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ANALYSIS OF SPATIAL AND TEMPORAL CHANGES OF THE ZOOPLANKTON FAUNA IN THE RÁCKEVE-SOROKSÁR DANUBE ARM

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Abstract: The section of the Ráckeve-Soroksár Danube arm (RSD) can be divided based on the Cladocera and Copepoda fauna well. Strong dividing lines, however, cannot be drawn only based on hydromorphological aspects, just as considering the above mentioned two faunas. For example, in the middle section of the arm there are no exclusively characteristic species. This fact is obvious as the river stretch here offers the most various habitats. The upper section can be separated well from the middle one and, the lower section is sharply separated from the other two sections. Though numerous sources of pollution have ceased, the number of species shows a decreasing tendency. A possible reason for this is eutrophication. Statistical analyses also reinforce the existence of spatial and temporal changes.

Introduction

The Ráckeve-Soroksár Danube arm (RSD) ranks among the most significant water bodies in Hungary. It is the second biggest arm in the Hungarian section of the Danube. The RSD arm diverges from the main arm on the left at the 1642 river kilometres under the Budapest Southern Railway Bridge and flows back into the main Danube direction at the 1586 river kilometres. The arm is 58 km long. The water surface is 14 km^2 and the body of water is around 40 million m^3. As it can be found close to the capital, it has always had an important role in transportation, economy and industry (Csepel Iron and Metal Works, Csepel Motor Works). In spite of its importance, scientific investigations of the RSD arm have begun rather late. Though examinations were carried out in the 19th century, they focussed mainly on technical tasks because of the flood prevention work that was in progress at that time. The first remarkable survey was made in 1954. Berinkey and Farkas (1953) studied the nutrient that was available for fishes. During the next decades, comprehensive surveys slowly have begun concerning especially biological, ecological and hydrological aspects. A detailed review of zooplankton investigations in the RSD arm is presented in authors' previous publication (Vadadi-Fülöp and Mészáros 2007) and a complex ecological review and evaluation of the RSD arm is also performed in a study (Vadadi-Fülöp et al. 2007), therefore these topics will not be dealt with hereby.

Studies discussing the RSD arm divide it traditionally into upper, middle and lower sections. However, strong dividing lines cannot be drawn between the sections, and section borders are often different in the literature. Division for sections is based mainly on hydrological and hydromorphological characteristics. The three sections show significant differences since the river bed is widening from the north to the south and current velocity is decreasing.

In the current study authors compare the three sections with regard to the zoo plankton fauna. Authors attempt to answer the question to what extent the zooplankton fauna is different in the externally well divided three river sections. The zooplankton components were investigated based on temporal changes, because since the 1970's considerable effects – both positive and negative – have been modifying the fauna composition in the river. Authors' goal was not to make artificial borders, but to demonstrate and analyse the existence of spatial and temporal changes with the help of statistical methods.

Materials and Methods

The zooplankton fauna has been analysed from the end of the 1960's up till current times. As few quantitative data are available, this work is dealing only with qualitative data (presence – absence). Authors set up a zooplankton faunistic database based on data from literature and own measurements. Charts were made with data classified according to sampling time (1960–1970 and 1990–2000) and sampling sites: river sections (upper, middle, lower) and settlements. Data were analysed by various statistical methods (ordination, cluster analysis) and using Past Program (HAMMER and HARPER 1999–2005) during statistical analysis. Names of species are given according to GULYÁS and FORRÓ (1999, 2001).

There was no opportunity for a more precise classification, since not all the publications present usable data. Valuable information about the zooplankton fauna of the 1960's and 1970's could be gained from the publications of BOTHÁR (1973), GULYÁS and TYAHUN (1974), GYŐRBÍRÓ (1974) and TYAHUN (1977). For the years 1990–2000 authors used data from the publications presented by GULYÁS (1997) and JUST et al. (1998). In addition, authors could make good use of own surveys (Mészáros 2005, VADADI-FÜLÖP 2006–2007, not published). Authors decided to use this classification because the data we could use and evaluate are mainly in accordance with these two aspects (spatial and temporal) and moreover, they can be the basis for a clear comparison. While analysing, authors had to leave out the Rotatoria taxa, because only one survey of them was carried out in 1995-1996 (GULYÁS 1997, JUST et al. 1998). Authors had no ground for comparison, though it was a comprehensive investigation as 36 taxa were found at 5 sampling sites. It has to be mentioned that GYŐRBÍRÓ in 1974 (not published) partly examined the Rotatoria fauna at 4 sampling sites, but it cannot be compared with the study mentioned above. Therefore, only Copepoda and Cladocera are presented in the analyses. As for Copepoda fauna so far only two species of Harpacticoida suborder have been found in this section of the Danube yet they are not described in the comparison as most of the studies do not deal with them. Ostracoda is also ignored for the same reasons.

The ecological requirements of the species and their description are presented in accordance with the works of GULYÁS and FORRÓ (1999, 2001) and EINSLE (1993). *Figure 1* shows the sampling sites and other important features.

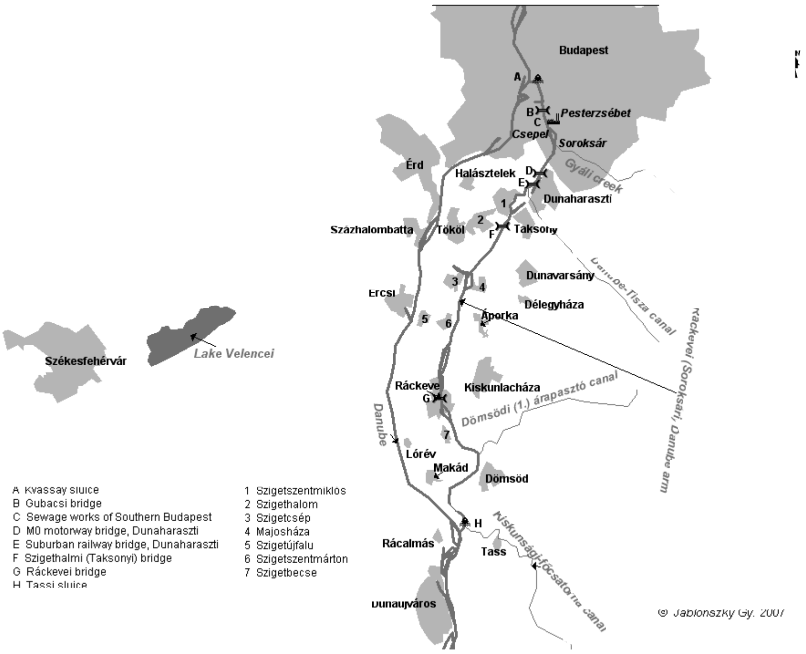

Figure 1. Map of the RSD with waters flowing into it, sampling sites and important establishments.
1.ábra. A RSD térképe a mintavételi helyekkel, befolyó vizekkel és fontosabb létesítményekkel.

Results and Discussion

In the RSD arm authors managed to reveal 64 different Copepoda and Cladocera species on the basis of own examinations and literature data. 59 out of these species can be found in the lower section located between Ráckeve and Tass, 37 species can be observed in the stretch extending between Szigethalom and Ráckeve. In the upper section, between Szigethalom and Kvassay sluice 41 species were described. Out of the 64 species in question 25 can be found in all the sections above. One of Copepoda species, *Graeteriella unisetigera* (GRAETER, 1908) has not been found so far anywhere else in Hungary (GULYÁS and FORRÓ 2001). The habitat of this species is in subsoil waters, caves, wells, interstitial waters and it is highly abundant in Central Europe. In 1974 GYŐRBÍRÓ presented this species in all the three sections of the RSD arm but his results were not published.

In *Table 1* authors revised the species investigated on the basis of literature data. Next to the species the years of their presence in the RSD arm can be seen. On the right, the river sections where the species were described can be found.

Table 1. The zooplankton fauna in the RSD arm and its temporal spatial changes
1. táblázat A RSD zooplankton (*Copepoda, Cladocera*) faunája, illetve annak időbeli és térbeli megoszlása.

	1960–1970	*1990–2000*	*lower*	*middle*	*upper*
Oxyurella tenuicaudis (Sars, 1862)	+	-	+	-	-
Alonella exigua (Lilljeborg, 1853)	-	+	-	-	+
Alonella nana (Baird, 1850)	-	+	-	-	+
Anchistropus emarginatus Sars, 1862	+	+	+	-	-
Bosmina longirostris (O. F. Müller, 1785)	+	+	+	+	+
Bosmina coregoni Baird, 1857	+	+	+	-	+
Camptocercus rectirostris Schoedler, 1862	+	+	+	+	+
Leptodora kindtii (Focke, 1844)	+	-	+	-	+
Sida crystallina (O. F. Müller, 1776)	+	+	+	+	-
Diaphanosoma brachyurum (Liévin, 1848)	+	+	+	-	+
Daphnia cucullata Sars, 1862	+	+	+	+	+
Daphnia hyalina Leydig, 1860	+	+	+	-	-
Daphnia longispina O. F. Müller, 1785	+	+	+	+	+
Disparalona rostrata (Koch, 1841)	+	+	+	+	+
Eurycercus lamellatus (O. F. Müller, 1785)	+	+	+	+	+
Graptoleberis testudinaria (Fischer, 1848)	+	-	+	+	-
Simocephalus serrulatus (Koch, 1841)	+	-	+	-	-
Simocephalus vetulus (O. F. Müller, 1776)	+	+	+	+	+
Moina macrocopa (Straus, 1820)	+	-	+	-	-
Moina micrura Kurz, 1874	+	+	+	+	+
Moina rectirostris Leydig, 1860	+	-	+	+	-
Monospilus dispar Sars, 1862	+	-	+	-	-
Ceriodaphnia quadrangula (O. F. Müller,1785)	+	+	+	+	-
Ceriodaphnia dubia Richard, 1894	+	+	+	+	+
Ceriodaphnia laticaudata *(*P. E. Müller, 1867)	+	+	+	-	+
Ceriodaphnia pulchella Sars, 1862	+	-	+	-	-
Scapholeberis mucronata (O. F. Müller, 1785)	+	+	+	+	+
Macrothrix laticornis (Fischer, 1848)	+	-	+	-	+
Macrothrix hirsuticornis (Norman & Brady, 1867)	-	+	-	+	+
Iliocryptus sordidus (Liévin, 1848)	+	+	+	-	-
Iliocryptus agilis Kurz, 1878	+	+	-	+	+
Acroperus harpae (Baird, 1834)	+	+	+	+	+
Pleuroxus truncatus (O. F. Müller, 1785)	+	+	+	+	+
Leydigia leydigi (Schoedler, 1863)	+	+	+	-	+
Chydorus sphaericus (O. F. Müller, 1776)	+	+	+	+	+
Pleuroxus trigonellus (O. F. Müller, 1785)	+	+	+	+	+
Pleuroxus uncinatus Baird, 1850	+	+	+	-	+
Pleuroxus aduncus (Jurine, 1820)	+	+	+	+	+
Pseudochydorus globosus (Baird, 1843)	+	+	+	+	-
Alona quadrangularis (O. F. Müller, 1785)	+	+	+	+	+
Alona affinis (Leydig, 1860)	+	+	+	+	+
Alona intermedia Sars, 1862	+	+	+	+	-

Contd. Table 1./1. táblázat folytatása

	1960–1970	*1990–2000*	*lower*	*middle*	*upper*
Alona guttata Sars, 1862	+	+	+	-	-
Alona rectangula Sars, 1862	+	+	+	+	+
Macrocyclops albidus (Jurine, 1820)	+	+	+	+	-
Macrocyclops fuscus (Jurine, 1820)	+	-	+	-	-
Eucyclops serrulatus (Fischer, 1851)	+	+	+	+	+
Eucyclops macruroides (Lilljeborg, 1901)	+	-	+	-	-
Eucyclops macrurus (Sars, 1863)	+	-	+	+	-
Paracyclops fimbriatus (Fischer, 1853)	+	+	+	-	+
Cyclops strenuus Fischer, 1851	+	-	+	-	+
Cyclops vicinus Uljanin, 1875	+	+	+	+	+
Graeteriella unisetigera (Graeter, 1908)	+	-	+	+	+
Megacyclops viridis (Jurine, 1820)	+	-	+	+	-
Acanthocyclops vernalis (Fischer, 1853)	+	-	+	+	+
Acanthocyclops robustus (Sars, 1863)	+	+	+	+	+
Diacyclops bicuspidatus (Claus, 1857)	+	-	-	-	+
Cryptocyclops bicolor Sars, 1927	+	-	+	-	-
Mesocyclops leuckarti (Claus, 1857)	+	-	+	+	+
Thermocyclops crassus (Fischer, 1853)	+	+	+	+	+
Thermocyclops oithonoides (Sars, 1863)	-	+	+	+	-
Eudiaptomus gracilis (Sars, 1863)	+	+	+	-	+
Eurytemora velox (Lilljeborg, 1853)	-	+	+	-	+
Ectocyclops phaleratus (Koch, 1838)	-	+	+	-	-

In the following part, the 3 RSD arm sections are described on the basis of Copepoda and Cladocera fauna and then on the basis of spatial and temporal changes.

<u>The upper section:</u> It is located between the Kvassay sluice and Szigethalom village, where the river bed is the narrowest (80-200 m) and the shallowest (average water depth is 2-3 m). The highest current velocity can be observed here. However, this velocity is substantially lower as compared with the main arm of the Danube. The reason for it is that the floating alluvial deposit from the Danube settles here and considerable amounts of mud can be observed. The inadequate quality of water derived from the main arm has the severest effect here. In addition, several sources of pollution emitted by industrial establishments transform the water quality even worse. Three islands are situated here: Molnár, Czuczor, and Dunaharaszti-Taksony, but their island-like character is hardly dominant, because of the large amounts of mud.

According to these examinations and literature data, 41 species can be identified in the upper river section. It is extremely remarkable that merely 3 of the 41 species can be regarded as typical for this river stretch (*Alonella exigua, Alonella nana, Diacyclops bicuspidatus*). *Alonella exigua* can be described as a species closely confined to reedgrass and its sparse existence can be announced mainly in peaceful, hidden places and creek. There is no record of its presence in the RSD arm in the 1960’s and 1970’s. In the meantime, based on our survey it can be stated that *Alonella exigua* is relatively common both in the main and side arms at Dunaharaszti. *Alonella nana* is the most resistant Cladoceran and is presented in a large variety of waters. Its size makes the species capable of living in every place where detritus occurs. In spite of the fact that this section of the RSD arm has the most sources of pollution it must be mentioned that *Alonella nana* is announced to be sensitive to pollution. The third species, *Diacyclops bicuspidatus* prefers waters that are rich in organic substance.

Further species that can be found in this river section: *Bosmina longirostris* is a species of the highest abundance in small, eutrophic lakes, on the other hand it avoids polluted waters. *Disparalona rostrata* lives in detritus accumulated in soft, deep mud. *Pleuroxus aduncus* is cosmopolitan and is the inhabitant of eutrophic waters. *Acanthocyclops vernalis* is a copepod of high abundance all over Central Europe. Upon these facts we can come to the conclusion that the upper river stretch of the RSD is the most polluted, but the rate of pollution is not extreme as e.g. *Bosmina* and *Alonella* species avoid highly polluted waters.

According to the species described hereby, the water in the upper section is moderately–highly polluted, where the signs of advanced eutrophication can be observed as the species described here like eutrophic waters. *Leydigia leydigi* must be mentioned as a species that has adapted so much to the circumstances with oxygen deficiency that even haemoglobin is present in its lymph.

Taking temporal changes into consideration when investigating Cladocera and Copepoda fauna, an interesting conclusion can be stated: based on the available data we can state the presence of 30 different species in the upper section and they were announced both in the 1960's – 1970's and 1990's. There are only 7 species of them that were described only in the 1960's in this section of the RSD arm, 5 species belong to Copepoda subclass and only 2 belong to Cladocera order. One of them is the rather scarce *Leptodora kindtii,* the only representative of Leptodoridae in Hungary. This species has considerable sizes (6-7 mm) that make it a real giant among Cladocera. Studying the needs and the habitats of these species we can see that they are the same more or less even nowadays. *Mesocyclops leuckarti* for example is the inhabitant of mainly eutrophic lakes, *Diacyclops bicuspidatus* likes waters rich in organic substance. *Macrothrix laticornis* lives mainly in the muddy bottom sediment of puddles and small lakes or among vegetation. Authors have already described the needs and habitat of *Alonella exigua* and *Alonella nana*. In the 1990's these two species were announced in the upper section just as *Macrothrix hirsuticornis* that can be described as the inhabitant of the shore zones of the most various waters. The occurrence of *Thermocyclops oithonoides* is the most remarkable fact in this river section. It can be observed mainly in large stagnant waters, needs oxygen and shows meso-oligotrophy. In any case it is strange that an oxygen demanding species was stated in this river stretch.

On the whole, if the species presented above are examined in accordance with temporal changes, authors cannot see any considerable differences between the conditions in the years 1960–1970 and 1990–2000. There are no significant changes in fauna composition. This fact is worth mentioning as numerous sources of pollution have ceased since the 1960's and in addition, the importance of transportation has declined on this waterway. Therefore, water in the main arm of the Danube seems to determine the water quality in the upper section of the RSD arm such as 40 years ago.

Middle section: It is located between Szigethalom and Ráckeve (22–38 rkm). This section is deeper (2,5–3 m) and wider (average bed width 350–400 m). The shorelines here are in the original state. On the shore several *Typha* species dominate but extended sedge (*Carex*) and sparse reeds (*Phragmites*) are characteristics of this stretch. This section is of great importance in respect of spawning. In addition, unique floating bogs can be found here.

In the middle section the number of species is the lowest (only 37 described species). It is interesting that there are no species exclusively characteristic of this section. All of the species here can be found either in the upper or the lower section and some species can be observed in both. This fact means the transient feature of the middle section. It is conspicuous that *Ceriodaphnia quadrangula* can be observed in this river stretch as this species is sensitive to pollution and eutrophication. The occurrence of *Moina micrura* is pleasing. This species contrasted with the other *Moina* species exists in cleaner waters that are less polluted by organic substance. In spite of this fact it was described in the river section both in the 1960's and 1990's. These facts show that the effect of pollution is less dominating and self-purification process can be considerable in this section.

We can observe bigger differences in temporal examinations rather than in comparing the species composition of this section with that of the other two sections. There are 7 species described in the 1960's, but they are not presented in the 1990's. In contradiction to this, there are only 2 species present only in the 1990's. *Eucyclops macrurus* lives sparsely and likes waters that are rich in vegetation. Therefore, in spite of the fact that this species was not identified in the 1990's, it has probably not vanished from the RSD arm as its vital conditions have not declined. *Grabtoleberis testudinaria* – also presented in the RSD arm in the 1960's – is the inhabitant of the coastal phytoid zone of larger lakes and rivers. Its presence has been announced in many places, but it likes mainly the acidic, poor water of swamps. *Mesocyclops leuckarti* also can be found on the checklist of the 1960's, though it is the inhabitant of eutrophic waters, while *Moina micrura* prefers clean waters. In spite of these facts, both of them were described in the middle section of the RSD arm. It is worth mentioning that *Mesocyclops leuckarti* was presented in all the three sections in the 1960's. It has to be remarked that in 2007, during authors' investigations this species could have been observed in a side-arm of the RSD arm. *Megacyclops viridis* was also presented only in the 1960's. Though this species is cosmopolitan and common everywhere, in the 1990's it was not described in the sections of the RSD arm. The tendency is similar for *Graeteriella unisetigera*. Literature data show its occurrence in the three sections of the RSD arm in the 1960's, but it was not announced in the 1990's. It is really interesting that this species exists in subsoils and in the water of caves, wells i.e. in places where the water is rich in oxygen and gets little light. Probably its occurrence is unique and sparse. *Thermocyclops oithonoides* was described in the middle section only in the 1990's. This species demanding oxygen prefers extended, stagnant waters and shows meso-oligotrophy. *Macrothrix hirsuticornis* is not confined to oxygen so much even it is a characteristic of sodic waters. It is the inhabitant of a great variety of waters mainly in the coastal zone covered by vegetation or it occurs close to the river bed.

Based on the above mentioned facts it can be stated that the middle section cannot be sharply seperated from the other two river sections considering the fauna composition as there are not any species exclusively found in it. It has to be added that the middle section offers the most various habitats. Large, open body waters can be found here as well as hidden creeks and – as the shores are partly in the original state – a great variety of coastal vegetation extends. This is why all species can find their vital conditions in the middle river section.

When examining temporal changes, the situation is different. Seven species were described in the 1960's and they were not found in the 1990's. Most of them are of high abundance. Though they are not really specific, some of them are really worth mentioning. E.g. some of the 7 species are definitely the inhabitants of eutrophic waters and in other waters that are rich in oxygen (caves, wells). Other species can be found in the most different waters.

Therefore we can come to the conclusion that some species have vanished not because of changing water quality, but because the other, less sensitive, cosmopolitan species have displaced them slowly.

Lower section: The lower river section located between Ráckeve and Tass sluice (0–22 rkm) has a bed width of 300 m and water depth of 3,5–6 m. The body of water is 20–25 million m^3 that adds up to 50–55% of the whole water body of the RSD arm. The current velocity is very low (even current in the opposite direction was observed) and it can be regarded as a stagnant water. The water quality is the most favourable, mostly suitable for fishing.

According to literature, the lower section has got the highest number of species. Since the 1960's 56 different species have been recorded. There are 13 species that exist or existed only in this section. This number can be regarded as significant. *Anchistropus emarginatus, Monospilus dispar, Ectocyclops phaleratus* also belong to the group above. In accordance with the guide (GULYÁS and FORRÓ 1999, 2001) all the three species are scarce, so their presence in this river stretch is really special. *Ectocyclops phaleratus* lives mainly in small waters while *Anchistropus emarginatus* and *Monospilus dispar* like stagnant waters and waters with low current velocity. *Ceriodaphnia pulchella* likes clean, small waters that are free of pollution based on organic matter content. Eutrophication is the biggest problem in the RSD arm so the presence of *Ceriodaphnia pulchella* is very important as this species restricts eutrophication. The fact that the three species above and *Ceriodaphnia pulchella* can be found in the lower section means that the water quality is favourable.

Daphnia hyalina is reported as an inhabitant of deep, moderately calcareous lakes, reservoirs and shallow lakes with large surface.

Alona guttata was also presented exclusively in the lower section. This fact is of great interest as this species is resistant and common so much that it was identified even in the collected water of hollow trees. In most cases, however, *Alona guttata* can be observed in the vegetation of reeds or in muddy circumstances with reed grass. A lot of places of this kind can be found in the other two sections so its exclusive presence in the lower section is unusual. *Oxyurella tenuicaudis* likes habitat that is quiet and rich in vegetation, where the water is smaller, swamps are characteristic and lives in the submerged vegetation. Based on the data from literature its presence only in this river section is surprising.

So far *Cryptocyclops bicolor* and *Eucyclops macruroides* - the representatives of Copepoda – have been announced mainly in lakes and small waters.

Comparing the fauna composition in the lower section with those in the other two sections one can see remarkable differences as for the 13 species living only in the lower section. In addition, there are scarce species among them and many of them like clean, unpolluted water. Moreover, *Ceriodaphnia pulchella* is definitely described by literature as an eutrophication restrictive species. Another similarity of species is that most of them are the inhabitants of stagnant water or water of low current velocity. This reflects the present conditions entirely i.e. the lower section of the RSD arm can be regarded as a stagnant water.

When considering temporal comparison even more significant differences must be mentioned. In the 1960's 18 species were pointed out and they were not described in the 1990's. On the other hand, only three species were described during the investigations in the 1990's. All these three species (*Thermocyclops oithonoides, Eurytemora velox, Ectocyclops phaleratus*) belong to Copepoda. *Eurytemora velox* definitely has been the member of the home fauna for 15 years. Its first occurrence was reported from Szigetköz in 1992. *Ectocyclops phaleratus* – scarce species, *Thermocyclops oithonoides* – oxygen demanding species, the inhabitant of bigger, stagnant waters, show meso–oligotrophy.

Going on with the analysis of Copepoda – based on literature – one can find 10 species described in the 1960's in the RSD arm and not identified in the 1990's. *Mesocyclops leuckarti* – presented mainly in eutrophic waters – has not been reported recently. This fact may give a reason for optimism to some extent. *Megacyclops viridis* and *Acanthocyclops vernalis* are common species. Similarly, it is surprising that *Alona guttata* was described in 1960's and it has not been reported since then. *Graeteriella unisetigera* was described in the 1960's in both the middle and lower section. Probably only few of them were found. *Cyclops strenuus* is highly resistant and is able to adapt well to pollution and the changes of conditions. Therefore, probably the stock of them existing in this river section was not small yet their presence was not announced in the 1990's. It has to be remarked that the absence of some species does not mean that they have vanished, but it may be a mistake when taking samples as scarce species do not always occur in samples. *Macrothrix laticornis* was the representative of Cladocera in the 1960's. On the basis of literature it is the habitant of puddles, smaller lakes, shallow water. Relatively few places of this kind exist in the lower section, so this species – just as some others – has been displaced from its habitat. Probably the some happened to *Ceriodaphnia pulchella*. It is the habitant of clean, smaller waters and restricts eutrophication. So the absence of this species is unfortunate. Whereas, *Simocephalus serrulatus* was identified only in this river stretch. It lives in smaller waters (lakes, puddles, creeks, ditches) and prefers to stay in vegetation, where the water contains colloidal organic substance.

To sum up, it can be stated that the lower section of the RSD arm is definitely different from the other two ones as numerous species can be observed only in this river stretch. Although in the course of time the number of species has decreased, it is still different from the middle and upper sections of the RSD arm.

Statistical analysis

Authors attempted to explore the spatio-temporal changes of the zooplankton community with multivariate statistical methods. Cluster analysis and non-metric multidimensional scaling (NMDS) were performed using Euclidean distance in both cases. The results of the former methods were compared to verify their efficiency. We considered examining the spatial and temporal patterns meaningful simultaneously, thus it can be answered whether the spatial or the temporal changes are larger. The similarity patterns of the main sampling sites were also carried out with the same methods.

The dendogram of the sections and the 1960–1970's respectively 1990–2000's is presented in *Figure 2*, based on cluster analysis. For comparison, the zooplankton fauna of the river Danube is represented with the water bodies of Szigetköz and without Szigetköz. It is evident that the river Danube isolated from the RSD. The result, that the fauna of the lower section is similar to the one of the 1960–70's, likewise the fauna of the upper section is similar to the one of the 1990–2000's is interesting. The middle section is near to the latter group. The transient character of the middle section was already apparent by the review of the species since no taxa were found existing only here. Particularly great similarity showed the 1960-1970's with the lower section on the grounds of their zooplankton fauna. The same result can be observed on the NMDS ordination (*Figure 3*), the middle section is located between the other two sections. The fauna of the Danube without the water bodies of Szigetköz is closer to the RSD which can be interpreted by the species living in the Szigetköz area, namely there are many rare species not occurring in the RSD. According to the results, there are differences between the sections and decades based on the zooplankton fauna that is the fauna of the upper section is similar to the fauna of our days and recent past, whereas the lower section shows greater similarity to the 1960–1970's. One reason for this phenomenon may be that most species occur at the lower section and in the 1960-1970's more species were detected in the water, whereas numerous taxa were found only in that time at the lower section. Consequently, the above-mentioned isolation of the lower section seems to be supported by statistics. To summarize the results we can appoint that greater difference exists between the two temporal intervals respectively between the sections, than between the spatio-temporal changes based on the zooplankton community.

The main sampling sites, where sufficient number of surveys were conducted for making correct conclusions, were also classified. Sampling sites were the following ones: Kvassay sluice (Kv), Soroksár (Sor), Dunaharaszti (Dh), Szigethalom (Szh), Majosháza (Maj), Ráckeve (Ráck), Dömsöd (Döm), Tass (Tass). The fauna of the three sections are represented as references (*Figure 4, Figure 5*.). Our results showed that the fauna of the lower section is very similar to that of Ráckeve, which were sharply isolated from the other sampling sites and were characterized by the highest number of species. The sampling sites of Soroksár, Dunaharaszti and the upper section formed one group whit the associating Kvassay sluice and Majosháza, which from the ulterior belongs actually to the middle section. As a matter of fact Majosháza and Kvassay sluice proved to be more isolated on the ordination diagram (*Figure 5*.). The former is the bound of the upper and middle section, thus its position is not so surprising. Least species were found by Majosháza and Kvassay sluice and these were relatively common species. The upper section is characterized by many common, pollution-resistant species. The third main group is the middle section, however, it contains the sampling sites of Tass and Dömsöd as well. Neither several common species nor many rare species are living here. To sum up the statements, the three typical sections seem to be isolated in point of the sampling sites, though, some deviation exist.

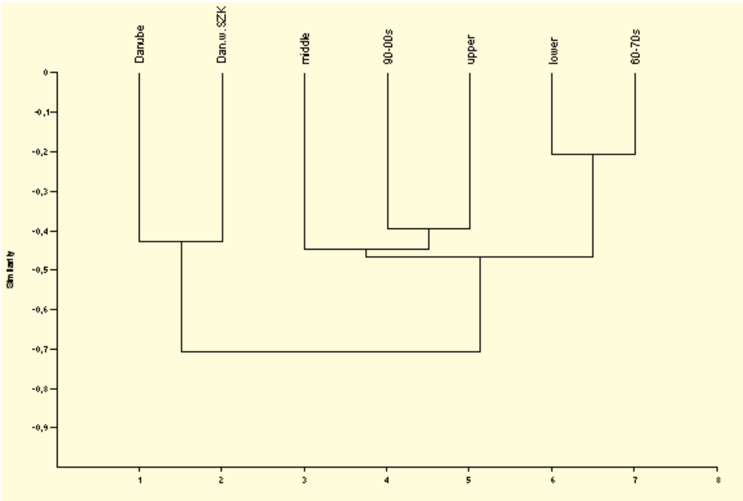

Figure 2. Dendogram of the sections and sampling dates (Euclidean distance)
2. ábra A szakaszok és mintavételi időpontok dendogramja (euklidészi távolság)

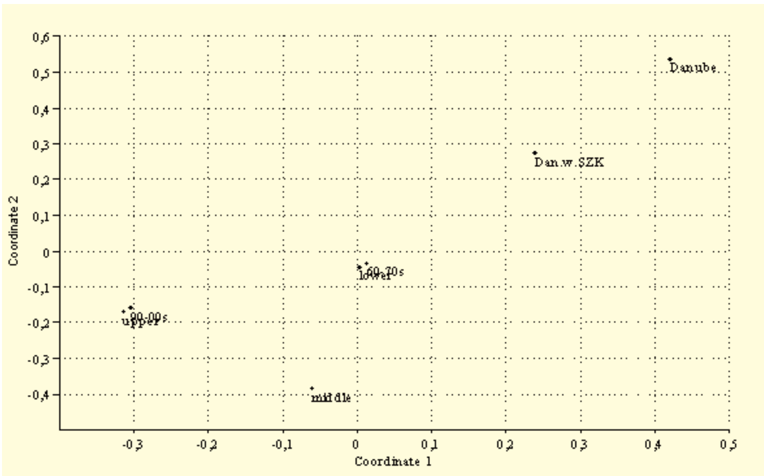

Figure 3. The NMDS ordination of the sections and sampling dates (Euclidean distance)
3. ábra A szakaszok és mintavételi időpontok NMDS ordinációja (euklidészi távolság)

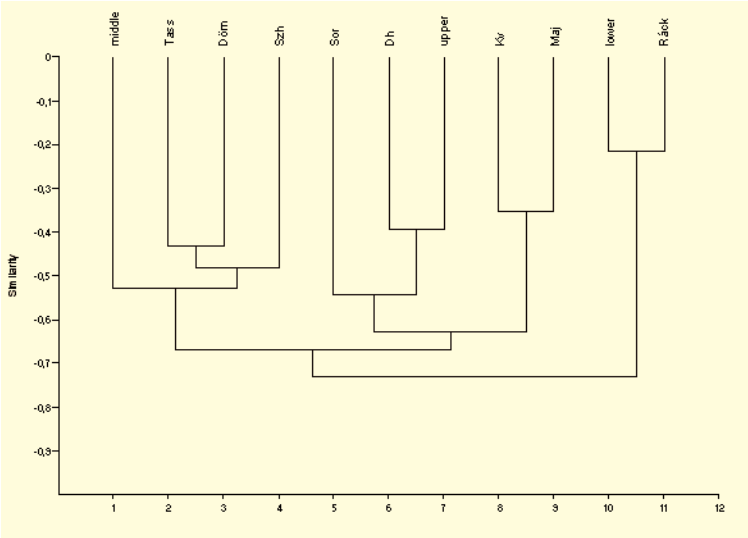

Figure 4. Dendogram of the sampling sites (Euclidean distance)
4. ábra A mintavételi helyek dendogramja (euklidészi távolság)

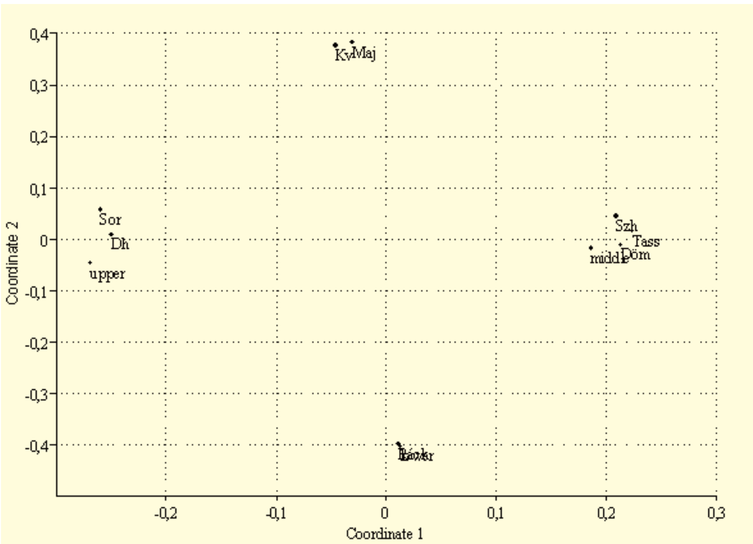

Figure 5. The NMDS ordination of the sampling sites (Euclidean distance)
5. ábra A mintavételi helyek NMDS ordinációja (euklidészi távolság)

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A RÁCKEVEI-SOROKSÁRI DUNA ZOOPLANKTON (*COPEPODA, CLADOCERA*) FAUNÁJÁNAK TÉR-IDŐBELI VÁLTOZÁSAI

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Kulcsszavak: zooplankton, RSD, fauna, állapot-jellemzés

Összefoglalás: A Ráckevei – Soroksári Duna-ág három szakasza a *Cladocera* és a *Copepoda* fauna alapján jól elkülöníthetőek. Statisztikai módszerekkel kimutattuk, hogy különbség tapasztalható az egyes szakaszok között csakúgy mint a 1960–1970-es évek és a 1990–2000-es évek faunája között. Azonban csakúgy, mint hidromorfológiai szempontok alapján, a kisrák fauna összetétele szerint sem húzhatóak meg élesen a határok. A középső szakaszon például egyetlen olyan faj sincs, ami csak itt volna megtalálható. Ez a szakasz azonban a legváltozatosabb élőhelyeket kínálja, így ezen nem is lehet csodálkozni. A felső szakasz már jól elkülöníthető, az alsó pedig élesen elkülönül a másik kettőtől. Az időbeni vizsgálatok pedig azt az eredményt adták, hogy ugyan sok szennyezőforrás megszűnt, a fajok száma mégis csökkenő tendenciát mutat, aminek valószínűleg az eutrofizáció az oka.