polluted than Tisza. The causes of this are probably different sampling periods, since also in our earlier investigations we established saprobity index values in Tisza within the limits of betamezosaprobity, which in recent years are deteriorating (Stanojevic and Pujin 1973; Pujin and Stajonevic 1979; Pujin and Rajkovic 1979).

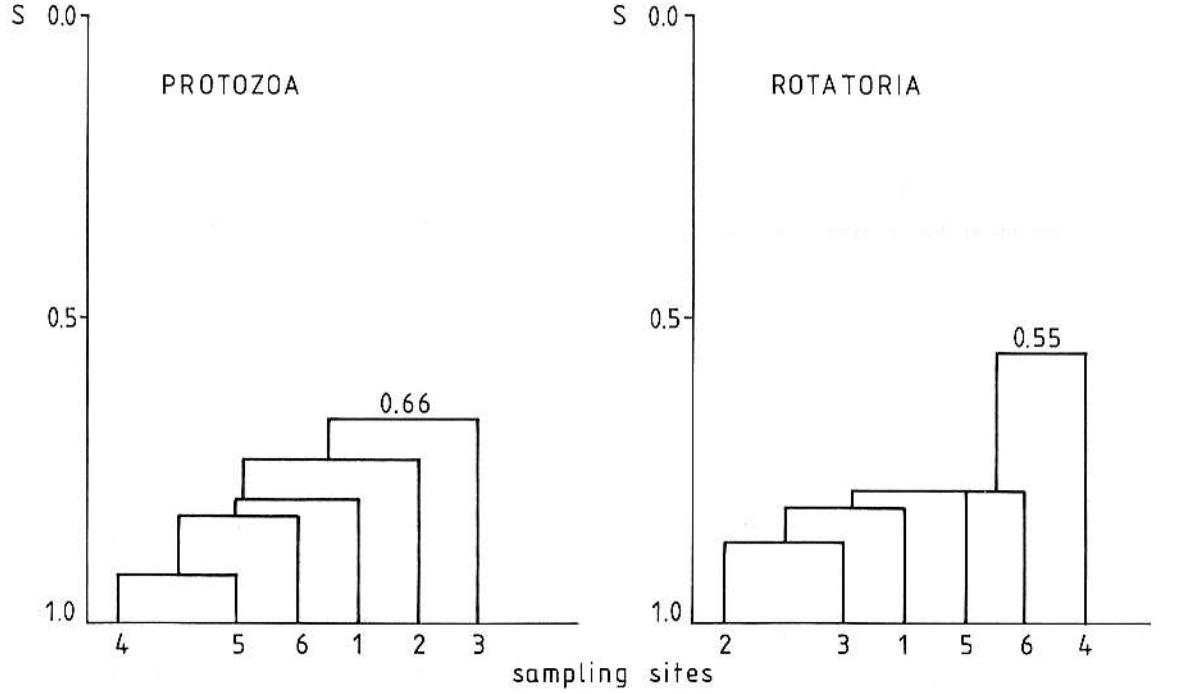

Fig. 4. Dendrograms at different sampling sites. Danube: 1-Bezdan, 2-Novi Sad, 3-Novi Banovci; Tisza: 4-Martonos, 5-Novi Becej, 6-Titel.

Conclusions

On the basis of comparative examinations of the zooplankton composition in the part of Danube and Tisza in Vojvodina (Yugoslavia), the following could be concluded:

In the period 1987-1989, a total number of 187 species and varieties were ascertained in these two rivers, out of which 31 *Protozoa*, 119 *Rotatoria*, 26 *Cladocera* and 11 *Copepoda*. The number of species in Danube was higher (172) than that in Tisza (131), differences were also observed

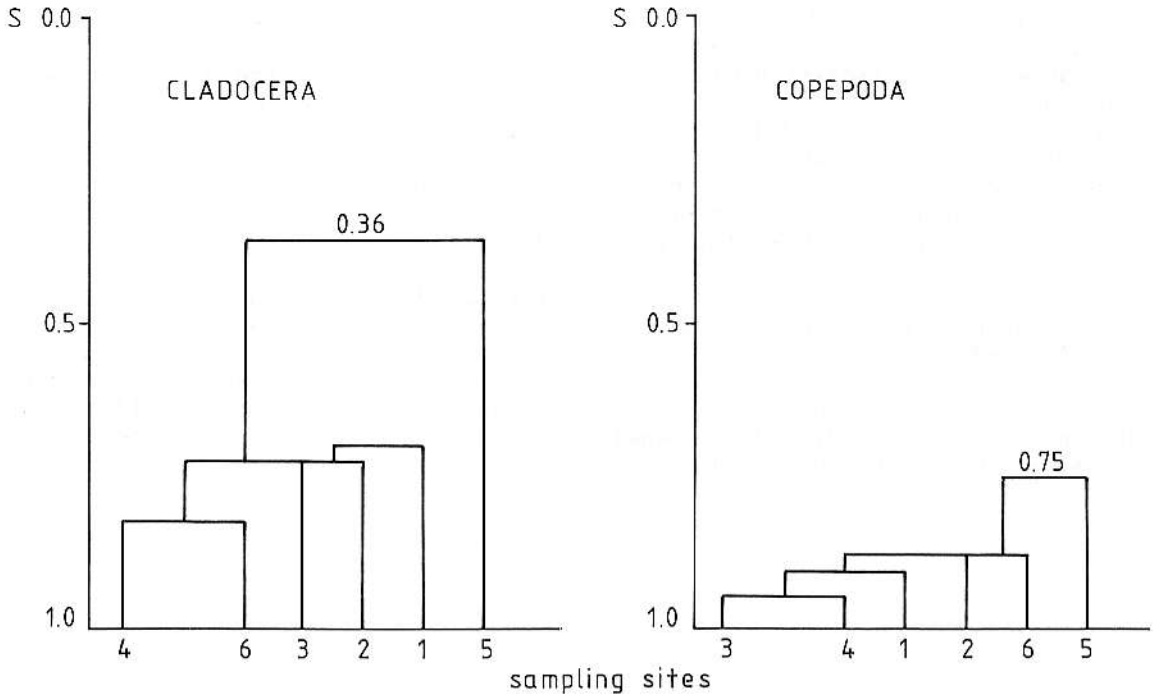

Fig. 5. Dendrograms at different sampling sites. Danube: 1-Bezdan, 2-Novi Sad, 3-Novi Banovci; Tisza: 4-Martonos, 5-Novi Becej, 6-Titel.

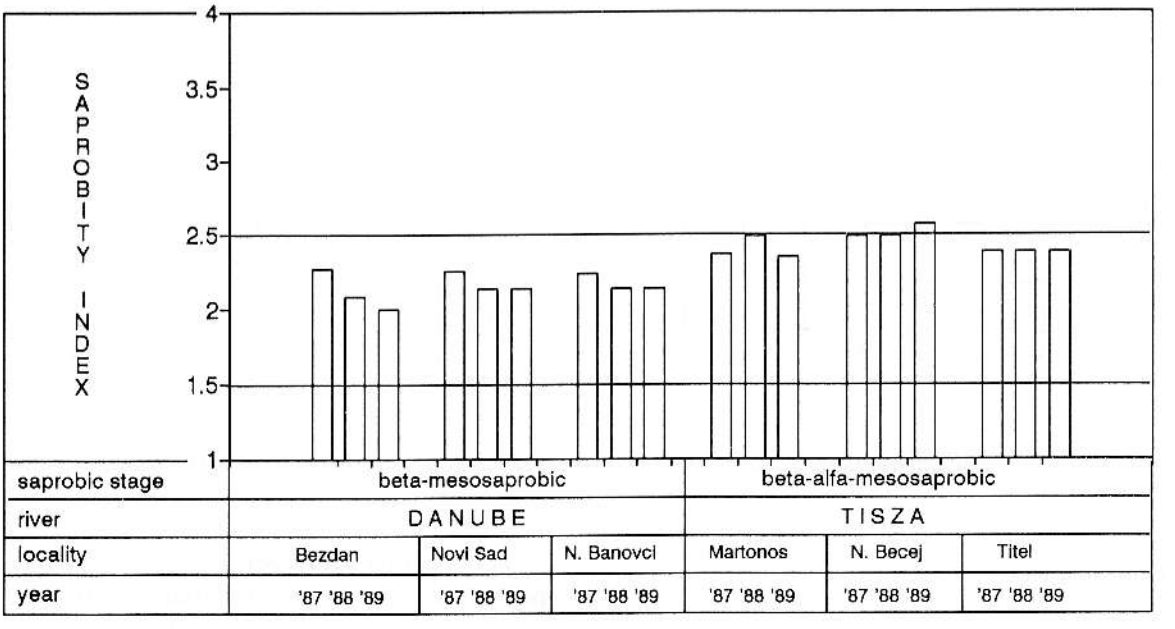

Fig. 6. Saprobity index of the Danube and Tisza (1987-1989) according to Pantle and Buck (1955)

depending on localities, that could to a great extent be connected to antropogenic influence of hydrotechnical actions and pollution.

Rotatoria represent the most diverse group in both water currents, among which especially emphasized are genera *Brachionus, Keratella, Cephalodella, Colurella, Lecane* and *Trichocera*.

On the basis of similarity index according to Sørensen (1948), the dendrograms indicate two complexes when in question are *Protozoa*, *Rotatoria* and *Cladocera*, which are linked through localities downstream the mouth of Tisza into Danube. The composition of *Copepodas* is similar.

The saprobity index according to Pantle and Buck (1955) indicates a betamesosaprobity grade of pollution in Danube in all three years, while that is beta-alfamezosaprobic in many cases for Tisza.

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APPENDIX

Tab.1. Qualitative composition of Zooplankton in the Vojvodina section of the river Danube and the River Tisza (1987-1989) Danube: 1.Bezdan, 2.Novi Sad, 3.Novi Banovci, Tisza: 4.Martonos, 5.Novi Becej, 6.Titel

Species	Localities					
	DANUBE			TISZA		
	1.	2.	3.	4.	5.	6.
PROTOZOA						
Actinophris sol EHR.	+	+				
Actinosphaerum eichorni EHR	+	+	+			
Acineta sp. EHR.	+					
Amoeba verrucosa EHR.	+	+				
A.vulgaris EHR.	+			+	+	+
Aspidisca costata (DUJARDIN) CI.L.	+	+		+	+	+
Carchesium polypinum L.	+	+	+	+	+	+
Centropyxis aculeata STEIN	+	+		+	+	
C.discoides EHR.	+			+	+	+
Chilodonella cuculus O.F.M.	+	+			+	+
Ch.uncinata EHR.	+			+	+	+
Colpidium colpoda (EHR.) STEIN	+	+		+	+	+
Difflugia corona WALLICH	+	+	+			
D.limnetica LEVANDER	+	+	+	+	+	+
Didinium nasutum O.F.M.	+	+				
Dileptus anser O.F.M.			+			
Epistylis plicatilis EHR.			+	+	+	
Lembus pusillus QUENNERSTEDT	+	+				
Paramecium aurelia EHR.	+	+	+	+	+	+
P.bursaria (EHR.)	+		+	+		+
P.caudatum EHR.	+	+	+	+	+	+
P.trichium STOCKES				+	+	+
Stylonychia mytilus EHR.	+			+	+	+
Tintinnidium fluviatile KENT	+	+	+	+	+	+
Tintinnopsis lacustris ENTZ	+	+	+	+	+	+
Tokophrya quadripartita CLAP.et LACH.	+	+	+			
Vorticella campanulata EHR.	+	+	+	+	+	+
V.convalaria (L.) HOLAND	+	+	+	+	+	+
V.microstoma EHR.	+	+	+		+	+
ROTATORIA						
Anureopsis fissa (GOSSE)	+	+	+	+	+	+
Ascomorpha agilis ZACHARIAS	+					
A.ovalis (BERGENDAHL)	+	+				
Asplanchna brightwelli GOSSE	+	+	+	+	+	+
A.girodi DE GUERNE	+	+		+		+
A.herricki DE GUERNE	+	+	+	+		+
A.priodonta GOSSE	+	+	+	+	+	+
A.sieboldi (LEYDIG)	+		+	+		+
Brachionus angularis GOSSE	+	+	+	+	+	+
B.angularis f.bidens PLATE	+	+		+		
B.bidentata f.inermis (ROUSS.)	+	+				+
B.budapestinensis DADAY	+	+	+	+	+	+
B.calyciflorus PALLAS	+	+	+	+	+	+
B.calyciflorus f.anureiformis BREHM	+	+	+	+	+	+
B.calyciflorus f.amphyceros EHR.	+	+	+	+	+	+
B.diversicornis DADAY	+	+	+	+	+	+
B.falcatus ZACHARIAS					+	+
B.forficula (WIERZEJSKI)				+	+	+

Species	Localities					
	DANUBE				TISZA	
	1.	2.	3.	4.	5.	6.
B.leydigi COHN	+	+	+	+		+
B.patulus (O.F.M.)	+		+		+	
B.plicatilis MULLER				+	+	
B.urceolaris (O.F.M.)	+	+	+	+	+	+
B.urceolaris v.rubens EHR.	+	+	+	+	+	+
Cephalodella auriculata (MULLER)	+	+	+	+		+
C.catellina (MULLER)	+	+	+	+		+
C.eva (GOSSE)	+		+			
C.exigua (GOSSE)	+					
C.forficula (EHR:)	+	+	+	+		
C.gibba (EHR.)	+	+	+	+	+	+
C.gracilis EHR.	+	+	+	+		+
C.tecta Donner	+					
Colurella adriatica (EHR.)	+	+	+	+		
C.colurus (EHR.)	+	+	+	+		+
C.dicentra GOSSE	+	+	+	+		+
C.obstusa (GOSSE)	+	+	+			
C.uncinata (EHR.)	+	+	+			
C.uncinata f.bicuspidata (EHR.)	+					
C.uncinata f.deflexa GOSSE	+					
C.oblonga DONNER	+	+	+	+		
Conochiloides natans SELIGO			+			
Dicranophorus uncinatus (MLINE)			+			
D.forficatus (MULLER)			+			
Dissotrocha aculeata (EHR.)	+					
Epiphanes macroura BARROIS et DADAY	+					
E.senta (MULLER)	+	+	+	+	+	+
Euchlanis dilatata (EHR.)	+	+	+	+	+	+
Filinia cornuta brachiata (ROUSSELET) nom.nov.	+		+	+		
F.longiseta (EHR.)	+	+	+	+	+	+
F.longiseta var.passa (O.F.M.)	+	+	+			
F.terminalis (PLATE)	+					
F.opoliensis ZACHARIAS	+	+	+	+		+
Gastropus stylifer IMHOF				+		+
Hexarthra mira (HUDSON)	+	+	+	+		+
H.fennica LEVANDER				+		
Kellicottia longispina KELL	+	+	+			
Keratella cochlearis (GOSSE)	+	+	+	+	+	+
K.cochlearis var.tecta (LAUTERBORN)	+	+	+	+	+	+
K.cochlearis var.tecta f. micracantha (LAUTER.)		+		+		
K.cochlearis f.macracantha (LAUTER.)	+			+		
K.cochlearis f.connectens (LAUTER.)				+		
K.cochlearis var.robusta (LAUITER.)	+	+	+	+		+
K.cochlearis var hispida LAUTERBORN	+	+	+	+		
K.cochlearis var irregularis LAUTERBORN	+	+	+	+		
K.cochlearis var.irregularis f.wartmani (ASPER,HEUSCHER)				+		
K.paludosa (LUCKS)				+		
K.quadrata (O.F.M.)	+	+	+	+	+	+

Species	Localities					
	DANUBE			TISZA		
	1.	2.	3.	4.	5.	6.
K.quadrata var.frenzeli (ECKSTEIN)	+	+	+	+	+	+
K.quadrata var.dispersa (CARLIN)	+	+	+	+	+	+
K.qudrata f.reticulata CARLIN	+		+	+		
K.testudo (EHR.)		+	+	+		+
K.ticinensis (CALLERIO)				+		
K.tropica (APSTEIN)	+	+				
K.valga (EHR)	+	+	+	+		
K.valga f.monospina (KLAUS.)	+	+	+	+	+	+
Lecane bulla (GOSSE)	+	+	+	+		
L.closterocerca (SCHMARDA)	+		+			
L.hamata (STOKES)	+					
L.luna MULLER	+	+	+	+		+
L.lunaris (EHR.)	+	+	+	+		+
L.quadricarinata (STENROOS)	+	+	+			
L.ungulata (GOSSE)	+					
Lepadella ovalis (MULLER)	+					
Lepadella patella (MULLER)	+					
L.quinquecostata (LUCKS)	+					
L.rhomboides (GOSSE)	+					
Liliferotrocha subtilis RODEWALD	+	+	+			+
Mytilina bicarinata (PERTY)	+					
M.mucronata (EHR.)	+	+		+		+
Natholca acuminata (EHR.)	+		+	+		
N.squamula (O.F.M.)	+	+	+	+		+
Philodina citrina EHR	+	+	+	+		+
Ph.roseola EHR.	+	+	+	+		
Platyias quadricornis (EHR.)	+					
Polyarthra dolichoptera IDELSON	+	+	+	+	+	+
P.euryptera WIERZEJSKI	+	+	+	+		+
P.major BURKHARDT	+	+		+		
P.remata SKORIKOW	+					
P.vulgaris CARLIN	+	+	+	+	+	+
Pomhlyx complanata GOSSE		+	+	+	+	
P.sulcata HUDSON		+				+
Rotaria neptunia (EHR.)		+	+		+	+
R.neptunoides HARRIG	+	+	+	+	+	+
R.rotatoria (PALLAS)	+	+	+	+	+	+
Synchaeta oblonga EHR.	+	+	+	+	+	+
S.pectinata EHR.	+	+	+	+	+	+
S.stylata WIERZ.	+		+	+		
Testudinella patina HERMANN	+	+	+	+		
Trichotria pocillum (O.F.M.)	+					
T.tetractis EHR.	+		+	+		
Trichocerca capucina (WIERZ et.ZACHARIAS)	+	+	+	+		
Tr.collaris (ROUSS.)		+	+			
Tr.dixon-nuttali JENNINGS		+	+			+
Tr.cylindrica (IMHOF)	+	+	+			
Tr.longiseta (SCHRANK)		+				
Tr.porcellus (GOSSE)	+	+				
Tr.pusilla (JENNINGS)		+	+			
Tr.rattus (MULLER)	+	+	+	+	+	+
Tr.stylata (GOSSE)		+	+			
Tr.tenuior (GOSSE)	+					

Species	Localities					
	DANUBE				TISZA	
	1.	2.	3.	4.	5.	6.
CLADOCERA						
Acroperus harpae BAIRD	+					
Alona affinis (LEYDIG)	+			+		
A.costata SARS	+					
A.quadrangularis (O.F.M.)	+	+	+	+	+	+
Alonella excisa (S.FISCHER)	+		+	+		
A.nana (BAIRD)	+					
Bosmina coregoni BAIRD	+		+			
B.longirostris (O.F.M.)	+	+	+	+	+	+
Ceriodaphnia quadrangula (O.F.M.)	+	+	+	+		+
Chydorus ovalis KURZ	+					
Ch.sphaericus O.F.M.	+	+	+	+	+	+
Daphnia cuculata SARS	+	+	+	+		+
D.hyalina LEYDIG	+					
D.longispina O.F.M.	+	+	+	+	+	+
D.pulex LEYDIG					+	
Diaphanosoma brachyurum LIEVIN	+			+		
Leydigia leydigi (SCHOLDER)	+		+	+		
Leptodora kindti (FOCKE)	+		+	+		
Moina brachiata (JURINE)	+		+			
M.micrura (KURZ) SRAMEK-HUSEK	+	+	+	+		+
Macrothrix laticornis (JURINE)	+	+	+	+		
Peracantha truncata (O.F.M.)	+	+	+			
Rhyncotalona rostrata (KOCH)	+		+			
Scapholeberis kingi SARS				+	+	+
S.mucronata SARS				+		+
Simocephalus vetulus (O.F.M.)	+	+	+	+		+
COPEPODA						
Acanthocyclops robustus SARS	+	+	+	+	+	+
A.vernalis FISCHER	+	+	+	+	+	+
Cyclops strenuus (FISCHER)	+					
C.vicinus (ULJANIN)	+	+	+	+	+	+
Diacyclops bicuspidatus SARS	+		+	+		
Eucyclops serrulatus FISCHER	+	+	+	+	+	+
E.speratus (LJILJEBORG)	+	+	+	+		+
Eupdiaptomus gracilis SARS	+		+	+		+
Macrocyclops albidatus JURINE				+		+
Mesocyclops leuckarti CLUS	+	+	+	+	+	+
Thermocyclops crassus (FISCHER)	+	+	+	+	+	+
total	158	116	120	101	66	91