Internat. Rev. Hydrobiol.	**89**	2004	3	326–333

DOI: 10.1002/iroh.200310727

A. V. Zhulidov[1], D. F. Pavlov[2], T. F. Nalepa[3,*], G. H. Scherbina[2], D. A. Zhulidov[4] and T. Yu. Gurtovaya[1]

[1]South Russian Regional Centre for Preparation and Implementation of International Projects Ltd, (CPPI-S), 200/1 Stachki Ave., Office 301, Rostov-on-Don, 344090, Russia
[2]Institute for Biology of Inland Waters, Russian Academy of Sciences, 152742 Borok, Yaroslavl Oblast, Russia
[3]National Oceanic and Atmospheric Administration (NOAA), Great Lakes Environmental Research Laboratory, 2205 Commonwealth Blvd., Ann Arbor, MI, 48105–1593, USA; e-mail: thomas.nalepa@noaa.gov
[4]Rostov State University, Rostov-on-Don, Bolshaya Sadovaya Street, 105, Russia

Relative Distributions of *Dreissena bugensis* and *Dreissena polymorpha* in the Lower Don River System, Russia

key words: zebra mussels, quagga mussels, dreissenid abundances, invaders, mineral content

Abstract

A survey was conducted in the lower Don River system in Russia to confirm the presence of *Dreissena bugensis*, and to compare its distribution relative to that of *Dreissena polymorpha*. In 1999 and 2001–2002, dreissenid mussels were collected at 15 sites in the main river, in connecting reservoirs, and in a major tributary, the Manych River. Collections were made near stations where long-term monitoring data on total mineral (sum of principal ions) and calcium content were available. Both dreissenid species were found at all sites, with *D. bugensis* comprising 4–75% of all dreissenids at individual sites. *D. bugensis* was relatively more abundant than *D. polymorpha* in the Manych River where total mineral and calcium content was significantly higher than in the Don River, suggesting the two species may have different calcium requirements. Examination of archived samples indicated that *D. bugensis* was present in the Don River system as early as the 1980s, presenting the unresolved enigma of why *D. bugensis* has not displaced *D. polymorpha* as the dominant species as typically found over shorter time periods in other water bodies.

1. Introduction

The expansion of species outside of their native ranges has become a world-wide problem (Carlton and Geller, 1993; Lodge *et al.*, 1998). Once introduced into a new environment, these invasive species often rapidly increase in number and may cause complex changes in food web structure and ecosystem processes. Given the importance of the problem, information on the biology and distribution patterns of these species within their native ranges may provide a better understanding of how populations respond in newly invaded systems. Two dreissenid species, *Dreissena bugensis* (Andrusov, 1897) (quagga mussel) and *Dreissena polymorpha* (Pallas, 1771) (zebra mussel), provide examples of invaders that now occupy vast areas far removed from their original places of origin. *Dreissena bugensis* originated from a quite restricted region in the Bug River where it was first described (Andrusov, 1890). It was later found in the nearby Bug-Liman Delta, and in reservoirs in the Ukraine (Zhuravel, 1951; Kharchenko, 1995). Within Eastern Europe, the first finding of the quagga mussel far removed from its natural range occurred in 1992 in the mid-Volga

* Corresponding author

 1434-2944/04/307–0326

River basin (ANTONOV, 1993). Presently, the quagga mussel is found throughout the Dnepr (Dneiper, Dnepro) River and Volga River basins, and the adjacent freshwater areas of the Northern Caspian Sea. D*reissena bugensis* is apparently absent from western Europe (BIJ DE VAATE *et al*., 2002), but is found in the North American Great Lakes where it was first reported in 1989 (MAY and MARSDEN, 1992).

It has been suggested that *D. bugensis* entered the Volga River Basin from the Bug River system by way of the Volga-Don channel (ORLOVA and SCHERBINA, 2001). Once in the Volga River, it rapidly spread downstream (southward) as carried by currents, and also upstream (northward) as transported by ships. If this species indeed arrived in the Volga basin through the Volga-Don channel, it seems logical that it would also be present in the Don River basin. However, there are no records of *D. bugensis* being found in this basin. ORLOVA and NALEPA (http://www.zin.ru/projects/invasions/gaas/drepol.htm) state that this species is now common in many rivers, reservoirs, and streams of the Black Sea drainage area, but exact locations were not given. Moreover, it has been suggested that *D. bugensis* is not present in the basin at all, but that individuals present are merely morphological variants of *D. polymorpha* (S. ZOZULYA, Hydrochemical Institute, Rostov-on-Don, Russia and A. PUSCHENKO, Rostov State University, Rostov-on-Don, Russia, personal communication). Recent articles on distributions of benthic invertebrates in the lower Don River do not acknowledge the presence of *D. bugensis* (MAKAROV *et al*., 1998).

The purpose of this study was to determine if *D. bugensis* is present in the lower Don River system and, if so, to document its abundance relative to *D. polymorpha*. Distributions were examined relative to total mineral (sum of principal ions) and calcium content of surrounding waters.

2. Materials and Methods

Samples of *Dreissena* were collected in 1999 and 2001–2002 at 15 sites in the main river and in reservoirs of the lower Don River basin, and also in water bodies within the Kuma-Manych Depression (Manych-Gudilo Lake – Manych River system), which is the location of a former water body connecting the ancient Black (Póntos)/Azov Sea and Caspian Sea Basins (Fig. 1). The lower Don River was defined as the river section from the Tsimlyansk Dam to the delta at Taganrog Bay of the Azov Sea. Our collection sites were located near the continuous monitoring stations of the State Service (Network) of Observation and Control of Environmental Pollution (OGSNK/GSN) of the Federal Service of Russia for Hydrometeorology and Environmental Monitoring (Roshydromet) (see: ZHULIDOV *et al*., 2000; 2001). At each site, 90–300 mussels were collected by hand from any accessible substrate along the shore (concrete piles, twigs, macrophytes, etc). Our purpose was to examine relative abundances of the two species over a wide area, so the focus was on collecting representative rather than quantitative samples. After specimens were collected, only large individuals of similar size (15–22 mm) were identified to species. Identifications were based on shell morphology as described by MAY and MARSDEN (1992). Specimens identified as *D. polymorpha* had a well-developed carina *(i.e*., acute angle) between the ventral and dorsal surfaces, while specimens identified as *D. bugensis* did not have a carina. Approximately 62% of *D. bugensis* generally fit the description of the "profunda" form as found in the North American Great Lakes (DERMOTT and MUNAWAR, 1997; CLAXTON *et al*., 1998). However, because of uncertainties in shell morphology, these individuals were not considered separately from the typical form of *D. bugensis*.

In September–October 2002, additional sampling was conducted at two sites to determine density and biomass of the two dreissenid species. One site was located in the Tsimlyansk Reservoir, 50 km upstream from the dam (site 1), and the other site was located in the Manych River, near the village of Vesyoly (site 13) (Fig. 1A). At each site, six replicate samples were collected with an Eckman-type box sampler (area = 0.01 m^2). All individuals were counted and identified as given above. Biomass of each species (wet weight including shell) was determined by weighting the total number of each species after removing excess water.

Values of total mineral and calcium content were obtained from the monitoring program of the OGSNK/GSN. As noted, the data were collected at stations near our sampling sites. Total mineral

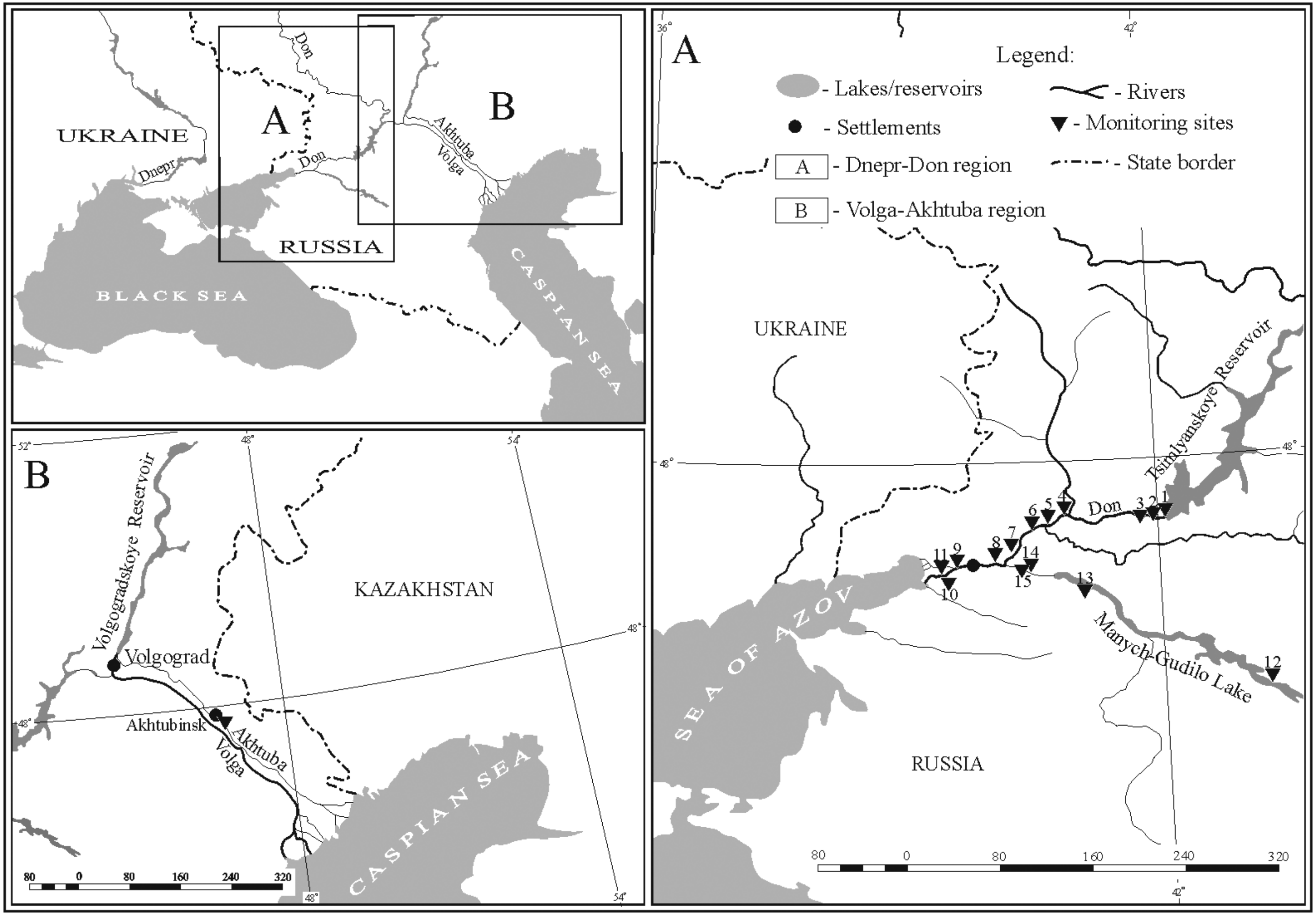

Figure 1. Location of the 15 sampling stations in the lower Don River system (A) and the one previous sampling station in the lower Volga River (B). Scales in (A) and (B) are in kilometers. The Tsimlyansk Dam is located 0.3 km east (upstream) of Site 2 (A). The Village of Vesyoly is located near site 13(A). Rostov-on-Don is located between sites 8 and 9(A).

content was calculated by summing concentrations of all principal ions as determined by standard methods (Semyonov, 1977; Zhulidov *et al.*, 2003), and calcium content was analyzed using titration with EDTA and naphthol green (limit of detection = 0.5 mg/L) (Semyonov, 1977; Zhulidov *et al.*, 2003). Values given at each site represent the mean of annual concentrations over the period between 1995 and 2000. Data for calcium content were not available from some of the stations.

Linear regression and the Pearson product-moment correlation coefficient were used to examine relationships between variables. All proportions were arcsine-transformed before analysis. Probabilities of < 0.05 were considered significant.

3. Results

3.1. Mineral and Calcium Content

Mineral content at the various stations ranged from 450 to 2,360 mg/L ($n = 13$), and calcium content ranged from 45 to 119 mg/L ($n = 10$) (Table 1). There were two obvious spatial trends in these two variables. First, concentrations were higher at stations in the Manych River system compared to stations in the Don River system. Mean values of mineral content were 2,100 mg/L in the former river and 670 mg/L in the latter, and this difference was significant (t-test; $P < 0.001$). Second, total mineral content and calcium content in the Don River decreased with increased distance (upstream) from the river mouth in Taganrog Bay of the Azov Sea (mineral content: $R^2 = 0.96$; $P < 0.001$; calcium content: $R^2 = 0.765$; $P < 0.01$). Although calcium content was measured at only one site in the Manych River system, the concentration at this site was greater than at any site in the Don River (Manych River: 119 mg/L; Don River: 45–78 mg/L) (Table 1). Given this and a strong relationship between mineral and calcium content at all sites (Pearson coefficient = 0.91; $P < 0.001$), it can then be generally assumed that calcium concentrations were also higher in the Manych River than in the Don River.

3.2. Distribution of Dreissenids

Both dreissenid species were found at all stations, but relative abundances varied (Table 1). Among individual sites, *D. bugensis* comprised 4–75% of all dreissenids collected, whereas *D. polymorpha* comprised 25–96%. *Dreissena polymorpha* was significantly more abundant than *D. bugensis* in the Don River system (t-test; $P < 0.001$), whereas *D. bugensis* was significantly more abundant in the Manych River system (t-test; $P < 0.01$). These differences were also apparent when densities and biomass of the two species were determined in the two river systems in 2002. At the site in the Tsimlyansk Reservoir, located in the Don River system, densities of *D. polymorpha* in the six replicates were 6,200–13,600/m^2, and biomass was 3,140–4,161 g/m^2. Densities and biomass of *D. bugensis* were 350–600/m^2 and 332–560 g/m^2, respectively. On the other hand, at the site in the Vesyoly Reservoir, located in the Manych River system, densities of *D. polymorpha* in the six replicates were 3,200–5,300/m^2, and biomass was 1,386–2,166 g/m^2. Densities and biomass of *D. bugensis* were 1,500–4,000 /m^2 and 1,346–3,440 g/m^2, respectively. As might be expected, given significant differences in relative abundances and mineral/calcium content between the two river systems, there was a strong positive relationship between the proportion of *D. bugensis* and total mineral content (Pearson coefficient = 0.73) and calcium content (Pearson coefficient = 0.62) at all stations in the two river systems, but a negative relationship for *D. polymorpha* (total mineral content = –0.86; calcium content = –0.87).

Table 1. Relative abundances of *Dreissena polymorpha* and *D. bugensis* at sites in the lower Don River (Stations 1–11) and in the Manych River system (Stations 12–15) in July 1999, August 2001 and September–October 2002. Values given for total mineral (sum of principal ions) and calcium content (mg/L) are the yearly mean (± SD) for 1995–2000.

Station Designation (see Figure 1. A)	Station Location	Distance from Don River mouth (km)	Sampling Date	Proportion (%) of *Dreissena* species		Mineral (upper) and Calcium (lower) Content
				Dreissena polymorpha	*Dreissena bugensis*	
1	Tsimlyansk reservoir, 50 km upstream from dam	373	October 2002	96	4	no data
2	Tsimlyansk reservoir (0.3 km downstream from dam)	323	July 1999	70	30	$\frac{450 + 80}{45 \pm 7}$
3	Don River, 32 km downstream town of Volgodonsk	291	July 1999	75	25	$\frac{450 + 85}{46 \pm 8}$
4	Don River, downstream Village of Konstantinovsk	207	July 1999	60	40	no data
5	Don River, 6.5 km downstream Village of Semikarakorsk	160	August 2001	65	35	$\frac{590 + 180}{77 \pm 19}$
6	Don River, Village of Razdorskaya	150	July 1999 August 2001	70 70	30 30	$\frac{660 + 130}{76 \pm 13}$
7	Don River, 15 km downstream Village of Bagaevskaya	97	July 1999	60	40	$\frac{710 + 190}{75 \pm 20}$
8	Don River, 1 km upstream Aksay settlement	61	July 1999	55	45	$\frac{800 + 230}{75 \pm 20}$
9	Don River, Village of Koluzaevo	33	July 1999	50	50	$\frac{790 + 230}{73 \pm 19}$
10	River Don delta, B. Kalancha branch, upstream village of Dugino	20	July 1999	50	50	$\frac{760 + 210}{75 \pm 19}$
11	Don River 1 km upstream Azov town	16	July 1999 August 2001	50 60	50 40	$\frac{810 + 240}{78 \pm 21}$
12	Manych River, Proletarskoye reservoir	258	July 1999	35	65	$\frac{2220 + 510}{\text{no data}}$
13	Manych River, Village of Vesyoly	160	July 1999 September 2002	30 50	70 50	$\frac{2360 + 360}{\text{no data}}$
14	Manych River, Ust-Manych reservoir	99	July 1999	25	75	$\frac{1880 + 270}{119 \pm 15}$
15	Manych River, near Manychskaya village	98	July 1999	30	70	$\frac{1780 + 400}{\text{no data}}$

4. Discussion

D. bugensis tends to displace *D. polymorpha* in areas where distributions overlap. For instance, when *D. bugensis* expanded within its native range in the main basins and reservoirs of the lower Dnepr River, Ukraine, it became the dominant dreissenid in about 4–9 years (Kharchenko, 1995; Mills *et al.*, 1996). In some areas within its expanded range in North America, it displaced *D. polymorpha* as the dominant dreissenid within 3 years (Mills *et al.*, 1999). Studies have shown that *D. bugensis* may have a competitive advantage over *D. polymorpha* based on physiological characteristics. *D. bugensis* has a higher assimilation efficiency than *D. polymorpha* so that at low food levels it maintains higher growth and fecundity rates (Baldwin *et al.*, 2002). Also, *D. bugensis* has a lower respiration rate under different seasonal temperature regimes (Stoeckmann, 2003). Lower respiration rates decrease metabolic costs, thereby allowing *D. bugensis* to have greater growth and greater allocations of energy to soft body mass than *D. polymorpha* at similar food conditions (Roe and MacIsaac, 1997). These attributes give *D. bugensis* a strong competitive advantage during periods of low food and high temperatures.

In this study, *D. bugensis* was less abundant than *D. polymorpha* in the lower Don River, which poses the question of whether *D. bugensis* just recently invaded this area and is in the process of displacing *D. polymorpha* as the dominant dreissenid, or whether populations of both species are stable and environmental conditions tend to favor *D. polymorpha*. Unfortunately, extensive data on relative abundances of both species prior to our sampling are lacking. However, some dreissenid specimens collected from a site in the lower Don River (near the city of Rostov-on-Don) in the early 1980s were available for re-examination. Although the sample size was relatively small, in 1982, 11 of 32 individuals were identified as *D. bugensis*. In a sample collected at the same location in 1985, 11 of 21 individuals were identified as *D. bugensis*. These specimens were originally considered to be morphological variants of *D. polymorpha*. Thus, *D. bugensis* apparently invaded the Don River system much earlier than outlined by Orlova *et al.* (1999a, b).[1] Given the nearly 20-year time period between the early 1980s and our sampling in 1999–2002, it would seem that *D. bugensis* should have been more dominant in our samples from the Don River. As noted, *D. bugensis* became the dominant dreissenid in the lower Dnepr River within 4–9 years, and comprised 71% of dreissenids at shallow depths (0–2 m) in some of the reservoirs in this system (Mills *et al.*, 1996). In contrast, at similar depths in the lower Don River, *D. bugensis* comprised 25–34% of all dreissenids in the early to mid-1980s, but increased to only 39% 20 years later. Further studies are needed to better characterize the physical and chemical features that may influence relative abundances of *D. bugensis* and *D. polymorpha* in these two river systems.

Based on allozyme analysis, May and Marsden (1992) hypothesized that environmental tolerances of *D. bugensis* may be more restricted than those of *D. polymorpha* since the former has a narrower genetic base. These analyses, however, were performed on North American populations. Genetic profiles, and hence environmental tolerances, may be quite different from profiles in populations within their native range. In testing thermal tolerances of North American populations of both species, it was found that *D. bugensis* had a lower threshold temperature limit than *D. polymorpha* (Domm *et al.*, 1993). Yet in similar tolerance

[1] Some dreissenid specimens collected from a site in the lower Volga River (near the town of Akhtubinsk – see Fig. 1 B) in July 1981 and September 1983 were also available for re-examination. In a sample collected in July 1981, 1 of 8 individuals was identified as *D. bugensis* and the remainder were *D. polymorpha*. In a sample collected in September 1983, 7 out of 15 individuals were identified as *D. bugensis*, and the remainder were *D. polymorpha*. These specimens were originally considered to be all *D. polymorpha*.

tests with populations from the Dnepr River basin, *D. bugensis* had a higher thermal tolerance limit than *D. polymorpha* (ANTONOV and SHKORBATOV, 1990). One interpretation from our study is that *D. bugensis* prefers waters of higher mineral and calcium content than *D. polymorpha* or, more likely, may tolerate higher levels better. Previous studies have indicated that *D. polymorpha* prefers calcium concentrations within the range of 20–125 mg/L, with an optimum at 70 mg/L (LUDYANSKIY *et al*., 1993). Calcium concentrations in the Manych River system were very close to the upper limit of this preferred range, and may have contributed to the lower relative abundance of *D. polymorpha* found there. Little is known of calcium requirements and tolerance limits of *D. bugensis* relative to *D. polymorpha*, but based on these findings, they may be quite different. Sampling depths and substrates sampled were the same in the two river systems, thus habitat differences was not likely a factor in the relative abundances observed.

5. Acknowledgements

This work was carried out under the Russian Federation Environmental Management Project (North-Caucasus water management and protection sub-component under the World Bank loan to the Government of the Russian Federation) and the Rostov Strategic Plan for Sewerage and Water Supply, financed by the British Department for International Development. Thanks to Dr. YU. DGEBUADZE (A. N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences), partial funding of the research was provided. We gratefully acknowledge the cooperation of Dr. OLEG KLIMENKO, Hydrochemical Institute, Rostov-on-Don, Russia and post-graduate student GENNADIY PODTOPTA, Rostov State University, Rostov-on-Don, Russia.

6. References

ANDRUSOV, N. I., 1890: *Dreissena rostriformis* DESH. in the Bug River. – Proc. Trudy St-Petersburg Society of Nature Researchers. Department of Geology and Mineralogy: 1–2 (in Russian)

ANTONOV, P. I. and G. L. SHKORBATOV, 1990: The ecological-physiological characteristics of *Dreissena* of lower reaches of the Dnepr River. – *In:* The Species in Its Range: Biology, Ecology and Productivity of Aquatic Invertebrates. Minsk, Navuka i tehnika, publ., pp. 135–141 (in Russian).

ANTONOV, P. I., 1993: On invasion of bivalve *Dreissena bugensis* (ANDR.) into the Volga River Reservoirs. Ecological problems of large rivers basins. – Book of abstracts of international conference, Togliatti, 6–10 September, 1993. Publishers of IEVB RAS, Togliatti, Russia: 52–53 (in Russian)

BALDWIN, B. S., M. S. MAYER, J. DAYTON, N. PAU, J. MENDILLA, M. SULLIVAN, A. MOORE, A. MA and E. L. MILLS, 2002: Comparative growth and feeding in zebra and quagga mussels (*Dreissena polymorpha* and *Dreissena bugensis*): implications for North American lakes. – Can. J. Fish. Aquat. Sci. **59**: 680–694.

BIJ DE VAATE, A., K. JAZDZEWSKI, H. A. M. KETELAARS, S. GOLLASCH and G. VAN DER VELDE, 2002: Geographical patterns in range extension of Ponto-Caspian macroinvertebrate species in Europe. – Can. J. Fish. Aquat. Sci. **59**: 1159–1174.

CARLTON, J. T. and J. B. GELLER, 1993: Ecological roulette: the global transport of nonindigenous species marine organisms. – Science **262**: 78–82.

CLAXTON, W. T., A. B. WILSON, G. L. MACKIE and E. G. BOULDING, 1998: A genetic and morphological comparison of shallow- and deep-water populations of the introduced dressenid bivalve *Dreissena bugensis.* – Can. J. Zool. **76**: 1269–1276.

DERMOTT, R. and M. MUNAWAR, 1993: Invasion of Lake Erie offshore sediments by *Dreissena*, and its ecological implications. – Can. J. Fish. Aquat. Sci. **50**: 2298–2304.

DOMM, S. R., W. MCCAULEY and E. KOTT, 1993: Physiological and taxonomic separation of two dreissenid mussels in the Laurentian Great Lakes. – Can. J. Fish. Aquat. Sci. **50**: 2294–2297.

KHARCHENKO, T. A., 1995: *Dreissena*: range, ecology, fouling impacts. – Hydrobiological Journal. **31**: 3–20 (in Russian).

LODGE, D. M., R. A. STEIN, K. M. BROWN, A. P. COVICH, C. BRÖNMARK, J. E. GARVEY and S. P. KLOSIEWSKI, 1998: Predicting impact of freshwater exotic species on native biodiversity: challenges on spatial scaling. – Australian J. Ecol. **23**: 53–67.

LUDYANSKIY, M. L., D. MCDONALD and D. MACNEILL, 1993: Impact of the zebra mussel, a bivalve invader. – Bioscience 533–544.

MARKAROV, E. V., S. P. VOLOVIK, and Y. E. TYUTINA, 1998: The Main Problems of Fisheries and Protection of Waterbodies with Fisheries in the Azov Sea Basin. – Research Institute of the Azov Sea Fisheries Problems, Rostov-on-Don, Russia, 735 pp. (in Russian).

MAY, B. and J. E. MARSDEN, 1992: Genetic identification and implications of another invasive species of dreissenid mussel in the Great Lakes. – Can. J. Fish. Aquat. Sci. **49**: 1501–1506.

MILLS, E. L., G. ROSENBERG, A. P. SPIDLE, M. LUDYANSKIY, Y. PLIGIN and B. MAY, 1996: A review of the biology and ecology of the quagga mussel (*Dreissena bugensis*), a second species of freshwater Dreissenid introduced to North America. – Amer. Zool. **36**: 271–286.

MILLS, E. L., J. R. CHRISMAN, B. BALWIN, R. W. OWENS, R. O'GORMAN, T. HOWELL, E. F. ROSEMAN and M. K. RATHS, 1999: Changes in the dreissenid community in the lower Great Lakes with emphasis on southern Lake Ontario. – J. Great Lakes Res. **25**: 187–197.

ORLOVA, M. I., E. S. ARAKELOVA and A. Y. KOMENDANTOV, 1999a: About co-occurrence of *Dreissena polymorpha* (PALLAS) and *Dreissena bugensis* (ANDR.) in the Volga delta and shallow waters of the Northern Caspian Sea. Volga Nature Reserve Scientific Conference, August 24–28, 1999, Astrakhan. Book of Abstracts, pp 67–69 (in Russian).

ORLOVA, M. I., A. Y. KOMENDANTOV and V. V. KHLEBOVICH, 1999b: *Dreissena bugensis* (ANDR.) in the North Caspian basin records and further invasion perspectives. – 16th Baltic Marine Biology Symposium, June 14–20, 1999, Klaipeda, Lithuania. Book of abstracts. pp. 29–30.

ORLOVA, M. I. and G. H. SCHERBINA, 2001: *Dreissena bugensis* (ANDR.) (Dreissenidae, Bivalvia): range expansion in Europe, invasion history, patterns and future invasion perspectives. – *In:* US-Russia Invasive Species Workshop, Borok, Russia, August 27–31 2001. Book of Abstracts, pp. 150–152 (in Russian).

ROE, S. L. and H. J. MACISAAC, 1997: Deepwater population structure and reproductive state of quagga mussels (*Dreissena bugensis*) in Lake Erie. – Can. J. Fish. Aquat. Sci. **54**: 2428–2433.

SEMYONOV, A. D., 1977: A Guide on Chemical Analysis of Surface Waters. Hidrometeoizdat, Leningrad. 541 pp. (in Russian).

STOECKMANN, A., 2003: Physiological energetics of Lake Erie dreissenid mussels: a basis for the displacement of *Dreissena polymorpha* by *Dreissena bugensis*. – Can. J. Fish. Aquat. Sci. **60**: 126–134.

ZHULIDOV, A. V., V. V. KHLOBYSTOV, R. D. ROBARTS and D. F. PAVLOV, 2000: Critical analysis of water quality monitoring in the Russian Federation and former Soviet Union. – Can. J. Fish. Aquat. Sci. **57**: 1932–1939.

ZHULIDOV, A. V., R. ROBARTS and V. V. KHLOBYSTOV, 2001: The need and requirements for modernizing surface water quality monitoring in the Russian Federation. – Water Internat. **26**: 536–546.

ZHULIDOV, A. V., R. D. ROBARTS, R. M. HOLMES, B. J. PETERSON, J. KÄMÄRI, J. MERILÄINEN and J. V. HEADLEY, 2003: Water Quality Monitoring in the Former Soviet Union and Russian Federation: Assessment of Analytical Methods. – The Finnish Environment, 620, Finnish Environment Institute, Helsinki, 48 p.

ZHURAVEL, P. A., 1951: On *Dreissena bugensis* (Mollusca) from the system of the Dnepr River and about it's recent appearance in Dneprovskoye Reservoir. – Zoological Journal **30**: 186–188 (in Russian)

Manuscript received June 27th, 2003; revised December 12th, 2003; accepted January 5th, 2004.