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Crustaceans (Crustacea: Cladocera, Copepoda) of the Morava River Alluvium on the Slovak Territory

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Abstract. The paper presents the first comprehensive survey of 58 Cladocera species and 38 Copepoda taxa from 15 localities of various types of arms, temporary pools and oxbows of the Morava River inundation on the Slovakian territory. Among the species found, the cladocerans *Bosmina coregoni* Baird, 1875, *Daphnia parvula* Fordyce, 1901, *D. ambigua* Scourfield, 1946, *Pleuroxus denticulatus* Birge, 1879, *Moina weismanni* Ishikawa, 1896 and the calanoid *Eurytemora velox* (Lilljeborg, 1853) are supposed to be either invaders or introduced species.Cladocerans *Bosmina longirostris* (O. F. Müller, 1776), *Moina micrura* Kurz, 1874, *M. weismanni* Ishikawa, 1896, the genus *Daphnia* and copepods of the genera *Eudiaptomus* and *Acanthocyclops* prevailed in relatively deep side arms situated in the inundation. Phytophilous assemblages of *Daphnia curvirostris* Eylman, 1887, *Megafenestra aurita* (Fischer, 1849), *Mixodiaptomus kupelwieseri* (Brehm, 1907), genera *Simocephalus*, *Scapholeberis*, and *Acroperus* dominated in waters of temporary character and shallow dead arms covered with macrovegetation.

Distribution, wetlands, floodplain, pools, Crustacea, Morava River, Palaearctic region

INTRODUCTION

Aquatic alluvial biotopes are often being terrestrialized. It is caused either by natural ageing or by anthropogenic intervention. The Slovak part of the Morava River floodplain, especially the inundated area, is the territory where the diversity of original aquatic biotopes has been preserved.

Several recent studies (Adámek & Sukop 1992, Kopecký & Koudelková 1997, Sukop & Kopecký 1999, Kopecký et al. 1999) have been published on the Cladocera and Copepoda fauna in the upper section of the Morava River and its tributary Dyje. There is a lack of data on Cladocera and Copepoda species composition in the lower section of the Morava River on the Slovak territory, except rare Crustacea in temporary pools (Brtek 1976 and 1992). This lack is caused by prohibited access to portion of the Morava River that forms the border between Slovakia and Austria over a long period of time. Systematic monitoring of the study area began only in 1994 thanks to project on revitalisation of cut-off meanders (Štěrba 1995, Lisický et al. 1997). The result of this project is the first list of Cladocera and Copepoda species in the Morava alluvium (Illyová 1999).

Our study focuses on different types of standing waters of the Morava River floodplain. Our goal is to explain the occurrence of cladocerans and copepods in the Slovak portion of the Morava River.

We dedicate this contribution to Doc. RNDr. Jaroslav Hrbáček DrSc., upon the occasion of the 80th anniversary of his birthday (*12th May 1921*).

Tab. 1. Description of study sites

number of locality	name of locality	river km	cadastre
1	meander XVIII.	65.6–66.0	Moravský Sv. Ján
2	meander XVII.	65.3–65.5	Moravský Sv. Ján
3	meander XVI.	63.5–64.0	Moravský Sv. Ján
4	meander VII.	18.9–20.6	Vysoká pri Morave
5	meander II.	11.7–12.3	Vysoká pri Morave
6	Šrek	11.5–14.5	Stupava
7	Nová Kakvica	22.8–24.7	Vysoká pri Morave
8	Rudavné jazero	51.5–52.1	Malé Leváre
9	Lepňa	57.0–57.9	Malé Leváre
10	Bezodné	13.0	Vysoká p.M.
11	Oblaz	27.0	Záhorská Ves
12	Štokrzí	49.0–50.0	Gajary
13	Bučany	61.0	Moravský Sv. Ján
14	Lantov	62.0–64.0	Moravský Sv. Ján
15	Pod Devínom	0.5	Devínska Nová Ves

STUDY AREA

Our 15 study localities (Table 1) are situated between the Moravský Svätý Ján village and the Devín village, or river km 66.0 and km 0.5, respectively, in the Záhorie lowland, Slovakia. They can be divided according to their distance from the main stream (sensu Roux et al. 1982) into three groups:

1. **The former meanders of the Morava River** (Localities 1, 2, 3, 4 and 5). They were permanently connected with the main channel during high discharge and correspond to the parapotamon type according to Roux et. al (1982) and Ward et al. (1995). Their depth is about 2 m. Locality 1 is in the advanced stage of terrestrialisation (Štěrba et al. 1995). Its littoral zone contain floating macrophytes (*Spirodela polyrrhiza*, *Lemna* sp.) and submersed and emergent macrophytes (*Ceratophyllum demersum* and *Glyceria* sp.), respectively.

2. **Dead meanders of the Morava River** (Localities 6, 7, 8 and 9) and meadow pool (15). Localities of this group are connected to the main channel only during inundation of the floodplain. They correspond to plesio-potamon of Roux et al. (1982). These localities can be further divided into subgroups:

(2a) Relatively deep meanders (Localities 6–9). Their length remarkably exceeds their width and the maximum depth reaches about 2 m. Macrophytes *Ceratophyllum demersum*, *Polygonum amphibium*, *Potamogeton* sp., *Nuphar lutea*, *Phragmites australis*, *Spirodela polyrrhiza* and *Lemna minor* are common in this subgroup.

(2b) A permanent floodplain meadow pool (Locality 15). It has a round shape, and maximum depth of 1 m. The pool is often dry in late summer and autumn. Its shore is overgrown by *Phragmites australis*.

3. **Old meanders of Morava** (Localities 10, 11, 12, 13 and 14). They are isolated from the main stream by a main dam. They correspond to paleopotamon of Roux et al. (1982). Old meanders can be divided into subgroups:

(3a) Shallow temporary pools (Localities 11, 12, 13 and 14). Their depth is less than 1 m and the length exceeds width. The maximum water level is achieved during the spring, or autumn. Prevailing vegetation at these localities contains *Rorippa amphibia*, *Schoenoplectus lacustris*, *Glyceria maxima* and *Typha* sp. Tn the locality 13 at Bučany *Hottonia palustris* and *Stratiotes aloides* occured, until the pool became cattle crossing. When the water became turbid and smelled of liquid manure, the vegetation contained only *Spirodela* and *Lemna*.

(3b) Relatively deep pool (Locality 10). It has an oval shape and 2.5 m depth. The original meander was most probably deepened by the gravel excavation. Its littoral zone contains *Ceratophyllum demersum*, *Batrachium* sp., *Rorripa amphibia*, *Carex gracilis* and *Schoenoplectus* sp.

METHODS

Samples of the cladoceran and copepod assemblages were taken using plankton net with 130–140 μm mesh. They were preserved in 4% formaldehyde. Medial zone samples were taken using vertical tows from boat or oblique tows from bank moved from bottom to surface. Littoral zone samples were taken as well.

Altogether 271 samples were analysed.

Cladocera samples were collected from the medial and littoral zone at 34 sampling sites of 12 localities (1–9, 12, 13 and 14) during August–September, 1994.

Altogether 105 oxbow samples were taken at 15 sampling sites of localities 1–5 as part of the meander revitalisation project of Štěrba et al. (1995) during 1994–95. Both Cladocera and Copepoda were studied. Samplings took place during May, July, August, October and December in 1994 and February and May in 1995.

In total, 75 samples of Cladocera and Copepoda were collected from the littoral zone of 5 oxbows during 1995. They were taken at 5 sampling sites of localities 1–5. Samples were collected as part of the project of Lisický et al. (1997). Sampling took place in May, July and October.

Altogether 70 Cladocera and Copepoda samples were collected from the medial and littoral zone of 10 localities during 2001. They were taken at 20 sampling sites of localities 6–15. Samples from localities 6, 9, 10 and 13 were collected during May–October. Locality 7 was sampled during May, June, September and October. Locality 11 was sampled during May and July–September. Localities 12 and 14 were sampled during May, September and October and Locality 15 was sampled during May–July. Locality 8 was sampled only once in May.

RESULTS

In total, 58 Cladocera species and 38 Copepoda taxa were found in the study area (Tabs 2 and 3). They belong to three different types of environment: (1) former meanders of the Morava River, (2) dead meanders and meadow pool inside-dikes, and (3) old meanders and oxbow outside-dikes.

The former meanders of the Morava River

The highest number of Cladocera species, 46 taxa, was found in side arms. They represent 79% of all species found. The species *Bosmina longirostris*, *Moina micrura* and *M. weismanni* prevailed in the medial zone. They occurred in mass at some localities. Other pelagic species *Daphnia galeata*, *D. ambigua*, *D. longispina* and *D. parvula* were present almost at all localities. Littoral Cladocera fauna was also abundant. *Sida crystallina*, *Pleuroxus aduncus*, *Graptoleberis testudinaria* were the most frequent (Table 2). The Copepoda taxocoenosis consisted of 28 taxa, amounting to 74% of all Copepoda species found. *Eudiaptomus gracilis*, *Diaptomus castor* and cyclopoids *Acanthocyclops robustus*, *A. vernalis* and *Cyclops vicinus* were the most frequent ones among pelagic calanoids species. *Eucyclops serrulatus* and *Macrocyclops albidus* prevailed among phytophilous species.

Cladocera *Bosmina coregoni*, *Pleuroxus denticulatus*, *Daphnia parvula*, *D. ambigua*, *Moina weismanni* and the calanoid *Eurytemora velox* were found from invaders.

Dead meanders and meadow pool inside-dikes

We found 36 Cladocera species in this arm type. There were species of genera *Diaphanosoma*, *Daphnia*, *Moina* and *Bosmina longirostris* present in this environment. The meadow pool Pod Devínom (Loc. 15) forms the exception. It recorded a significant prevalence of littoral species *Daphnia curvirostris*, *Megafenestra aurita*, *Simocephalus vetulus* and *S. congener* (Table 2). The Copepoda taxocoenosis included 20 species. Invaders *Daphnia ambigua* and *Eurytemora velox* were found.

Old meanders and oxbow outside-dikes

In this arm type we found 36 Cladocera and 22 Copepoda. Littoral species prevailed (81%) in the Crustacea taxocoenosis. The typical species were *Daphnia curvirostris*, *Mixodiaptomus kupelwieseri* and *Megacyclops viridis*. Other common species were *Daphnia pulex*, *D. pulicaria*, *Oxyurella tenuicaudis*, *Canthocamptus staphylinus*, *Paracyclops poppei* and *Attheyella* (*B.*) *trispinosa*. From invader species only *E. velox* was found in the arm Bezodné (Loc. 10).

Tab. 2. Species composition and presence (+) of cladocerans (Crustacea, Cladocera) of water bodies of the Morava river floodplain in 1994–1995 and 2001

locality number taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ctenopoda															
Sididae															
Sida crystallina (O. F. Müller, 1776)	+	+	+	+	+	+	+		+	+					
Diaphanosoma brachyurum (Liévin, 1848)		+	+			+	+		+	+					
Diaphanosoma mongolianum Ueno, 1938			+												
Diaphanosoma orghidani Negrea, 1982		+	+			+		+	+						
Anomopoda															
Bosminidae															
Bosmina coregoni Baird, 1875				+	+										
Bosmina longirostris (O. F. Müller, 1776)	+	+	+	+	+	+	+	+	+	+		+		+	+
Chydoridae															
Eurycercus lamellatus (O. F. Müller, 1776)		+		+						+			+		
Pseudochydorus globosus (Baird, 1843)		+	+	+	+										
Chydorus sphaericus (O. F. Müller, 1776)	+	+	+	+	+	+	+	+	+	+	+	+	+		+
Graptoleberis testudinaria (Fischer, 1848)	+	+	+	+	+	+		+	+	+				+	
Pleuroxus truncatus (O. F. Müller, 1776)	+	+	+	+		+	+	+	+						
Pleuroxus laevis Sars, 1862							+			+					
Pleuroxus trigonellus (O. F. Müller, 1776)				+											
Pleuroxus aduncus (Jurine, 1820)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Pleuroxus denticulatus Birge, 1879					+										
Leydigia leydigii (Schoedler, 1862)		+	+		+					+					
Dunhevedia crassa King, 1853									+					+	
Alonella nana (Baird, 1843)															
Alonella excisa (Fischer, 1854)	+	+		+					+		+	+		+	+
Alonella exigua (Lilljeborg, 1853)				+										+	
Alona guttata G. O. Sars, 1862	+	+	+	+	+	+		+		+				+	
Alona costata G. O. Sars, 1862									+						
Alona rectangula G. O. Sars, 1862	+		+	+	+	+		+	+		+			+	
Alona quadrangularis (O. F. Müller, 1776)		+		+											
Alona affinis (Leydig, 1860)				+	+	+				+					
Oxyurella tenuicaudis (Sars, 1862)										+					
Tretocephala ambigua (Lilljeborg, 1900)													+	+	+
Acroperus harpae (Baird, 1836)	+						+	+	+						
Acroperus neglectus (Lilljeborg, 1900)				+			+		+	+		+	+		
Daphnidae															
Ceriodaphnia reticulata (Jurine, 1820)	+	+				+	+	+		+		+	+	+	
Ceriodaphnia pulchella G. O. Sars, 1862	+	+	+	+	+	+	+	+	+	+			+		
Ceriodaphnia megops G. O. Sars, 1862	+				+	+			+	+					
Ceriodaphnia laticaudata P. E. Müller, 1867	+														+
Ceriodaphnia rotunda Sars, 1862					+	+								+	
Ceriodaphnia quandrangula (O. F. Müller, 1785)	+	+				+			+	+					+
Simocephalus serrulatus (Koch, 1841)				+											
Simocephalus vetulus (O. F. Muller, 1776)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Simocephalus exspinosus (Koch, 1841)	+	+	+	+	+							+	+	+	
Simocephalus congener Schoedler, 1858						+				+		+	+		+
Daphnia pulex Leydig, 1860													+		
Daphnia pulicaria Forbes, 1893		+										+			
Daphnia curvirostris Eylmann, 1887												+	+	+	+
Daphnia parvula Fordyce, 1901	+	+	+	+											
Daphnia ambigua Scourfield, 1946		+	+	+	+		+		+						
Daphnia longispina O. F. Müller, 1785	+	+		+	+			+		+	+	+	+	+	+

Tab. 2. continuation

locality number taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Daphnia galeata G. O. Sars, 1863	+	+	+	+	+	+	+	+	+						
Daphnia cucullata G. O. Sars, 1862	+		+	+			+		+						
Megafenestra aurita (Fischer, 1849)					+	+				+		+			+
Scapholeberis rammneri Dumont et Pensaert, 1983		+			+						+	+			
Scapholeberis mucronata (O. F. Müller, 1776)	+	+	+	+	+	+	+	+	+	+	+	+			+
Moinidae															
Moina micrura Kurz, 1874	+	+	+	+	+	+			+	+					
Moina weismanni Ishikawa, 1896	+	+	+	+	+	+		+	+			+		+	
Macrothricidae															
Ilyocryptus sordidus (Liévin, 1848)		+	+												
Ilyocryptus agilis Kurz, 1878			+		+	+			+						
Macrothrix laticornis (Jurine, 1820)						+			+						
Haplopoda															
Leptodora kindtii (Focke, 1844)	+		+												

DISCUSSION

A relatively high number of Cladocera (58 taxa) and Copepoda (38 taxa) found in the area between the 66th and 0,5th river kilometre confirms that the Morava floodplain is a relatively undisturbed biotope (see Hudec 1999). The occurrence of genus *Daphnia* at our localities corresponds to their natural habitats and the present status of their distribution (Hrbáček 1987). The Cladocera taxocoenosis represents 60% of the 96 cladocerans species (Hudec 1998) occurring on the Slovak territory. The number of planktonic crustaceans species found in the alluvium of Morava (96 taxa) appears to be high also in comparison with findings of other authors who examined biotopes of other inundation areas. This number is a little higher than 80 taxa of Terek & Obrdlík (1992), found in several habitats of the Rhine River. It is also higher than 50 planktonic crustacean species of Gulyás (1994), found in waters of the Sigetköz arms of the Danube inundation in Hungary.

Vranovský (1997) determined 30 Copepoda taxa from five Danube arms and two main stream profiles on the Slovak territory. The harpacticoid *Nitocra hibernica* (Brady, 1880) was one of the most dominant species. It was not recorded from the Morava alluvium. However, 80% of copepods that Vranovský (1997) had found in Danube arms were found also in Morava arms.

During the extensive recent faunistic research of ten Danubian side arms, 72 Cladocera and 25 Copepoda taxa were found between Dobrohošť and Čičov villages (river km 1841–1081) (Illyová 1996). Danubian arm species, which were not found in the Morava floodplain, are the rare cladoceran *Anchistropus emarginatus* Sars, 1862 and the benthic cladocerans *Disparalona rostrata* (Koch, 1840), *Macrothrix hirsuticornis* (Norman et Brady, 1867) and *Pleuroxus uncinatus* (Baird, 1850).

Adámek & Sukop (1992) found approximately the same number of Cladocera (53 taxa) and Copepoda (41 taxa) in Morava waters to the north of our study area.

Part of the Morava floodplain, namely the confluence of Morava and Dyje rivers, was studied in the project on aquatic invertebrates in the biosphere reserve Pálava in Czech Republic (Opravilová et al. 1999). Sukop & Kopecký (1999) found 29 Cladocera species in this area. We found all of them in our study area, except of *Daphnia magna* Straus, 1820. Only *Eudiaptomus vulgaris* (Schmeil, 1898) from 17 copepod taxa determined by Kopecký et al. (1999) was not present in our study area.

Tab. 3. Species composition and presence (+) of copepods (Crustacea, Copepoda) of selected habitats of Morava river floodplain in 1994–1995 and 2001

locality number taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Calanoida															
Temoridae															
Eurytemora velox (Lilljeborg, 1853)	+					+				+					
Diaptomidae															
Arctodiaptomus bacillifer (Brady, 1880)	+		+												
Diaptomus castor (Jurine, 1820)	+	+	+	+	+										
Eudiaptomus gracilis (Sars, 1863)	+	+	+	+	+	+	+		+	+				+	+
Eudiaptomus zachariasi (Poppe, 1886)	+		+		+						+				
Mixodiaptomus kupelwieseri (Brehm, 1907)							+					+		+	+
Cyclopoida															
Cyclopidae															
Eucyclopinae															
Macrocyclops fuscus (Jurine, 1820)										+			+		
Macrocyclops distinctus (Richard, 1887)						+									
Macrocyclops albidus (Jurine, 1820)	+	+	+	+	+	+	+		+	+	+		+		
Eucyclops macrurus (Sars, 1863)		+													
Eucyclops speratus (Lilljeborg, 1901)	+	+	+	+	+										
Eucyclops serrulatus (Fischer, 1851)	+	+	+	+	+	+	+	+	+	+	+		+		
E. serrulatus var. *proximus* (Lilljeborg, 1901)						+									
Tropocyclops prasinus (Fischer, 1860)	+														
Mesocyclops leuckarti (Claus, 1857)		+	+	+	+	+	+			+	+		+		
Paracyclops fimbriatus (Fischer, 1853)				+	+										
Paracyclops poppei (Rehberg, 1880)											+				
Cyclopinae															
Metacyclops gracilis (Lilljeborg, 1853)								+						+	
Cryptocyclops bicolor (Sars, 1863)									+		+	+	+	+	
Microcyclops varicans (Sars, 1863)									+			+	+		
Megacyclops viridis (Jurine, 1820)						+			+	+	+	+	+	+	+
Megacyclops gigas (Claus, 1857)			+		+										
Megacyclops latipes (Lowndes, 1927)	+		+												
Acanthocyclops robustus (Sars, 1863)	+	+	+	+	+	+	+	+	+	+			+		+
Acanthocyclops vernalis (Fischer, 1853)	+	+	+	+	+										
Diacyclops bicuspidatus (Claus, 1857)	+	+	+	+	+							+		+	
Diacyclops bisetosus (Rehmberg, 1880)		+	+	+	+										
Cyclops furcifer Claus, 1857	+	+	+	+											
Cyclops insignis Fischer, 1857	+														
Cyclops strenuus Fischer, 1851	+	+	+	+				+				+	+	+	+
Cyclops vicinus Uljanin, 1875	+	+	+	+	+	+	+	+	+		+				
Thermocyclops crassus (Fischer, 1853)	+	+	+	+	+	+		+	+	+	+	+			+
Thermocyclops dybowskii (Lande, 1890)															+
Thermocyclops oithonoides (Sars, 1863)		+	+	+	+	+	+	+	+	+	+				
Ectocyclops phaleratus (Koch, 1838)						+			+						
Harpacticoida															
Attheyella (*B.*) *trispinosa* (Brady, 1880)														+	
Bryocamptus (*B.*) *minutus* (Claus, 1863)		+	+	+	+										
Canthocamptus staphylinus (Jurine, 1820)	+	+	+	+	+	+		+		+		+	+	+	+

We assume that invaders drifted into the Morava inundation either from the South Moravia lenitic biotopes (*D. parvula*, *D. ambigua*, *M. weismanni* and *B. coregoni*) or expanded from the Danube inundation area (*P. denticulatus* and *E. velox*); both alternatives are possible. For example, the species *Bosmina coregoni* probably drifted from the Nové Mlýny dam where is was

determined by Adámek & Sukop (1992). However, the species could migrate also from the Danube River where Vranovský (1974) and Hudec (1989) found it in the main stream and Číčov Arm, respectively. The direction in which the species *Daphnia parvula* migrated into the Morava alluvium remains questionable. The species was frequent in Morava side arms in 1994–1995 and occurred also in the Křivé jezero lake plankton (Sukop & Kopecký 1999) in the South Moravia region. Other authors do not mention *Daphnia parvula* in the Morava alluvium. It has not been found in the Danube inundation either.

Hudec (1998) assumes that *Daphnia parvula* migrates to Slovakia from the Morava and Danube river basins similarly as *B. coregoni* and *D. ambigua*. Invader cladocerans could get to this region from the water systems of the South Moravia. This could relate to the fact that water birds, potential carriers, migrate in larger numbers than before after the construction of the Nové Mlýny Dam. The species *Eurytemora velox* penetrated into the Morava inundation most probably from the Danube where it was the dominant species in mid nineties at several localities (Vranovský 1997). The species *Pleuroxus denticulatus* spread in the Danube inundation with the same velocity. It was recorded for the first time in 1992 (Terek 1997) but it occurred almost in the whole Slovak Danube section in mid nineties (Hudec & Illyová 1998).

Crustaceoplankton taxocoenoses in various types of arms, oxbows and temporary pools reflected different character of these environments. Pond assemblage prevailed in water bodies with the stable water level. Small Cladocera species and small-size plankton (unpublished data) indicated high densities of planktivorous fish (Hrbáček 1962). Phytophilous crustaceans inhabited the littoral overgrown with macrovegetation. The assemblage of phytophilous and benthic species, *Tretocephala ambigua*, *Daphnia curvirostris*, *Mixodiaptomus kupelwieseri*, *Megacyclops viridis*, *Paracyclops poppei*, *Thermocyclops dybowskii*, *Attheyella* (*B.*) *trispinosa,* in old meanders and pools with abundant macrovegetation occurred. Kopecký & Koudelková (1997) found the similar species composition in two pools of the Morava River floodplain. The crustaceans taxocoenosis (*Cyclops strenuus*, *Mixodiaptomus kupelwieseri* and *Daphnia curvirostris*), found in periodic pools and temporary arms, corresponds to associations described from the Záhorie and Podunajská lowlands (Štěrba 1988), with exception of missing *D. magna*.

Protection of the original aquatic ecosystems undisturbed by anthropogenic impact is the inevitable condition of preservation of aquatic fauna biodiversity in the Morava inundation. The uniqueness of this area is supported by the presence of rare species such as *Hemidiaptomus hungaricus* Kiefer, 1933 or *Heterocope saliens* (Lilljeborg, 1863) in the Záhorie lowland (Brtek 1953). Other crustaceans worthy of protection are *Lepidurus apus* Linnaeus, 1758 and *Siphonophanes grubii* (Dybowski, 1860) occurring in snow and flood pools (Lukáš 2000).

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