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Zooplankton of two arms in the Morava River floodplain in Slovakia

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Abstract: The species composition, seasonal dynamic of biomass and density of zooplankton were studied in two arms with a different hydrological regime. The samples were collected in two hydrologically different years – extremely wet in 2002 and extremely dry in 2003. In the first arm the mean annual chlorophyll-*a* concentration was 31.6 μg L^{-1} (2002) and relatively high 64.7 μg L^{-1} during 2003. Mean seasonal zooplankton wet biomass was low and varied: 11.6 g m^{-3} (2002) and 2.93 g m^{-3} (2003). Total zooplankton density was high (7,370 N L^{-1}) in 2002, when rotifers predominated in an open water zone and contributed up to 81% of the total zooplankton biomass and 83% of the total zooplankton density. In medial and littoral zone, in total, 22 cladoceran and 15 copepod species were identified. In the second arm the mean annual concentration of chlorophyll-a was high: 74.8 μg L^{-1}(2002) and 61.4 μg L^{-1} (2003). Mean seasonal zooplankton wet biomass varied from 92.5 g m^{-3} (2002) and 44.10 g m^{-3} (2003). In 2002 the planktonic crustaceans predominated; their mean biomass was 87.1 g m^{-3} and *B. longirostris* formed more than 91% of this value. In 2003, the zooplankton density was high (15,687 N L^{-1}), when rotifers contributed up to 94% of this value. The boom of rotifers (58,740 N L^{-1}) was recorded in June 2003. In total, 45 cladoceran and 14 copepod species were recorded in the medial and littoral zones. During observation we concluded that the structure of zooplankton, particularly species composition, abundance, biomass and seasonal dynamics are affected by the fluctuation of water levels in the arms of the rivers' inundation areas. This unstable hydrological regime prevented the development of planktonic crustaceans.

Key words: River arms, chlorophyll-*a*, zooplankton, seasonal dynamic, Morava River, Slovakia.

Introduction

The river bodies of the plesiopotamal type are often characterized by a high diversity of planktonic crustaceans (Gulyás, 1994; Bothár, & Ráth, 1994; Hudec, 1999) and high quantitative attributes of zooplankton. These properties of zooplankton depend on abiotic factors, food resources and also on fish stock (Hrbáček, 1962; Brooks & Dodson, 1965). In the floodplain area, floods can affect the composition of zooplankton of the water bodies. The study of biota in the waters of river inundation areas has a long tradition in the Czech Republic (e.g., Straškraba, 1965; Ošmera, 1973; Pechar et al., 1996; Kopecký & Koudelková, 1997).

Also in Slovakia studies of zooplankton in river branches were carried out, namely from the Danube River (Vranovský, 1985, 1997) and from the Východoslovenská nížina lowland – Uh River basin (Hudec & Stano, 1997) and the Latorica River (Terek, 1990). The Slovak part of the Morava River floodplain is the territory, where the diversity of original aquatic biotopes has been preserved since World War II. The systematic study of this area began only in 1994 and the first records of zooplankton in the Morava alluvium were published only recently (Illyová, 1999; Illyová & Kubíček, 2002; Illyová & Némethová, 2002).

The aim of this study is to present the results of a two-year study of zooplankton in the medial zone: comparison of species composition, seasonal changes in biomass, and density in two arms of a different hydrological regime that are situated in the inundation of the Morava River.

Study sites

Two study areas are situated between Malé Leváre and Stupava villages, between 60 and 12 r. km, respectively, in the Záhorie lowland.

Šrek arm (M1) is a plesiopotamal type of water body (sensu Ward et al., 2002). This side arm is situated near the confluence of the Danube and the Morava rivers, abreast of river km 11.5–14.5 (48°16′24″ N, 16°57′18″ E). The arm is 1400 m in length, 60 m width and 1.5 m deep, with gravel ground. The water level depends on the hydrological conditions of the Morava and Danube rivers and varies from 0.0 to 1.5 m. When the water stages (Fig. 1) are over 400 cm – measured at the profile of Záhorská Ves village (by SHMU – Slovak Hydrometerological Institute) – the whole area is flooded. Conversely it dries up when the water stages are low. Every year the natant vegetation *Nuphar*

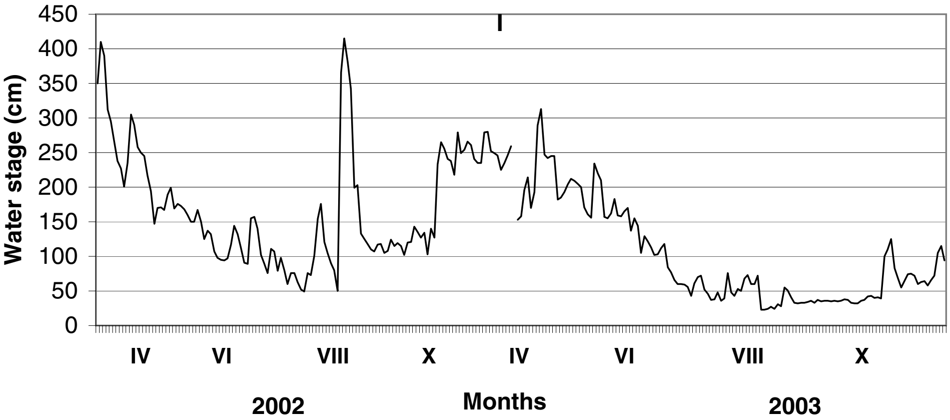

Fig. 1. The water stages measured at the profile of Záhorská Ves village (by SHMU) in 2002 and 2003.

Table 1. Mean values of some physical and biological parameters in open water of two arms in production period 2002 and 2003.

Sites	Unit	Šrek arm (M1)		Stará Morava arm (M2)	
Year		2002	2003	2002	2003
Water temperature	(℃)	17.3	15.2	15.9	17.4
Oxygen	(mg L^{-1})	5.2	7.1	11	13.4
Chlorophyll-*a*	(μg L^{-1})	31.6	64.7	74.8	61.4
Rotifera	(N L^{-1})	6,173	1,618	3,189	14,815
Cladocera	(N L^{-1})	7	76	2,081	414
B. longirostris	(N L^{-1})	3.8	65	1,985	324
Copepoda	(N L^{-1})	1,190	1,131	692	458
Total density of zooplankton	(N L^{-1})	7,370	2,824	5,963	15,687

lutea is formed and in marginal parts *Phragmites australis* also forms.

Stará Morava arm (M2) is a plesiopotamal type of water body – prolonged oxbow lakes, the remnant of a river meander, situated at river km 57.0–57.9 (48°31′51″ N, 16°57′10″ E). The arm length is 1,500 m, the width 100 m and the ground is formed by clay with sand. Maximum depth can reach 2 m. In the littoral zone submersed vegetation is formed by the *Hydrocharition* association; *Ceratophyllum demersum* and *Carex* sp. were common. The arm is commonly overflowed in spring and during big floods (August 2002).

Methods

The samples were collected during the growing season from March (April) to November (December), during the years 2002 and 2003. No samples were collected from the Šrek arm in 2002 during March, August, and October because the arm was overflowing; and in 2003 during September because the biotope had dried up.

Zooplankton samples for the qualitative analysis were taken from the open water zone by vertical tows from the bottom of plankton net (60–70 μm mesh size). Complete qualitative zooplankton samples were collected from several littoral locations. At the taxa level all Cladocera and Copepoda species were identified; from Rotatoria only the dominant species, found in quantitative samples, were identified. For the quantitative analysis a Patalas type plankton sampler took the samples and 10 L were taken from a water column. Zooplankton was concentrated using a phosphorbronze sieve (40–50 μm mesh size) and preserved in formalin. Zooplankton density (N L^{-1}) was assessed in a 1-ml Sedgwick-Rafter chamber. Biomass (g m^{-3}) was established as wet weight calculated from the mean recorded body lengths and from the body length/biomass ratio using tables compiled from several bibliographic sources by Morduchaĭ-Boltovskoĭ (1954), Ulomskiĭ (1951, 1961), Nauwerck (1963), Düssart (1966). Frequency of occurrence was evaluated according to Losos et al. (1984). Water temperature (℃), oxygen saturation (mg L^{-1}) and chlorophyll-*a* (chl-*a*) concentration (μg L^{-1}) were recorded. Oxygen according to the Winkler method was measured. Chl-*a*, by ISO Standard method (ISO 10260:1992) was measured; phytoplankton, identification and enumeration, was not analysed in detail.

Cluster analyses were used to compare the community structure of Cladocera by means of the computer program PC ORD (McCune & Mefford, 1999). The Jaccard and Ward's method, narrow width and double spaced methods were used. The hierarchical clustering method used the correlation dissimilarity coefficient on the density of 16 cladoceran species from the Šrek arm and 21 cladoceran species from the Stará Morava arm. Cladoceran species detected in quantitative samples of the arms' medial were used as the input data for a cluster analyses.

Results

The inundation area of the Morava River is typical for its high water in spring (Fig. 1).

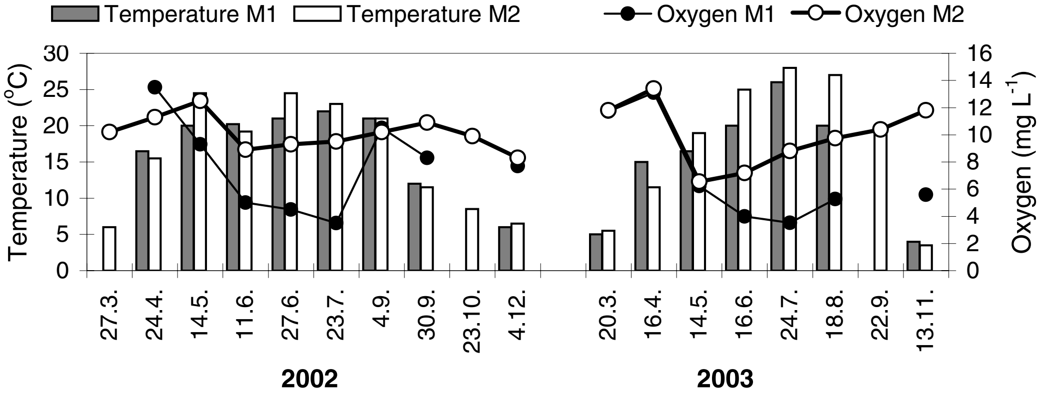

Fig. 2. Seasonal changes of water temperature and oxygen in Šrek arm (M1) and Stará Morava arm (M2) in 2002 and 2003.

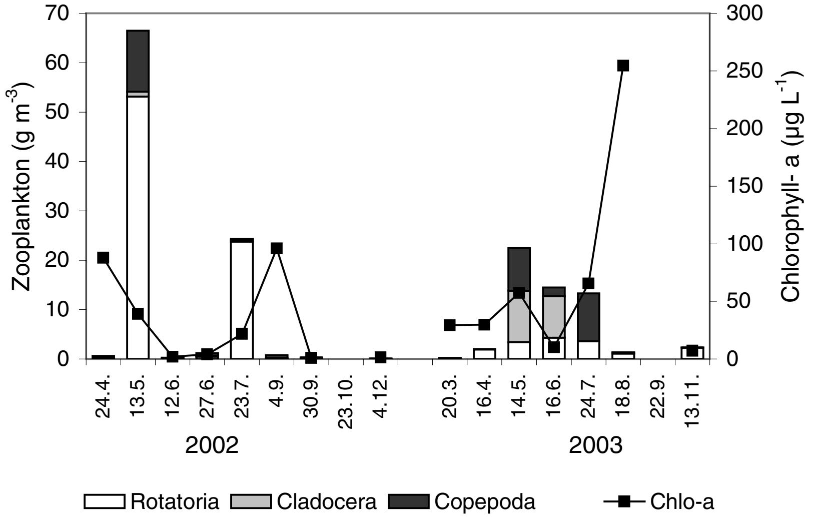

Fig. 3. Development of wet biomass of zooplankton (Rotatoria, Cladocera and Copepoda) with relation to chlorophyll-*a* in Šrek arm during the season in 2002–2003.

Temperature, oxygen (Tab. 1, Fig. 2)
Since these are relatively shallow pools at a maximum depth of 2 m, the water was overheated in summer months. Particularly in 2003 higher July water temperatures were recorded in both of the arms (26 °C, M1 and 28 °C, M2); in addition to that the average summer temperature in M2 was a remarkable 26.7 °C.

The oxygen content was noticeably higher in the Stara Morava arm, mainly in summer when phytoplankton was abundant and temperature was high. In contrast, there was considerable decrease in the oxygen content observed in the Šrek arm in summer months where water surface was shaded by natant macrovegetation.

Chlorophyll-a (Tab. 1, Figs 3, 4)
Mean chlorophyll-*a* (chl-*a*) concentration (48.18 μg L^{-1}) was relatively high during 2002–2003 in the Šrek arm (M1). The mean annual values were 31.6 μg L^{-1} (2002) and 64.7 μg L^{-1} (2003) and the highest concentrations were recorded in late summer.

In 2002, two peaks of the chl-*a* increase were observed (Fig. 3). At first there was a typical spring peak (87.9 μg L^{-1}) (April). From May to August the water surface was covered with *Nuphar lutea*, so the chl-a concentration was low. The second peak of chl-*a* was recorded on September 4 (95.5 μg L^{-1}); after a flood. At that time the chrysophytes *Synura* sp. dominated. Phytoplankton was low from September to the end of the season.

In 2003, chl-*a* concentration was low (Fig. 3) during the whole season except for the summer extreme peak on August, 18 (254 μg L^{-1}). The high value of chl-*a* significantly influenced the annual concentration in that year.

In the Stará Morava arm (M2) the mean concentration of chl-*a* was high (68.09 μg L^{-1}) and the summer maxima were recorded (Fig. 4). The mean annual values were 74.8 μg L^{-1} (2002) and 61.38 μg L^{-1} (2003). In the summer of 2002 two peaks of chl-*a* were recorded (173.8 μg L^{-1}, 162.2 μg L^{-1}) (July, September, respectively). In the first half of June, *Asterionella* sp. was very abundant in the plankton. The cyanophyte wa-

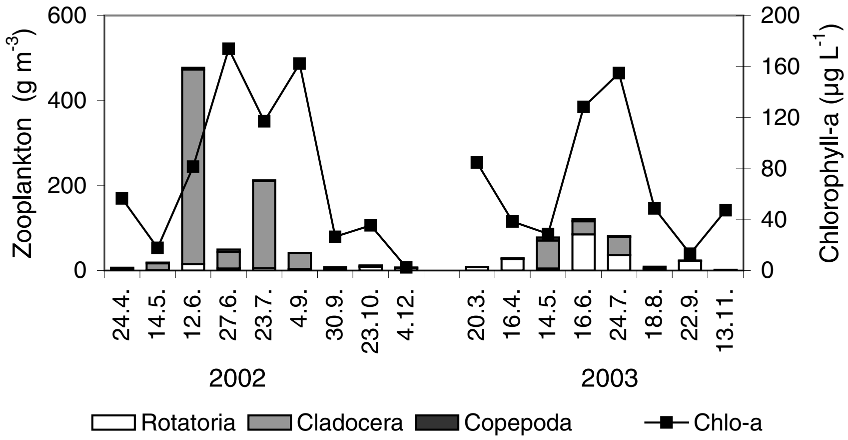

Fig. 4. Development of wet biomass of zooplankton (Rotatoria, Cladocera and Copepoda) with relation to chlorophyll-*a* in Stará Morava arm during the season in 2002–2003.

ter bloom of the *Microcystis* spp. was observed in the late summer phytoplankton in both years. In the second year the typical spring peak of chl-*a* was observed in March (84.65 μg L^{-1}), but the maximum was recorded in July (154.9 μg L^{-1}).

Zooplankton density, biomass and seasonal dynamics

Šrek arm (M1) (Tabs 1, 2, Fig. 3)

In 2002 rotifers predominated in open water zone and contributed up to 81% of the total zooplankton biomass and 83% of the total zooplankton density. Zooplankton density peaked in May (31,800 N L^{-1}), coinciding with that of rotifers (especially of *Keratella cochlearis*), which represented 83% of all individuals. After the short decrease in density during June, the second peak (16,704 N L^{-1}) was recorded in July (*Polyarthra* sp., *Brachionus angularis*).

Cladocerans were represented by small sized species and reach a very low annual density (7 N L^{-1}). A relatively higher density was reached only by the species *Bosmina longirostris* (24 N L^{-1}) (May) and *Ceriodaphnia pulchella* (16 N L^{-1}) (July). The annual density of copepods (1,190 N L^{-1}) was much higher than the one of cladocerans. They peaked in May but mainly nauplia and copepodites were observed.

Mean seasonal zooplankton wet biomass was 11.6 g m^{-3} and varied during the study period between 0.11 and 65.75 mg m^{-3} (Fig. 3). Mean biomass of planktonic crustaceans was 1.7 g m^{-3}. The relationship of the zooplankton biomass to chl-*a* fluctuation is shown in Fig. 3. The spring peak of phytoplankton (24 April) enabled the development of rotifers and copepodites in May, when the total zooplankton biomass was highest (rotifers 83%). The second peak of chl-*a* was recorded on September 4, when the total biomass of zooplankton decreased.

In 2003 the spring and summer peak of rotifers was not observed during the seasonal dynamics of the zooplankton (Fig. 3). The increase in density of rotifers (*K. cochlearis*) and total zooplankton (5,028 N L^{-1}) in May were low and the same values were maintained until the end of June. In summer *Polyarthra* gen. spec (max. 88%) dominated.

Cladocerans were present with a low average density (76 N L^{-1}). There were species present with a higher density: *B. longirostris* (252 N L^{-1}, 202 N L^{-1}) (May, June, respectively); *Chydorus sphaericus* (32 N L^{-1}) (May), and *Daphnia ambigua* (24 N L^{-1}) (June). Copepods were present mostly in developmental stages. Of the adults, the *Thermocyclops crassus* population reached a density maximum of 20 N L^{-1} in July. On 18 August the arm became shallow, and only a pool remained. With a low density the species *T. pusilla* (90%), *Moina micrura* and *Scapholeberis mucronata*, *Thermocyclops oithonoides* and *T. crassus* were observed.

Mean seasonal zooplankton wet biomass was 8.01 g m^{-3} and fluctuated between 0.11 g m^{-3} and 22.61 g m^{-3} in 2003 (Fig. 3). Mean biomass of planktonic crustaceans was 5.6 g m^{-3} and represented a significant part (70%) of the total biomass. The May maximum (22.61 g m^{-3}) was influenced by *B. longirostris* and in June the developmental stages of copepods predominated.

Stará Morava arm (M2) (Tabs 1, 2, Fig. 4)

In 2002 cladocerans predominated in open water zone and contributed up to 91% of the total zooplankton biomass (Fig. 4). The annual density of Cladocera was also high (Tab. 2). That year the zooplankton density (rotifers and cladocerans maximum) peaked in June (23,432 N L^{-1}). *Keratella quadrata* and *K. cochlearis tecta* predominated in spring and in October, *Polyarthra* gen. spec. (December, 70%) dominated from summer until winter.

Cladoceran density peaked in June and July (2002) coinciding with that of *Bosmina longirostris,* with its maximum density in June (11,280 N L^{-1}). *Moina micrura* (248 N L^{-1}) (June) also significantly participated in the summer density of cladocerans. The species of

Table 2. Species composition of cladocerans (Crustacea, Cladocera) and copepods (Crustacea, Copepoda) of Šrek arm (M1) and Stará Morava arm (M) in 2002 and 2003.

Sites	Code	M1		M2	
Taxon/year		2002	2003	2002	2003
Cladocera					
Acroperus harpae (Baird, 1834)	ACRHAR			+	
Acroperus neglectus Lilljeborg, 1900		+		+	
Alona affinis (Leydig, 1960)				+	+
Alona guttata Sars, 1962				+	+
Alona rectangula Sars, 1862	ALOREC	+	+	+	+
Alona quadrangularis (O.F. Müller, 1785)					+
Alonella excisa (Fischer, 1854)					+
Bosmina longirostris (O.F. Müller, 1860)	BOSLON	+	+	+	+
Camptocercus rectirostris Schoedler,1862				+	
Ceriodaphnia megops Sars, 1862	CERMEG	+	+	+	+
Ceriodaphnia pulchella Sars, 1862	CERPUL	+	+	+	+
Ceriodaphnia quadrangula (O.F. Müller, 1785)	CERQUA		+	+	
Ceriodaphnia reticulata Sars, 1820	CERRET	+	+		+
Daphnia ambigua Scourfield, 1948	DAPAMB		+		+
Daphnia cucullata Sars, 1862	DAPCUC			+	+
Daphnia curvirostris Eylmann, 1887				+	
Daphnia galeata Sars, 1864	DAPGAL		+	+	+
Daphnia longispina (O.F. Müller, 1785)		+		+	
Daphnia parvula Fordyce, 1901	DAPPAR			+	+
Diaphanosoma brachyurum (Liévin, 1848)				+	
Diaphanosoma mongolianum (Ueno, 1939)				+	
Diaphanosoma orghidani (Negrea, 1982)	DIAORG			+	+
Disparalona rostrata (Koch, 1841)	DISROS			+	+
Dunhevedia crassa King, 1853					+
Eurycercus lamellatus (O.F. Müller, 1875)		+		+	
Graptoleberis testudinaria (Fischer, 1851)	GRATES	+		+	+
Ilyocryptus agilis Kurz, 1878			+	+	+
Chydorus sphaericus (O.F. Müller, 1785)	CHYDSP	+	+	+	+
Leptodora kindtii (Focke, 1844)	LEPKIN			+	
Leydigia leydigii (Schoedler, 1863)				+	+
Macrothrix laticornis (Fischer, 1851)	MACLAT			+	+
Moina micrura Kurz, 1874	MOIMIC	+	+	+	
Moina weismanni Ishikawa, 1896	MOIWEI			+	+
Pleuroxus aduncus (Jurine, 1820)	PLEADU	+	+	+	+
Pleuroxus denticulatus Birge, 1875					+
Pleuroxus laevis Sars, 1862				+	
Pleuroxus trigonellus (O.F. Müller, 1785)				+	
Pleuroxus truncatus (O.F. Müller, 1785)	PLETRU	+	+	+	+
Pleuroxus uncinatus Baird, 1850		+			+
Pseudochydorus globosus (Baird, 1843)				+	+
Scapholeberis mucronata (O.F. Müller, 1785)	SCAMUC		+	+	+
Sida crystallina (O.F. Müller, 1776)	SIDCRY	+		+	+
Simocephalus congener Schoedler, 1858		+	+	+	
Simocephalus serrulatus (Koch, 1841)				+	
Simocephalus vetulus (O.F. Müller, 1776)	SIMVET	+	+	+	+
Copepoda					
Acanthocyclops robustus (Sars, 1863)		+	+	+	+
Attheyella (B.) trispinosa (Brady, 1880)				+	
Canthocamptus staphylinus (Jurine, 1820)		+			
Cryptocyclops bicolor (Sars, 1863)				+	+
Cyclops strenuus Fischer, 1851				+	+
Cyclops vicinus Uljanin, 1875			+	+	+
Ectocyclops phaleratus (Koch, 1838)		+	+	+	+
Eucyclops serrulatus (Fischer, 1851)		+	+	+	+
E. s. var. *proximus* (Lilljeborg, 1851)		+		+	+
Eucyclops speratus (Lilljeborg, 1901)					+
Eudiaptomus gracilis (Sars, 1863)		+		+	+
Eurytemora velox (Lilljeborg, 1853)		+			
Macrocyclops albidus (Jurine, 1820)			+	+	+
Megacyclops viridis (Jurine, 1820)		+	+		
Mesocyclops leuckarti (Claus, 1857)		+	+	+	+
Mixodiaptomus kupelwieseri (Brehm, 1907)		+			
Paracyclops poppei (Rehberg, 1880)				+	
Thermocyclops crassus (Fischer, 1853)			+	+	+
Thermocyclops oithonoides (Sars, 1863)		+	+	+	+

Key: Code – abbreviation of corresponding taxa for cluster analysis (Figs 7, 8); + taxa found.

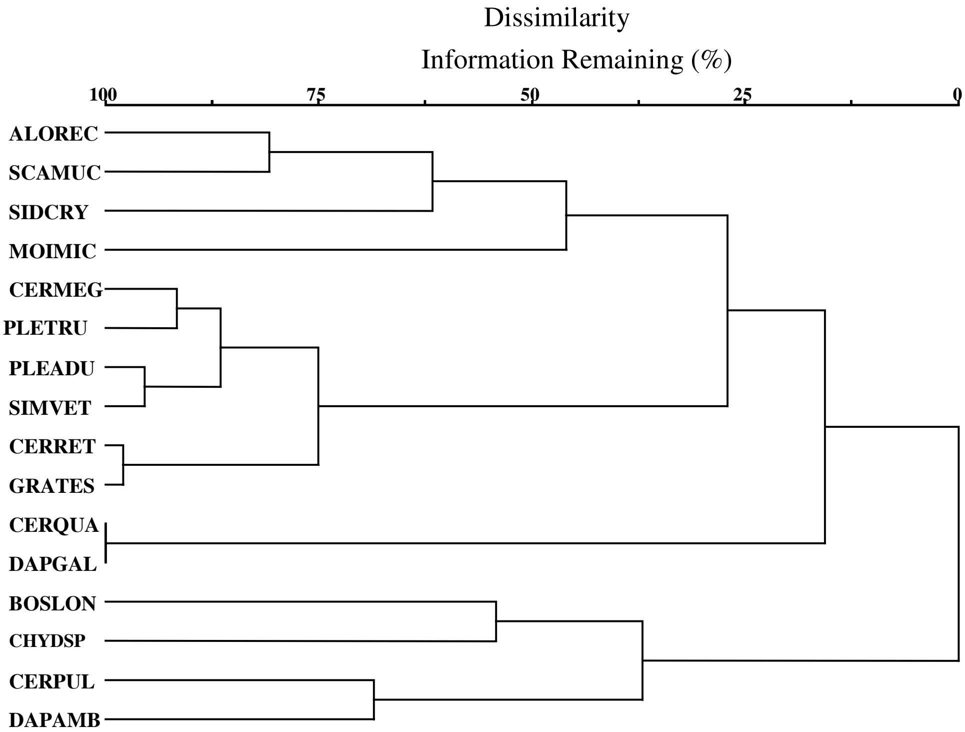

Fig. 5. Dendrogram based on 16 Cladocera species present in medial zone of Šrek arm in 2002–2003 (hierarchical clustering, Ward's method, Jaccard similarity index).

Daphnia genus appeared in the medial in September, although at very low density (6 N L^{-1}, *D. parvula*). Copepods were represented mostly by their developmental stages. The adults of *T. oithonoides* reached the highest density (56 N L^{-1}) in July.

Mean zooplankton wet biomass was 92.5 g m^{-3} and fluctuated between 6.4 to 447.1 g m^{-3} (Fig. 4). Mean biomass of planktonic crustaceans was 87.1 g m^{-3} and *B. longirostris* represented more than 91% of this value.

In 2003 rotifers predominated in the open water zone and contributed up to 94% of the total zooplankton density. The boom in rotifers (58,740 N L^{-1}) was recorded on 16 June; however, there was also a high density (21,414 N L^{-1}) on 24 July.

The maximum density of cladocerans was recorded in May, when *B. longirostris* predominated (1,636 N L^{-1}). In the summer months *Moina weismanni* was also present at a higher density (336 N L^{-1}) in June. Of the adult copepods *Thermocyclops oithonoides* was the main representative showing a high density from April to September with a maximum in May (72 N L^{-1}); while *Thermocyclops crassus* (48 N L^{-1}) (June) and *Mesocyclops leuckarti* (80 N L^{-1}) (May) were also abundant during this season.

The zooplankton biomass fluctuated between 2.1 to 121.7 g m^{-3} (Fig. 4). Mean zooplankton biomass 44.1 g m^{-3} was half that of 2002, because crustaceans are a less important part of plankton in this oxbow. Their mean biomass was 20.3 g m^{-3} and *B. longirostris* formed 64% of this value.

Species composition of planktonic crustaceans (Tab. 2, Figs 5, 6)
In total, 45 species of Cladocera and 20 species of Copepoda (Cyclopoidea and Calanoidea) were identified from samples collected in open water and in the littoral of two oxbows; 65% of cladocerans and 52% of copepods were recorded in the both areas.

In the Šrek arm 22 cladoceran and 15 copepod species were determined. From this number 21 cladoceran species and 11 copepod species were found in the littoral. The highest frequency was reached by *Simocephalus vetulus* (73%), *C. pulchella* (65%), *Macrocyclops albidus* (82%), *Eucyclops serrulatus* (73%) and *T. crassus* (64%). As a result of cluster analysis of the medial cladoceran community two main groups were identified (Fig. 5). In the first group 12 cladoceran species were identified in a cluster at a density lower than 1 N L^{-1}. These were littoral (benthic and phytophilous) species, apart from *Moina micrura* and *Daphnia galeata*. In the second group four species were clustered, the ones occurring in the medial with the density higher than 1 N L^{-1}: *B. longirostris, Chydorus sphaericus*, *Ceriodaphnia pulchella* and *Daphnia ambigua*.

In the Stará Morava arm there were 45 cladoceran and 14 copepod species recorded. From this total, 41 cladoceran species, of which 21 were chydorids, and 13 copepod species were present in the littoral. The highest frequency was reached by *Chydorus sphaericus* (71%), *Ceriodaphnia pulchella* (64%), *Alona rectangula* (63%)

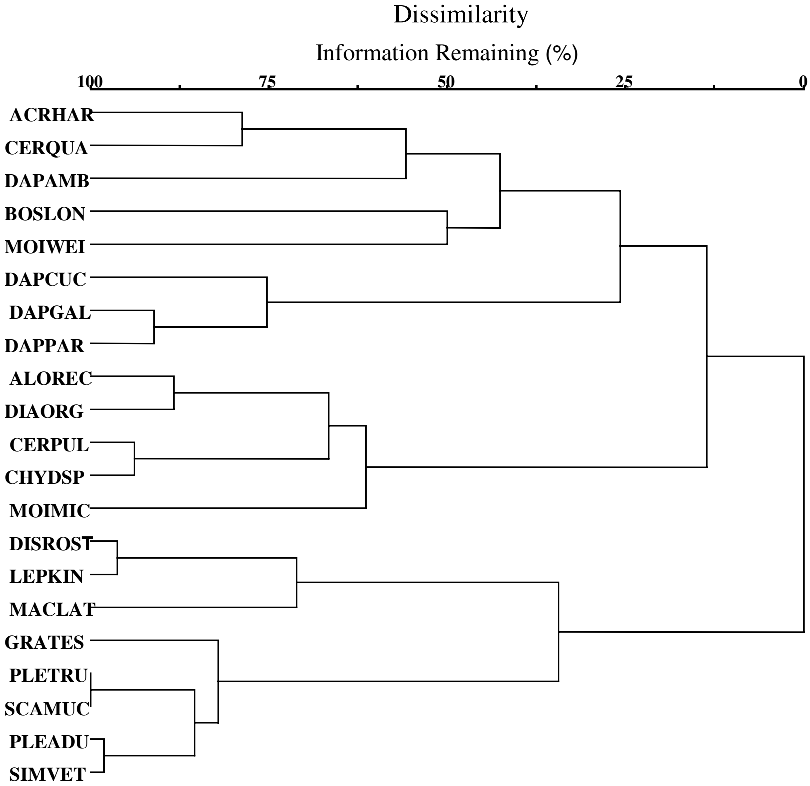

Fig. 6. Dendrogram based on 21 Cladocera species present in medial zone of Stará Morava arm in 2002–2003 (hierarchical clustering, Ward's method, Jaccard similarity index).

and *Eucyclops serrulatus* (60%). From cluster analyses two main groups were identified (Fig. 6). In the first group 13 planktonic species were clustered, apart from *Acroperus harpae, Ceriodaphnia quadrangula* and *Chydorus sphaericus*, which are littoral. In the second group eight species were clustered, and apart from *Leptodora kindtii* and *Scapholeberis mucronata* all of them are littoral.

Discussion

The values of zooplankton biomass were low in the Šrek arm. Specific medial zooplankton, typical for lenitic biotopes (Vranovský, 1985; Kořínek et al., 1987), was not formed and the relatively low cladoceran diversity (24) was also noted. It is probable that these unfavourable parameters were caused by a considerable fluctuation of a water level in this arm. The first year (2002) was hydrologically above average and was characterized by spring floods and the great flood in August (Fig. 1). The Šrek arm is situated at river km 11.5–14.5, near the confluence of the Morava and the Danube rivers, whereby both rivers significantly affect its hydrological regime. The arm is overflowed and reconnects with other water bodies in the inundation when the water stage exceeds 400 cm, measured at the profile of Záhorská Bystrica village (according to SHMU reports) (Fig. 1). In 2002, the Šrek arm was flooded at the beginning of April, in August and in October. In this year the maximal chl-*a* content and zooplankton density alternated with sudden falls of these values. It seems that the ecosystem of this arm is highly labile. When the typical spring flood was over there was the development of phytoplankton. The second increase in chl-*a* was recorded in August when the flood had receded. The high concentration of chl-*a* can be a result of flow of the nutrient input from the main channel and side arms. Afterwards we could observe a boom in rotifers and copepods in spring, which is typical for the seasonal dynamics of zooplankton (Devetter, 1998). However, an unstable hydrological regime and frequent flood over the whole area prevented the development of planktonic crustaceans. When considering the mean biomass value of planktonic crustaceans (1.7 g m^{-3} in 2002) the arm resembled the arms in the Morava River basin that were artificially reconnected. Here the planktonic crustaceans biomass decreased from 18 g m^{-3} and 43 g m^{-3} before reconnection, to values of 0.6 g m^{-3} and 0.9 g m^{-3} after reconnection (Illyová, 1999).

In contrast, the following year (2003) was extremely dry; with low water stages (Fig. 1), additionally the macrovegetation *Nuphar lutea* covered the water level. The shading effect was observed from the beginning of May to July. This also corresponded with low values of oxygen (July, 3.5 mg L^{-1}) and chl-*a* (June, 10.06 mg m^{-3}); in addition zooplankton did not prove to be at the typical peak of its spring and autumn density (Devetter, 1998; Kořínek et al., 1987). In August, because of the decrease in the water level, the arm changed into a shallow pool. The rest of the water surface was suffused with light and since filtrating zooplankton was missing an extreme growth of phytoplankton occurred (254.5 mg m^{-3}).

The number of Cladocera (22) and Copepoda (15) species in the Šrek arm is relatively low and did not reach the potential of the area (Hudec, 1999). It is possible to assume that the dominance of phytophilous cladoceran fauna in the arm's medial is related to presence of *N. lutea.* Korochvinsky (1986) also found in *N. lutea* a diverse community consisting of the species *Sida crystallina, Pleuroxus truncatus, Chydorus sphaericus, Graptoleberis testudinaria, Alonella exiqua, Alona costata, Polyphemus pediculus,* and various species of the *Ceriodaphnia* genus.

In the Stará Morava arm there was high density, biomass, and also species diversity of individual zooplankton groups. This can be explained by the stable hydrological regime of the arm, where there were favourable conditions for zooplankton development. This arm was inundated only by the spring floods. It is likely that there was natural eutrophication in the Stará Morava arm in both years. There massive bloom, over 100 μg L^{-1} of chl-*a* and massive development of small-bodied zooplankton supports this theory (Kořínek et al., 1987); also the presence of the cladoceran *Moina weismanni* that prefers shallow and strongly eutrophic waters (Hudec, 1988). Phytoplankton development was observed in the arm in the summer months; according to Bailey-Watts (1987) the development of rich summer algal growth is typical for nutrient-rich lakes. The high chlo–*a* value was reached despite high macrovegetation development, which usually takes away nutrients from the surroundings (e.g., Kořínek et al., 1987).

The high quantity of the zooplankton in the Stará Morava arm corresponds with our previous findings (Illyová & Némethová, 2002). Previously we also found high mean values of abundance (up to 2,909 N L^{-1}) and biomass (up to 72.43 g m^{-3}). The high qualitative values of plankton were probably caused by an excessive supply of nutrients, which is the basis for production of a plankton community. Biomass with the same high zooplankton values (42.54 mg L^{-1}) was found in a meadow pool of the Morava basin also by Kopecký & Koudelková (1997)

In addition to eutrophication we predict a high level of fish stock, as suggested by Hrbáček (1962). The composition of zooplankton, especially a mass growth of rotifers and the dominance of small-bodied crustaceans, of the Stará Morava arm was the most similar to zooplankton in a pond with a high fish predation (Pechar et al., 1996; Kořínek et al., 1987; Hudcovicová & Vranovský, 2000). The relatively high density of the two species *Thermocyclops oithonoides* and *T. crassus* also suggests the presence of fish. According to Pechar et al. (1996), these species prevail in habitats that are stocked with fish. Also Hudcovicová & Vranovský (2000) established that *T. oithonoides* reaches middle and high values of relative abundance only in waters with a high fish density. The second aspect of the development of thermophilic and stenothermic *Thermocyclops* genus is probably the warm summer of 2003 (Fig. 2). The cladoceran *B. longirostris* significantly affected the total wet biomass during the whole vegetation period, mainly in 2002. In our previous studies (Illyová & Némethová, 2002) we already stated its high average density (1,443 N L^{-1}) in the littoral of four water bodies in the Morava basin, compare to the relatively low mean density (63 N L^{-1}) in five Danubian arms.

The number of planktonic crustaceans in the Stará Morava arm (63) is high and compares with the diversity of identical biotopes of big rivers in C Europe (Gulyás, 1994; Bothár & Ráth, 1994; Hudec & Stano, 1997). Considering the number of species – according to classification of the biotope origin (Hudec, 1999) – the Stará Morava arm belongs to the category of original biotopes, which deserve protection. The identified number of cladoceran species (44) represents as many as 76% of cladoceran diversity (58) that were found in 15 areas of the Morava basin in the area from r km 0.5–66.00 (Slovakia) (Illyová & Kubíček, 2002). The high species diversity in the arm was caused by a stable hydrological regime and by the presence of macrovegetation. The cluster analysis results suggest that the phytophilous cladoceran species penetrated from the littoral macrovegetation into the medial zone. In the littoral zone, the high occurrence (70–100%) of *Chydorus sphaericus* and *Simocephalus vetulus*, *Eucyclops serrulatus* and *Macrocyclops albidus* in macrovegetation of *Ceratophyllum* sp. corresponds with the findings of other authors (e.g., Ošmera, 1973; Hudec, 1987; Illyová & Némethová, 2002) and proves the affinity of these species to this macrovegetation.

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