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Effects of Salinity on the Zooplankton Communities in the Fore-Delta of Kyliya Branch of the Danube River

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Abstract: This investigation comprised the fore-delta shallow water habitats of Kyliya branch of the Danube River. It included bays on the marine edge and branches of the mouth of the Danube River. The mixing zone of seawater and freshwater was characterised by variability of hydrophysical and hydrochemical parameters which was reflected in the dynamics of the zooplankton structure. This paper presents the results of zooplankton studies (*i.e.* Cladocera, Copepoda, Rotifera; Ostracoda, Foraminifera and veliger larvae) being performed in waters with salinity between 0.28‰ and 12.00‰. The freshwater complex dominated but with the increasing salinity, the species richness decreased, freshwater species disappeared and the frequency of occurrence of euryhaline species decreased. A significant decline in zooplankton species numbers was observed at a salinity of about 2.00‰.

Keywords: Zooplankton, fore-delta, salinity

Introduction

A wide range of hydrophysical and hydrochemical parameters characterise the transitional waters (*i.e.* the mixing zone of marine water and freshwater) of the Danube delta. This is also reflected in the structure and quantitative development of the aquatic populations. The water chemistry, and namely the degree of salinity, exerted the greatest influence on the zooplankton in the wave protected bays at the marine edge. The aim of this study was to investigate the structural indices of zooplankton in relation to changes in water salinity.

Material and Methods

A total of 94 zooplankton samples were collected from 16 stations (Fig. 1), with a salinity ranging from 0.28‰ to 12.00‰. Sampling stations differed in a number of parameters, *e.g.* wave influence; depths; composition and density of vegetation.

Salinity was measured in the surface water layer with the assistance of the "HANNA HI 9835" conductometer. The classification of water habitats was carried out according to the WFD (Common implementation strategy for the Water Framework Directive 2003).

The zooplankton samples were collected and processed following the standard hydrobiological techniques (Romanenko 2006). The zooplankton components were determined to species level. Ostracoda, naupliar stages of Copepoda and Mollusca veliger were counted separately and considered as one species.

On the basis of reference material concerning salinity tolerance of the organisms (Kuticova 1970, Manuilova 1964, Monchenko 1974, Vodianitskyi 1968, 1969), the recorded species were grouped into freshwater, freshwater-oligohaline and freshwater-mesohaline groups.

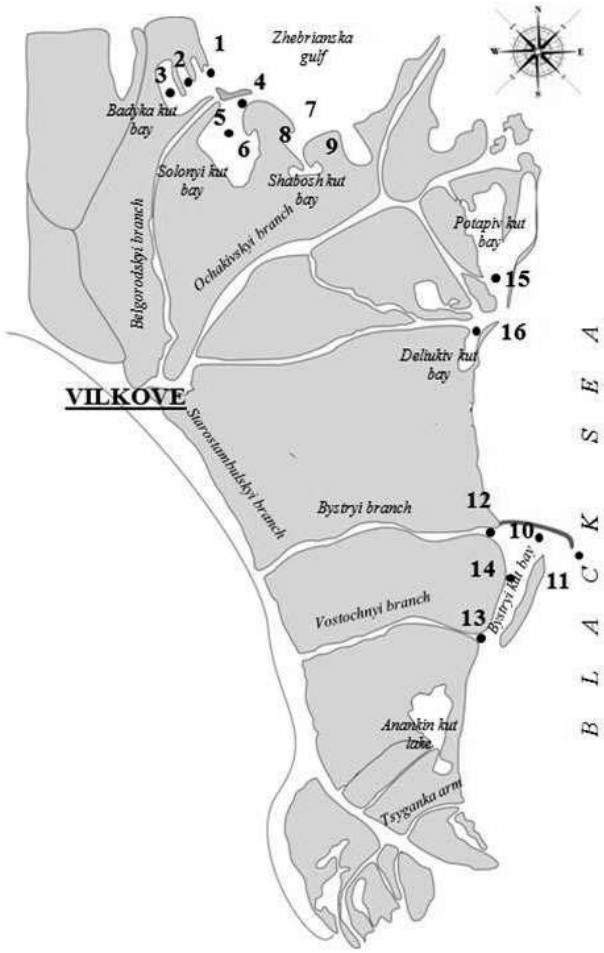

Fig. 1. Map of the sampling stations (St.). Legend: St. 1-3 – Badyka Kut Bay, St. 4–6 – Solonyi Kut Bay, St. 7–9 – Shabosh Kut Bay, St. 10 – marine approach canal, St. 11 – the sea near the top of protective dam of the marine approach canal, St. 12 – mouth of Bystryi branch, St. 13 – mouth of Vostochnyi branch, St. 14 – Bystryi Kut Bay, St. 15 – Potapiv Kut Bay, St. 16 – Deliukiv Kut Bay

Results and Discussion

At the majority of the sampling stations the degree of salinity varied between oligo- and mesohaline water habitats, in the northern part of the delta, and between freshwater to oligohaline in the eastern part of the fore-delta. The northern part of the fore-delta was characterised by higher salinity (*i.e.* mesohaline water habitats) and a wider range of values, with maxima at stations 7-9 (the Shabosh Kut Bay) (Fig. 2). Oligohaline water habitats were predominant in the eastern part of the delta, at sections of the marine approach canal (stations 10 and 11), as well as in the Bystryi Kut Bay (St. 14), while freshwater predominated in the mouths of the branches (stations 12 and 13) and the half-open freshwater bays (stations 15 and 16). The range of the salinity values of the eastern part of the delta was much narrower than in the northern part. A wide range of values was reported only at stations near the marine approach canal and in the Bystryi Kut Bay (Fig. 2).

Eighty one taxa of invertebrates were recorded (Fig. 3). The species richness of the basic zooplankton groups was almost identical. Ostracoda, Foramenifera and Mollusca larvae were reported as well. The greatest number of zooplankton species, 40 and 41 respectively, was recorded at St. 10 (the marine approach canal) and St. 16 (the Deliukov Kut Bay), from which 15 species belonged to Rotifera and 13 species belonged to Cladocera. The lowest species number was recorded at St. 9: three taxa, from which one species belonged to Rotifera (*Brachionus calyciflorus* Pallas), and the others were juvenile specimens of Cyclopoida and naupliar stages of Copepoda.

The zooplankton was represented by freshwater, freshwater-oligohaline and freshwater-mesohaline species, from which 17 species being exclusively freshwater, 24 were freshwater-oligohaline and 29 were freshwater-mesohaline. The total species richness and the number of species in the groups were increasing with the decreasing salinity (Fig. 4). The greatest prevalence revealed the freshwater species *Bosmina coregoni* Baird (Cladocera) that was recorded at 39% of stations.

Among the freshwater-oligohaline species, the rotifer *Brachionus calyciflorus* Pallas, the cladocerans *Alona affinis* (Leydig), *Bosmina longirostris* O. F. Müller and the copepod *Eucyclops macruroides* (Lilljeborg), prevailed. Most likely, some of the species, *e.g. E. macruroides*, were occurring constantly in the mesohaline Shabosh Kut Bay (stations 7-9), and therefore were adapted to higher salinity than it demonstrated in the literature (Monchenko 1974).

The freshwater-mesohaline species, dominating by the number of species, were characterised by the highest species numbers at the majority of the sampling stations. This group was represented by the so-called "haloxens" (Tseyeb 1961), surviving salinities up to 8‰. With the further increase in salinity, these species disappeared. The freshwater-mesohaline complex was equally represented at the majority of the stations (10-17 species). The most widespread species of this group were the rotifers *Brachionus quadridentatus* Hermann, *Filinia longiseta* (Ehrenberg) and *Keratella quadrata* (Müller),

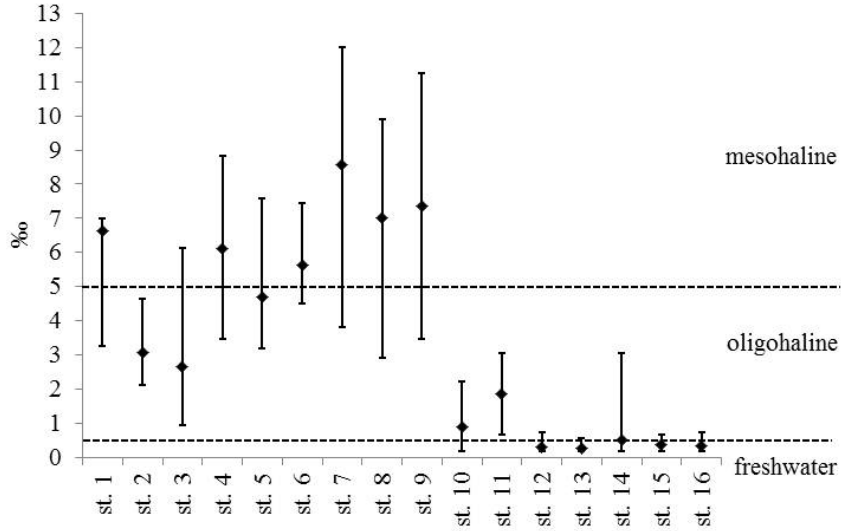

Fig. 2. Salinity at the sampling stations (with mean and range values)

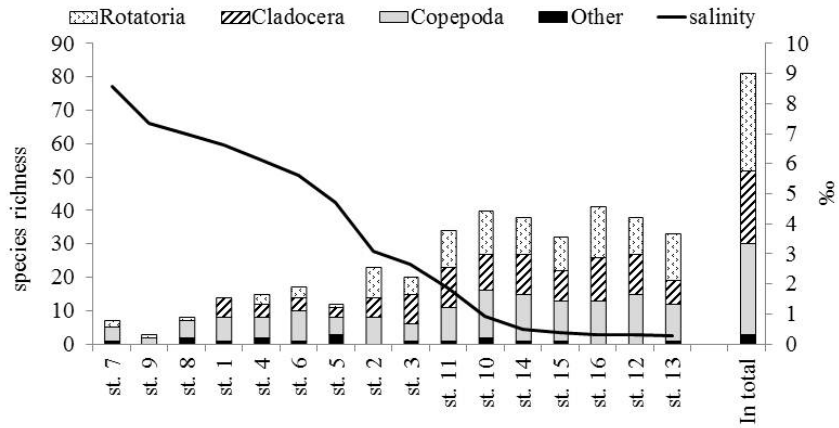

Fig. 3. Species richness and zooplankton community structure along the salinity gradient

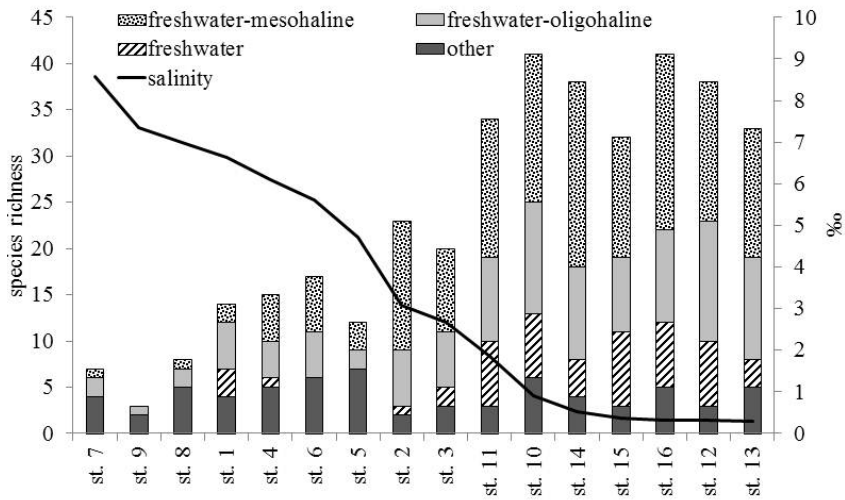

Fig. 4. Zooplankton species richness and their affinity to salinity

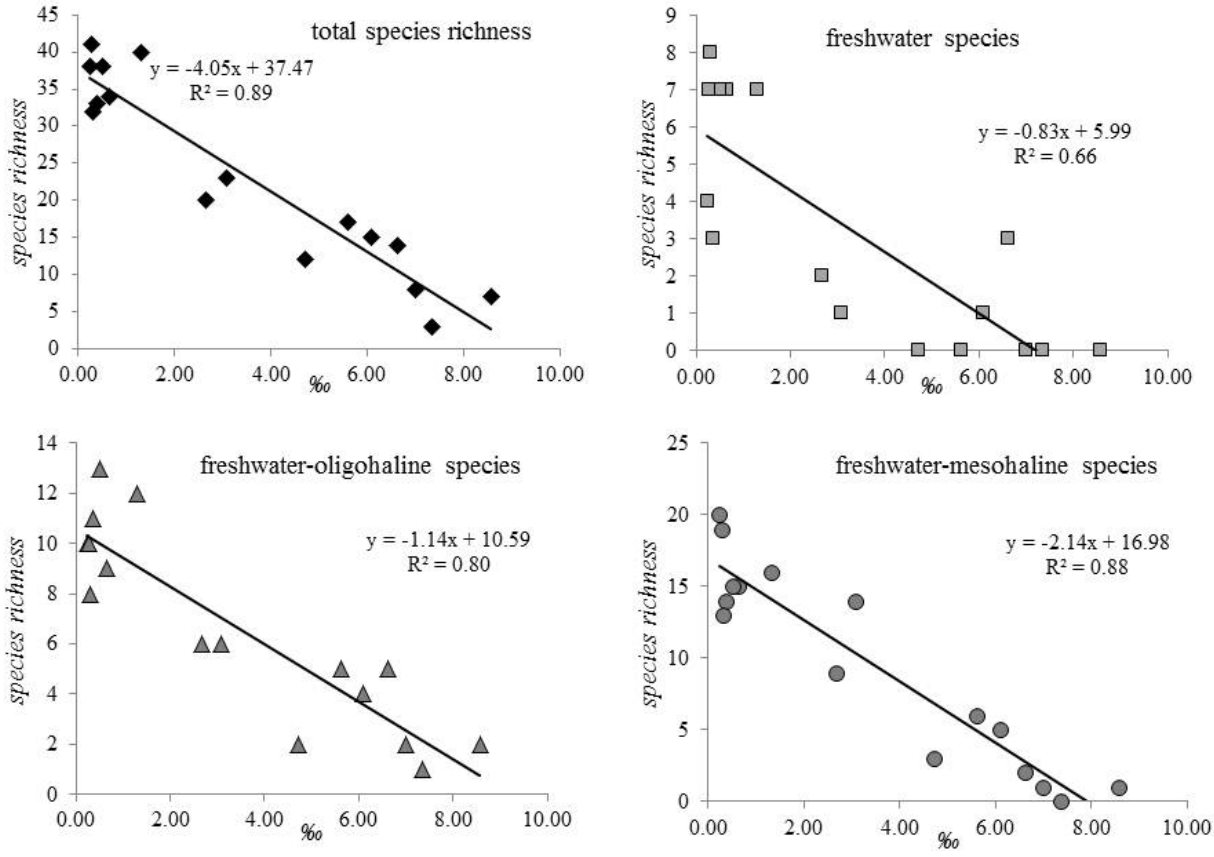

Fig. 5. Relationship between salinity and species richness.

the cladoceran *Daphnia longispina* Müller and the copepods *Eurytemora velox* (Lilljeborg) and *Thermocyclops crassus* (Fischer).

Figure 5 shows the relationships between the zooplankton species richness (total, freshwater, freshwater-oligohaline and freshwater-mesohaline species) and salinity in a range from 0.5‰ to 9.0‰. In all cases the species numbers increased linearly with the decreasing of salinity.

With a salinity increase above 1.5–2.0‰, a reduction in the number of freshwater species was evident, which was not compensated by the increase in the numbers of freshwater-oligohaline and freshwater-mesohaline species. Within the range from 2.0 to 6.0‰, the number of species decreased slightly (from 20 to 17 species). A pronounced decrease in species richness became obvious within the range of salinity between 7.0 and 9.0‰. With the further increase in salinity (in our studies up to 12.0‰) the occurrence of marine species would have been expected, however, they were not recorded.

The low species richness of the zooplankton in the mesohaline waters of the Black Sea estuaries and the area of water mass transformation was also documented for the marine zooplankton (Vorobiova 1970, Bolshakov 1970). Critical values of the salinity of 5.0–8.0‰ certainly resulted in a reduced species richness (Khlebovich 1974, Khlebovich 2002, Telesh 2006). However, in our studies, a salinity of 1.5–2.0‰ was already the critical threshold for the freshwater zooplankton. A complex of factors may be responsible for this phenomenon, and not only the critical salinity.

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