Gastropoda in the Danube – Carpathian hydrographic space: possible impact of climate change

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1 Introduction

The Danube hydrographical basin including the Danube Delta and all tributaries represents one of the areas with the richest fauna of gastropods.

The distribution of the gastropods between the Carpathians and the Danube, as well as in the Upper Danube, the Middle Danube, the Lower Danube, and the Danube Delta provides a biogeographical unity of gastropods (Cioboiu Codoban 2003, Cioboiu 2008).

2 The distribution of gastropods in the Danube

So far, in the Upper Danube 33 species of gastropods have been identified (Table 1). The species *Viviparus ater, Valvata (Cincinna) studeri, V. (Tropidina) macrostoma, Bythinella austriaca, B. cylindrica, Stagnicola fuscus, Radix lagotis* are characteristic of torrents and mountain streams. They represent 4 percent of the gastropod populations present in the Danube (Frank 1987; Tittizer 1990). Further, more or less ubiquitous species occur, such as *Theodoxus (Th.) danubialis, Th. fluviatilis, Viviparus acerosus, Valvata (V.) cristata, Lithoglyphus naticoides, Bithynia (B.) tentaculata, Physa fontinalis, Stagnicola corvus, St. turricula, Radix ampla, Galba truncatula, Planorbarius corneus* (Jurgen 1988; Grossu 1993).

In the Middle Danube, where relatively uniform biotopes with a mostly sandy-clayish benthic facies prevail, the gastropod populations are represented by the species *Theodoxus (Th.) transversalis, Valvata (C.) piscinalis, Borysthenia naticina, Bythinella hungarica, Lithoglyphus fuscus, Bithynia (B.) mostarensis, Esperiana esperi, Amphimelania holandri, Lymnaea stagnalis, Stagnicola palustris, Ferrissia (P.) clessiniana, Anisus (A.) leucostoma, Gyraulus (Lamorbis) riparius, Planorbarius corneus* (Oertel 2000). Some of these species also appear in the Upper Danube (Table 1). They represent 11 percent of the total species number of this area.

In the Lower Danube, due to the connectivity between the river and its floodplain and to the influence of its numerous tributaries, the species diversity of the gastropods is higher (Cioboiu 2008). In the river, we can find lentic species characteristic of the eutrophic lacustrine ecosystems – *Theodoxus (Th.) danubialis stragulatus, Theodoxus (Th.) pallasi, Viviparus acerosus, Valvata (C.) piscinalis, Lymnaea stagnalis, Stagnicola corvus, Radix auricularia, Planorbis planorbis, Gyraulus (G.) acronicus*, as well as lotic (reophilic) species that are better adapted to the conditions of stream ecosystems – *Lithoglyphus naticoides, L. pygmaeus, Esperiana (M.) daudebardii acicularis, Radix ampla, Segmentina nitida.*

On the other hand, some species prefer the sandy facies – *Theodoxus (Th.) prevostianus, Turricaspia (Oxypyrgula) ismailensis, Radix balthica*, while others prefer the clayish facies – *Lithoglyphus apertus, Galba truncatula.* Within the areas characterized by rocky banks, typically the species *Bythinella austriaca* and *Amphimelania holandri* do occur. Thus, it results that the variable environmental factors of the Danube (the flow velocity, the bed structure, the trophic state) influence this distribution of gastropods (Buşniță & Brezeanu 1970; Negrea 1994; Cioboiu & Brezeanu 2000; Oertel 2000).

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There are no strict limits between these river sectors; therefore an interference of the gastropod species between different Danube sectors can be noticed; the Lower Danube features the majority (86 percent) of gastropod species (Table 1).

3 The distribution of gastropods in the Danube Delta

The Danube Delta (area about 434,000 ha) represents the final segment of the Danube; 70 percent of its surface is covered by a great diversity of aquatic ecosystems: channels, lakes, marshes.

Up to now, 45 species have been identified (Table 1); the most frequent are *Theodoxus (Th.) danubialis, Th. fluviatilis, Viviparus acerosus, Pseudamnicola (P.) dobrogica, P. leontina, P. razelmiana, Potamopyrgus antipodarum, Turricaspia (Laevicaspia) lincta, T. dimidiata, Physella (Costatella) acuta, Anisus (A.) spirorbis, Gyraulus (Torquis) laevis, Planorbarius corneus* (Grossu 1993).

Even if the aquatic ecosystems of the Danube Delta display an unique character, due to the structure of the biotopes and biocoenoses, the areas located near the shore of the Black Sea show a particular character because they are influenced by brackish water. This mixohaline feature reflected also the structure of the gastropod populations, as certain species are tolerant to salt water (*Pseudamnicola razelmiana, Potamopyrgus antipodarum, Turricaspia lincta)* (Table 1).

4 The distribution of gastropods in the river system of Romania

The river system, which includes 16 main rivers, is more than 66,000 kilometers long. Its ecosystem diversity (mountain and hill rivers with rapid flow and torrents, plain rivers with slow flow, and floodplains) determine the structure and the specific distribution of the gastropods.

According to the ecological character of the rivers, the species *Lithoglyphus apertus, Radix ampla, Radix balthica, Stagnicola palustris* appear more often in the mountain and hilly area; *Bythinella austriaca, Amphimelania holandri, Ancylus fluviatilis* mostly populate the mountain torrents and rivulets; *Theodoxus (Th.) fluviatilis, Viviparus viviparus, Lithoglyphus naticoides, Esperiana esperi, E. (Microcolpia) acicularis daudebardii* are characteristic of the rivers from the plains (Table 1).

Table 1. *The gastropods in the Danube, the Danube Delta, and the other rivers in Romania*

No	Species	The Danube			The Danube Delta	The rivers in Romania
		Upper sector	Middle sector	Lower sector		
1.	*Theodoxus (Th.) danubialis* (C. Pfeiffer, 1828)	+	+	+	+	+
2.	*Theodoxus (Th.) d. stragulatus* (C. Pfeiffer, 1828)		+	+		+
3.	*Theodoxus (Th.) euxinus* (Clessin, 1887)			+	+	
4.	*Theodoxus (Th.) fluviatilis* (Linnaeus, 1758)	+	+	+	+	
5.	*Theodoxus (Th.) pallasi* Lindholm, 1924			+	+	
6.	*Theodoxus (Th.) prevostianus* (C. Pfeiffer, 1828)			+		
7.	*Theodoxus (Th.) transversalis* (C. Pfeiffer, 1828)		+	+		+
8.	*Viviparus acerosus* (Bourguignat, 1862)	+	+	+	+	+
9.	*Viviparus ater* (De Cristofori & Jan, 1832)	+				
10.	*Viviparus contectus* (Millet, 1813)		+	+		+
11.	*Viviparus mamillatus* (Kuster, 1852)		+	+		
12.	*Viviparus viviparous* (Linnaeus, 1758)			+	+	+

13.	*Viviparus viviparous penthicus* (Servain, 1884)	+				
14.	*Valvata (Cincinna) piscinalis* (O. F. Muller, 1774)		+	+	+	+
15.	*Valvata Cincinna) studeri* Boeters & Falkner, 1998	+				+
16.	*Valvata (Cincinna) piscinalis antiqua* Morris, 1838			+	+	
17.	*Valvata (Tropidina) macrostoma* Morch, 1864	+				
18.	*Valvata (Valvata) cristata* O. F. Muller, 1774	+	+	+		+
19.	*Borysthenia naticina* (Menke, 1845)		+	+	+	+
20.	*Pseudamnicola (P.) dobrogica* Grossu, 1986			+	+	
21.	*Pseudamnicola (P.) leontina* Grossu, 1986				+	
22.	*Pseudamnicola (P.) penchinati* (Bourguignat, 1870)			+	+	
23.	*Pseudamnicola (P.) razelmiana* Grossu, 1986				+	
24.	*Bythinella austriaca* (Frauenfeld, 1857)	+				
25.	*Bythinella cylindrica* (Frauenfeld, 1857)	+				
26.	*Bythinella hungarica* Hazay, 1880		+			
27.	*Potamopyrgus antipodarum* (J. E. Gray, 1843)			+	+	+
28.	*Lithoglyphus apertus* (Kuster, 1852)			+	+	+
29.	*Lithoglyphus fuscus* (C. Pfeiffer, 1828)		+			
30.	*Lithoglyphus naticoides* (C. Pfeiffer, 1828)	+	+	+	+	+
31.	*Lithoglyphus pygmaeus* Frauenfeld, 1863			+		
32.	*Bithynia (Bithynia) mostarensis* Moellendorff, 1873		+			
33.	*Bithynia (Bithynia) tentaculata* (Linnaeus, 1758)	+	+	+	+	+
34.	*Bithynia (Codiella) troschelii* (Paasch, 1842)	+	+	+		
35.	*Bithynia (Codiella) leachii* (Sheppard, 1823)	+		+	+	+
36.	*Turricaspia (Clessiniola) variabilis* (Eichwald, 1838)			+		
37.	*T. (Laevicaspia) lincta* (Milaschewitch, 1908)				+	
38.	*T. (Oxypyrgula) ismailensis* (Gol. & Starob., 1966)			+	+	
39.	*T. (Turricaspia) dimidiata* (Eichwald, 1841)			+	+	
40.	*Esperiana esperi* (A. Ferussac, 1823)		+	+	+	+
41.	*E. (Microcolpia) daudebardii* (Prevost, 1821)		+	+	+	+
42.	*E. (Microcolpia) daudebardii acicularis* (A. Ferussac, 1823)		+	+	+	+
43.	*Amphimelania holandri* (C. Pfeiffer, 1828)		+	+		+
44.	*Physa fontinalis* (Linnaeus, 1758)	+	+	+		+
45.	*Physella (Costatella) acuta* (Draparnaud, 1805)			+	+	+
46.	*Physella (Costatella) heterostropha* (Say, 1817)		+	+		+
47.	*Aplexa hypnorum* (Linnaeus, 1758)		+	+		+
48.	*Lymnaea stagnalis* (Linnaeus, 1758)		+	+	+	+

49.	*Stagnicola corvus* (Gmelin, 1791)	+	+	+	+	+
50.	*Stagnicola fuscus* (C. Pfeiffer, 1821)	+				
51.	*Stagnicola palustris* (O. F. Muller, 1774)		+	+	+	+
52.	*Stagnicola turricula* Held, 1836	+	+	+		+
53.	*Radix ampla* (W. Hartmann, 1821)	+	+	+		+
54.	*Radix auricularia* (Linnaeus, 1758)		+	+	+	+
55.	*Radix balthica* (Linnaeus, 1758)		+	+	+	+
56.	*Radix labiata* (Rossmassler, 1835)		+	+		+
57.	*Radix lagotis* (Schrank, 1803)	+				
58.	*Galba truncatula* (O. F. Muller, 1774)	+	+	+		+
59.	*Ancylus fluviatilis* O. F. Muller, 1774	+	+	+		+
60.	*Ferrissia (Pettancylus) clessiniana* (Jickeli, 1882)	+	+	+	+	+
61.	*Acroloxus lacustris* (Linnaeus, 1758)		+	+	+	+
62.	*Planorbis (Planorbis) carinatus* O. F. Muller, 1774	+	+	+	+	+
63.	*Planorbis (Planorbis) planorbis* (Linnaeus, 1758)	+	+	+	+	+
64.	*Anisus (Anisus) calculiformis* (Sandberger, 1874)		+	+		+
65.	*Anisus (Anisus) leucostoma* (Millet, 1813)		+			
66.	*Anisus (Anisus) spirorbis* (Linnaeus, 1758)			+	+	+
67.	*Anisus (Disculifer) vortex* (Linnaeus, 1758)		+	+		+
68.	*Anisus (Disculifer) vorticulus* Troschel, 1852		+	+	+	+
69.	*Bathyomphalus contortus* (Linnaeus, 1758)	+	+	+	+	+
70.	*Gyraulus (Armiger) crista* Linnaeus, 1758		+	+	+	+
71.	*Gyraulus (Gyraulus) acronicus* (A. Ferussac, 1807)	+	+	+		+
72.	*Gyraulus (Gyraulus) albus* (O. F. Muller, 1774)	+	+	+	+	+
73.	*Gyraulus (Gyraulus) chinensis* (Dunker, 1848)	+				
74.	*Gyraulus (Lamorbis) riparius* (Westerlund, 1865)	+	+			
75.	*Gyraulus (Lamorbis) rossmaessleri* (Auerswald, 1852)	+				
76.	*Gyraulus (Torquis) laevis* (Alder, 1838)			+	+	+
77.	*Hippeutis complanatus* (Linnaeus, 1758)		+	+	+	+
78.	*Segmentina nitida* (O. F. Muller, 1774)		+	+	+	+
79.	*Planorbarius corneus* (Linnaeus, 1758)	+	+	+	+	+
80.	*Oxyloma (Oxyloma) dunkeri* (L. Pfeiffer, 1865)		+	+	+	+
81.	*Oxyloma (Oxyloma) elegans* (Risso, 1826)		+	+	+	+
82.	*Oxyloma (Oxyloma) pinteri* Grossu, 1987			+		+
83.	*Oxyloma (Oxyloma) sarsii* (Esmark, 1886)	+				

5 Hypothetical modifications of the gastropod populations as an effect of global climate change

The Danubian-Carpathian space, located in the south-east of Europe, is quite close to the arid areas of the Near Orient. This may represent a model of climate evolution in Romania as part of this region.

The models of these changes emphasize that Romania faces a warming tendency, the forecasted temperature increase oscillating between 2.4 and 7.4°C (Bălteanu & Şerban 2005). Thus, the structures of the plant and animal populations will surely undergo significant modifications induced by the environmental factors.

Climatic changes will certainly affect water resources. The spring maximum flows will occur earlier; the water quality will significantly decrease due to high temperatures and the changed discharge. At the same time, due to the general increase of the sea level, salt water will affect the near-shore aquifers (Budyko 1999).

These modifications will obviously influence the life of the aquatic organisms, including the gastropods. A general image of the gastropods populating the Romanian river system emphasizes the individual ecological features (reproduction period, development rhythm, nature of benthic facies, food structure). In case climatic changes occur, these features will modify. Under these circumstances, certain species may disappear, while others may increase in number and frequency, exceeding the present limits (Busuioc 2003; Bălteanu & Şerban 2005).

The ecological requirements of gastropods represent an important parameter for forecasting their tendency of evolution. Thus, cryophilic and aerophilous species such as *Bythinella austriaca, B. cylindrica, Stagnicola palustris* ssp. *flavida* adapted to clean water may be limited in space or may disappear. On the contrary, ubiquitous species, *Lymnaea stagnalis, Radix ampla, Planorbis planorbis, Planorbarius corneus,* adapted to highly eutrophic and poly-saprobic water, may spread and become abundant since an increase in temperature will change hydrological features and water quality. If brackish water extends, the species *Theodoxus (Th.) euxinus, Pseudamnicola razelmiana, Turricaspia (Laevicaspia) lincta, T. dimidiata* tolerant to salt water will be favoured and become more frequent.

6 Conclusion

The global evaluation of the gastropod populations in the Danube – Carpathian hydrographic space represents an important part of the European malacofauna (Fauna Europaea 2005). It is worth mentioning that the highest species diversity (Table 1) is found in the Lower Danube, especially the Romanian part of the river, where the floodplain, the delta and the tributaries represent factors that enrich the biodiversity. The afore-mentioned ecological features of the gastropods can be a realistic criterion to reflect tendencies of evolution of population structures as influenced by realistic or hypothetical climate change scenarios.

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