ZEBRA MUSSELS

BIOLOGY, IMPACTS, AND CONTROL

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CHAPTER 13

Some Aspects of the Zebra Mussel, *(Dreissena polymorpha)* in the Former European USSR with Morphological Comparisons to Lake Erie

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INTRODUCTION

The main objectives of this work are to discuss the origin of the zebra mussel, *Dreissena polymorpha*, and to present data on the physiological, morphological, and cytogenetic polymorphism of this species in the former European USSR.

HISTORICAL

Dreissena was first found in the lower course of the Ural River in 1769 and later described as a zoological species in 1771 by the Russian zoologist

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Piter Pallas. *Dreissena* became of great interest during the 1820s when it was found at the London docks and then in different places of western Europe. In Germany it acquired the name of the wandering mussel ("Wundermuschel") because of its ability to spread rapidly to different areas. Later in the same century, this mollusk began to block water supply pipes in Paris, Arlee, Berlin, and many other towns and cities throughout Europe (Zhadin, 1946).

The contemporary family of Dreissenidae is represented by only two genera, *Dreissena* and *Congeria*. The most ancient representatives of *Dreissena* belong to the genus *Congeria*, which appeared in the early Eocene. *Congeria* was most widespread and abundant during the epoch of the first and second Pontic Pier. However, in the Pliocene period *Congeria* almost completely disappeared from Europe and was replaced by the genus *Dreissena*. The largest distribution of *Dreissena* occurred during the Khvalynsk epoch of the Quarternary period. During this period, *Dreissena* was found in the Volga River and its tributaries, in northern areas of Eastern Europe, in Western Europe, and in the Aral Sea (Andrusov, 1897).

During the Quarternary glacial epoch, the geographic range of *Dreissena* declined dramatically. This was probably a result of coarse material suspended in glacial outwash and the negative impact this material had on the sensitive siphons of this species. While the effects of turbid glacial flows were widespread, there were areas in its former range that were not affected and *Dreissena* survived. These areas were the brackish waters of the Caspian and Aral Seas, in the freshwater portions of the Azov and Black Seas, and also in some water bodies of the Balkan peninsula.

PHYSIOLOGICAL, MORPHOLOGICAL, AND CYTOLOGICAL VARIABILITY

Dreissena, as is typical of an organism that is very adaptable and able to occur over a wide range of environmental conditions, can form populations that are locally distinct. Along the Volga River, populations of *Dreissena* have formed distinct ecotypes or races that differ in their tolerances to various environmental parameters, most notably temperature and salinity. Studies have shown that these different tolerance limits are distinctive at both the organism and cell level. For example, populations from six different sites along the Volga (Figure 1) were subjected to thermal tolerance tests. Individuals from the most southern site (Astrahan) and from a site subject to thermal discharges (Kostroma) were more tolerant of elevated temperatures than individuals from two of the more northern sites (Rybinsk and Kuibyshev) (Figure 2). In experiments to determine salinity tolerances, individuals from the site nearest to the Caspian Sea (Astrahan) had a lower mortality in relation to increases in salinity than individuals from the site farthest from the Caspian (Rybinsk) (Figure 3). In addition, survival of ciliary epithelial cells under

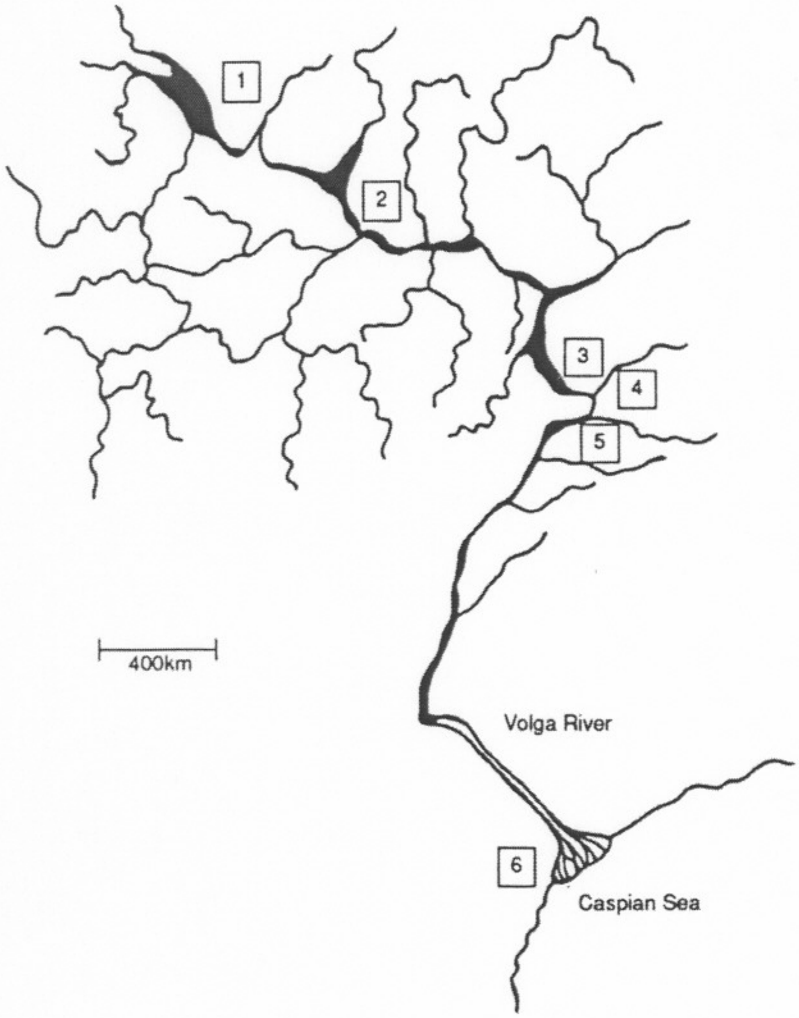

Figure 1. Location of sampling stations along the Volga River; 1 = Rybinsk, 2 = Kostroma, 3 = Kuibyshev, 4 = Samara, 5 = Chapaevsk, 6 = Astrahan. (Redrawn from Shkorbatov, G. L. *System of Integration of Species as a System* [Vilnus, 1986]).

increased salinity conditions (25‰) was much greater in individuals from near the Caspian than from a freshwater site (Kuibyshev) (Figure 4).

An examination of polymorphism in both color and pattern of *Dreissena* shells from different parts of the former European USSR revealed six main varieties or phenotypes (Figure 5). Differences in the frequencies and relative proportions of occurrence of these varieties indicate five main population

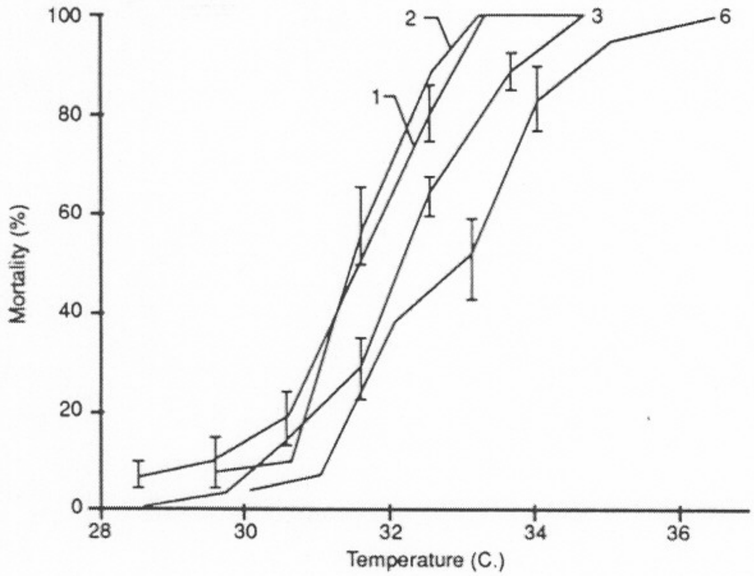

Figure 2. Relationship between mortality (%) and temperature in *Dreissena* from different water bodies in the former European USSR. Numbers correspond to the water bodies as shown in Figure 1. (Redrawn from Shkorbatov, G. L. *System of Integration of Species as a System* [Vilnus, 1986]).

groups: Aral-Caspian, Ponto-Caspian, Middle-Russian, Baltic, and Northeast. The maximum number of varieties and the greatest differences in the ratio of these phenes are found in the Aral-Caspian group, which is indicative of the unique position of this group in the system of intraspecific differentiation of *Dreissena* populations (Biochino and Slynko, 1988 and 1990; Biochino, 1990). These five groups are mostly confined to specific and separate geographical regions that can be differentiated by the time period in which *Dreissena* first colonized that region (Morduhai-Boltovski, 1960). Further, since these regions coincide with the separation of Eurasian mammal fauna (Starobogatov, 1970), it may be assumed that these *Dreissena* groups possess the status of distinct geographical races (Mayr, 1974).

Specimens of *Dreissena* were collected from Lake Erie near Monroe, MI in summer 1990 to compare shell color and pattern of North American individuals to those from the former European USSR. Preliminary analysis indicates that the specimens from Lake Erie are most similar to specimens from the Ponto-Caspian region; that is, only Lake Erie and the Ponto-Caspian group have individuals with the DD phenotype (Table 1). To further assess the degree of similarity between populations from the different regions, the similarity index of Zhivotovsky (1982) was used. This index is calculated as: $r = \Sigma (p_m q_m)^{0.5}$ where p is the occurrence frequency (or proportion) of

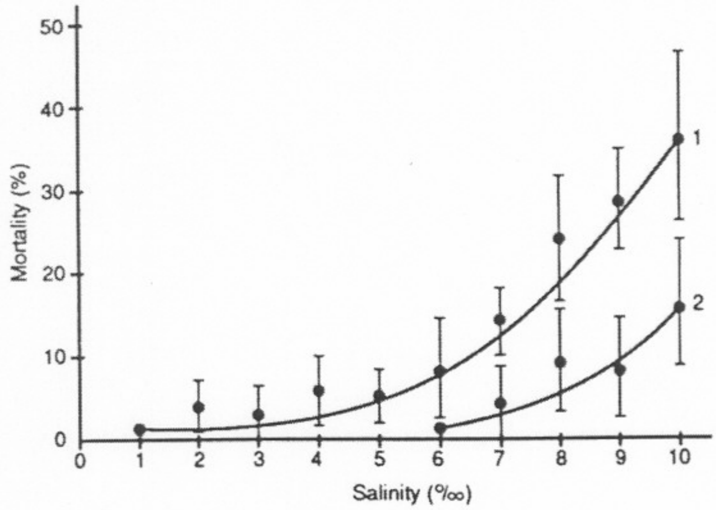

Figure 3. Relationship between mortality (%) and salinity (‰) in *Dreissena* from two different water bodies in the former European USSR. The exposure period was 2 weeks. 1 = Rybinsk (freshwater), 2 = Astrahan (near Caspian Sea, brackish water). (Redrawn from Antonov, P. I., and Shozbatov, G. L. *Species and Its Productivity Within Distribution Area* [Moscow, 1983]).

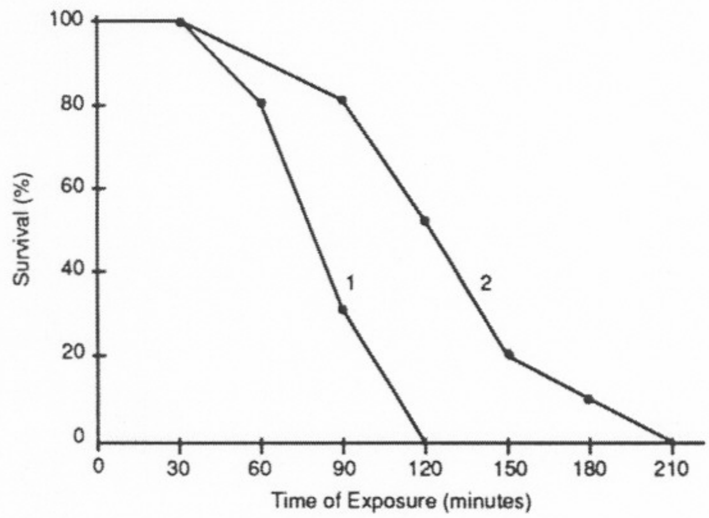

Figure 4. Relationship between survival (%) and time of exposure (min) for ciliated cells from the gill epithelium of *Dreissena* in water of 25‰ salinity. The *Dreissena* cells were taken from individuals from two different water bodies in the former European USSR. 1 = Rybinsk (fresh water), 2 = Astrahan (near Caspian Sea, brackish water). (Redrawn from Antonov, P. I., and Shozbatov, G. L. *Species and Its Productivity Within Distribution Area* [Moscow, 1983]).

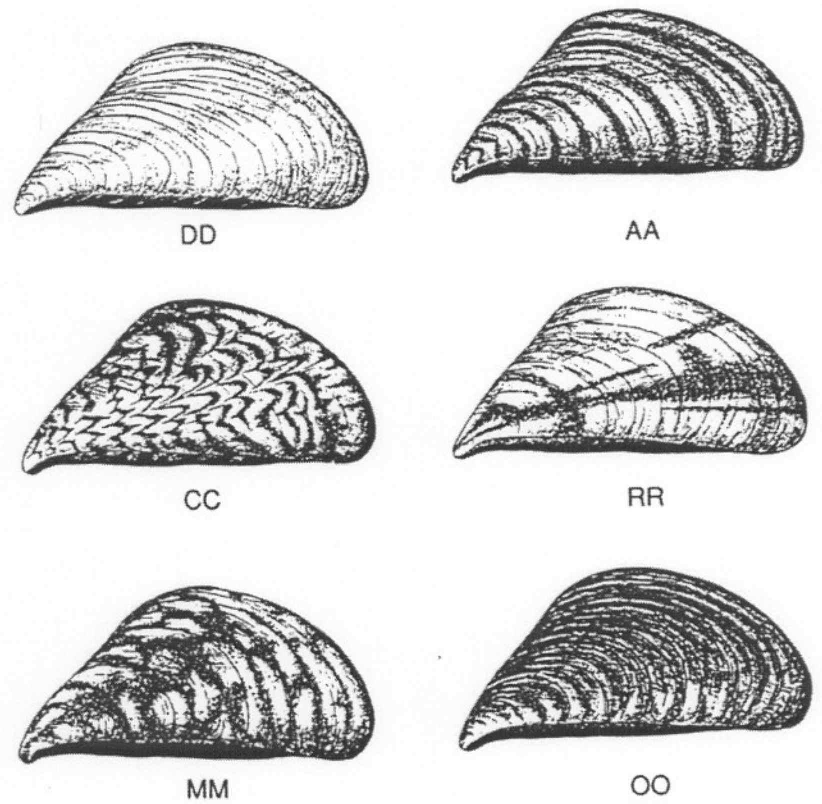

Figure 5. The six varieties (phenotypes) of *Dreissena* found in the former European USSR. Differences based on color and pattern of shells. DD = light, stripeless; AA = arched stripes; CC = mixed, zigzag; RR = radial striped; MM = spotted; OO = dark, stripeless.

Table 1. Proportion of Different Phenotypes in Populations of *Dreissena* from Different Regions in the Former European USSR and from Lake Erie

	Phenotype					
Region	**AA**	**DD**	**OO**	**RR**	**MM**	**CC**
Ponto-Caspian	0.094	0.022	0.056	0.008	0.006	0.814
Middle-Russian	0.170	0.000	0.110	0.002	0.010	0.708
Baltic	0.080	0.000	0.015	0.005	0.001	0.899
Lake Erie	0.120	0.030	0.170	0.110	0.190	0.380

Note: The different phenotypes are shown in Figure 5. Specimens from the various regions were collected from the following water bodies: Ponto-Caspian Region — lower Volga River, Tsymlyansk and Krenenchug reservoirs, and mouth of the Don river; Middle-Russian Region — Kuibyshev, Cheboksarsk, Saratov, and Volgograd reservoirs; Baltic Region — Rybinsk and Ivankovsk reservoirs and Kurshsky Bay.

Table 2. Index of Similarity Between Populations of *Dreissena* from Regions in the Former European USSR and Lake Erie

	Region			
Region	**Ponto-Caspian**	**Middle-Russian**	**Baltic**	**Lake Erie**
Ponto-Caspian	—	0.976	0.980	0.849
Middle-Russian	—	—	0.961	0.830
Baltic	—	—	—	0.760
Lake Erie	—	—	—	—

Note: Samples collected from water bodies as given in Table 1. See text for index derivation.

a phene of the first population and q is the occurrence frequency of the same phene in the second population. Values are calculated for each phene, and then the values are added to get the index r. The index ranges from 0 (no common phene) to 1 (all phenes similar). Based on this index, it is apparent that specimens from the Ponto-Caspian, Middle-Russian, and Baltic regions are more similar to each other than to specimens from Lake Erie (Table 2). Thus, given the extent of these phenotypic differences, it may be proposed that the introduction of *Dreissena* into North America occurred with individuals from outside these particular regions of the former European USSR. It must be noted, however, that Lake Erie specimens were not compared to specimens from the Northeast and Aral-Caspian regions.

In addition to examining the physiological and morphological variability in these populations, it is also useful to examine cytogenetic variability. Peculiarities in the organization of chromosomes are directly linked to formation of reproductive isolation, differences in fecundity and viability of the organisms, formation of geographical races, etc. Investigations of cells of the gill epithelium and gametes of *Dreissena* from the former European USSR have shown that the chromosome number varies from 21 to 32 and that the karyotype of 32 chromosomes is modal (Grishanin, 1990). The modal complex included 24 meta, 4 submetacentric, 2 subtelocentric, and 6 acrocentric chromosomes. The percentage of modal chromosomes, however, is highly variable. For instance, in specimens from cooling waters of the Litovskaya power station, the modal number of chromosomes was found in 87% of the nuclei; but in specimens from the Rybinsk reservoir, the modal number of chromosomes was found in only 23% of the nuclei (Barshene, 1990).

YEAR-TO-YEAR FLUCTUATIONS

Various long-term studies of *Dreissena* larvae in reservoirs of the former European USSR have shown natural year-to-year fluctuations in numbers. In the Dnepropetrovsk reservoir, numbers declined every third year (Dyga, 1966)

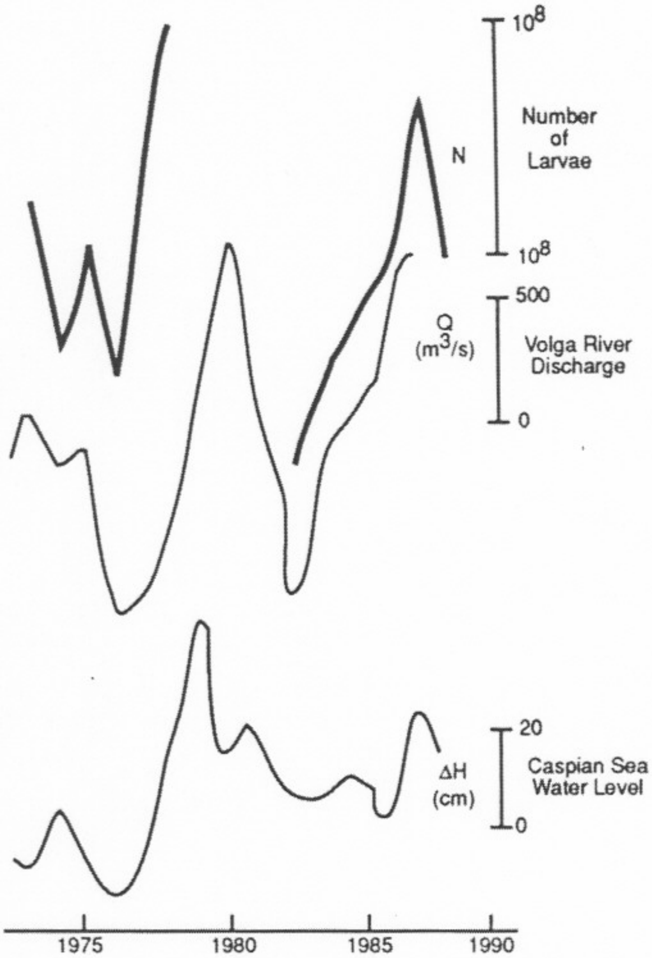

Figure 6. Year-to-year fluctuations in the number of *Dreissena* in the Ivankovsk and Uglich Reservoir relative to fluctuations in the discharge in the Volga River and water levels of the Caspian Sea. N = Mean total number of larvae in the two reservoirs, Q = discharge of the Volga River (m^3/s), ΔH = changes in water levels of the Caspian Sea (cm).

and in the Kyibyshevsk reservoir numbers declined every fourth year (Kirpichenko, 1964). We examined annual fluctuations in larvae number, water temperature, and water transparency in the Ivankovsk and Uglich Reservoirs over the period of 1973–1988. In general, larvae numbers were greater in years when temperatures were higher than normal and water transparency was lower. Since these reservoirs are located on the Volga River, many of their physical and chemical characteristics are influenced by discharge patterns of this river. Therefore, we further examined changes in larval numbers relative to annual changes in water volume of the Volga. Water volume is primarily influenced by changes in the level of the Caspian Sea which, in turn, is related to changes in the earth poles (Smirnov, 1969, Sarukhanyan and Smirnov, 1971). The number of larvae in the reservoirs was clearly related to discharge volume of the river and changes in levels of the Caspian Sea (Figure 6).

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