

Long-term monitoring of Zebra mussel (*Dreissena polymorpha*) invasion in the central Moravia water basins

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Abstract: In the last the dispersal of zebra mussel (*D. polymorpha*) to small man-made water basins is observed. Flooded sandpits and quarries are typically new invaded localities. Continual observation of zebra mussel population size structure is appeared to be an appropriate way of this species monitoring, and it's impact on native communities. In the long-term study we are engaging in comparison of zebra mussel population size structure in three different small water basins in the Olomouc region (Poděbrady and Troubky sandpit, and Výkleky quarry). Population size structure is classified by periodical, yearly sampling of individuals and consequently laboratory analysing – throughout measuring and taking weights of the individuals. Samples are collected by two independent SCUBA divers at the late autumn (after the zebra mussel spawning period). Maximum shell length is measured; individuals are classified to millimetre categories. The population in the Poděbrady sandpit is most extended studied (since 2000), data for the Troubky sandpit and the Výkleky quarry have been recorded for years 2004 and 2006. In the monitored years the population size structure in the Poděbrady shows strong years-dependent fluctuations. That was showed especially in proportion of juveniles (<10 mm), which fluctuates from zero (absence of population reproduction in 2001-2003) up to 63% on population state (2004). In the other basins these fluctuations were not observed, there were differences between localities (Troubky 24% [2004]; 79% [2006]), Výkleky 2% [2004]; 18% [2006]). Moderate differences were in average size of adults (max. 28 mm Poděbrady, 20 mm Troubky, 20 mm Výkleky). There were no significant differences observed in length-weight population structure. Zebra mussels from monitored populations run into 42 mm shell length..

Keywords: Zebra mussel, *Dreissena polymorpha*, population dynamics, population structure, basin, sandpit, quarry, invasion, monitoring, depth, SCUBA

Introduction

The non-controlled spread of the plant and animal invasive species is one of the present day major environmental problems. The zebra mussel *Dreissena polymorpha* (Pallas 1771) is considered as one of the 100 most important invasive species of organisms all over the world. This species mostly shows typical invasive species population dynamics in new invaded localities (Walker 1991). Massive population growth can take place just one year after initial invasion. The zebra mussel run into maximal population densities in water basins mostly after 7-12 years from introduction (Burlakova et al. 2006). Zebra mussel densities in small basins can reach up to 23 000 individuals/ m² (Martel 1995), and often formed dominant component of benthic communities. The zebra mussel is gonochoristic species, breeding is pursued by periodical, synchronized spawning. The breeding potential of the zebra mussel is very high, in dependence on body size, number of oocytes are about 310 000 - 1 610 000 cells per female (Garton 1992, Neumann et al. 1993). Zebra mussels can self-create base for attaching by successive growing of druses, even on places, where exploitable material is limited (e.g. mudded bottom of sandpits). Amount of colonisable space is a one of the main zebra mussel populations limiting factors (Smit et al. 1993, Lauer & Spacie 2004, Burlakova et al. 2006).

Studying of individuals' size distribution in selected localities is frequently used method of zebra mussel monitoring (Uvírová et al. 2005). If the regular spawning and low variability in growth rate between individuals is presented in locality, this method is usable. In ideal case, individuals in age classes are distinguishable by size (Tošenovský et al. 2007). Continual observation of zebra mussel population size structure is appeared to be an appropriate way of this species monitoring and it's impact on native communities. However,

detection of the zebra mussel may be problematic in first years of invasion, because not ordinary, demanding methods of hydrobiologic research (such as SCUBA scouting) must be used.

Materials and methods

The zebra mussel population dynamics is observed by collecting of random samples from populations on three isolated localities: **1)** flooded, old and flat sandpit Poděbrady (near Olomouc); **2)** deep, stratified drink-water reservoir and sandpit near Troubky village, with current mining of sand-gravels, and **3)** deep, flooded stone quarry near Výkleky village. All basins are located in the central Moravia Olomouc region (Czech Republic).

Samplings were done in the Poděbrady sandpit yearly between 2000-2007, and in the Troubky and Výkleky basins in 2004 and 2006. Samples were collected each year at the end of the season (autumn), after the zebra mussel spawning period. Mussel druses were randomly collected by using SCUBA. Two independent divers picked up druses during dive, then samples were cleaned, in laboratory dried up and shells measured. Then shells were classified to millimetres groups and the weight of one shell in each size category was determined. On the basis of individual measuring of the length of all collected individuals, the size structure of the population was evaluated.

Results

In the monitored years, the population size structure of the mussel in the Poděbrady basin shows strong years-dependent fluctuations (Fig. 1). That was showed especially in proportion of juveniles (<10 mm), which fluctuates from zero (absence of population reproduction in 2001-2003) up to 63% on population state in 2004 (Tab. 1). In the other basins these fluctuations were not observed, but differences between localities were observable. Moderate differences were found also in average size of adults (max. 29 mm at Poděbrady, 20 mm at Troubky, 20 mm at Výkleky). In the Výkleky quarry sampling was done in two depths (2 and 7 m). Population size structures from these depths were significantly different in both years - 2004/06 (Kruskal-Wallis $p < 0.0001$; $\alpha = 0.05$) (Fig. 2). Zebra mussels from monitored populations reached 42 mm of the maximum shell length (Tab. 1). If data from monitored years are averaged, differences in percentage of main size groups between localities are obvious (Fig. 3). In the Poděbrady sandpit, the proportion of all size groups is noticeable. Over against, percentage (especially) of the biggest adults (31-42 mm) in the Troubky and Výkleky basin is very low (<1% in the both basins). In the Troubky sandpit, high proportion of juveniles (51%) is also remarkable.

Discussion

The presence of zebra mussels in the Poděbrady basin was first recorded in 1998 (Uvířová et al. 2005), one year after disaster flooding of this locality. So this year (1997) is probably the initiate date of zebra mussel invasion in the Poděbrady sandpit. First studied year (2000) was (at least) third year of this species presence in the locality. It was showed also in high mussels abundance (practically whole usable material on the bottom was covered by druses) and high occurrence (25%) of one year old juveniles (size 1-10 mm) (Tab. 1). This year maximal length about 35 mm also signs, if registered growth rate for this locality (cca. 10 mm per year) is notified (Tošenovský et al. 2008), approximately 3 or 4 years old individuals. Other localities were observed for a shorter time (just years 2004 and 2006), so the generalization is more problematic. Population density fluctuations were not observed in monitored years in the Troubky sandpit and the Výkleky quarry. It seems that maximum lengths of shells are

smaller in these localities than in the Poděbrady sandpit (but trend is slow, stable growing). However, essential aspect of dissimilar growth rate of zebra mussel in various basin types we must notify to (Karatajev et al. 2006, Uvírová et al. 2007). Especially if the growth rate is dependent on many environmental factors (Tošenovský et al. 2008).

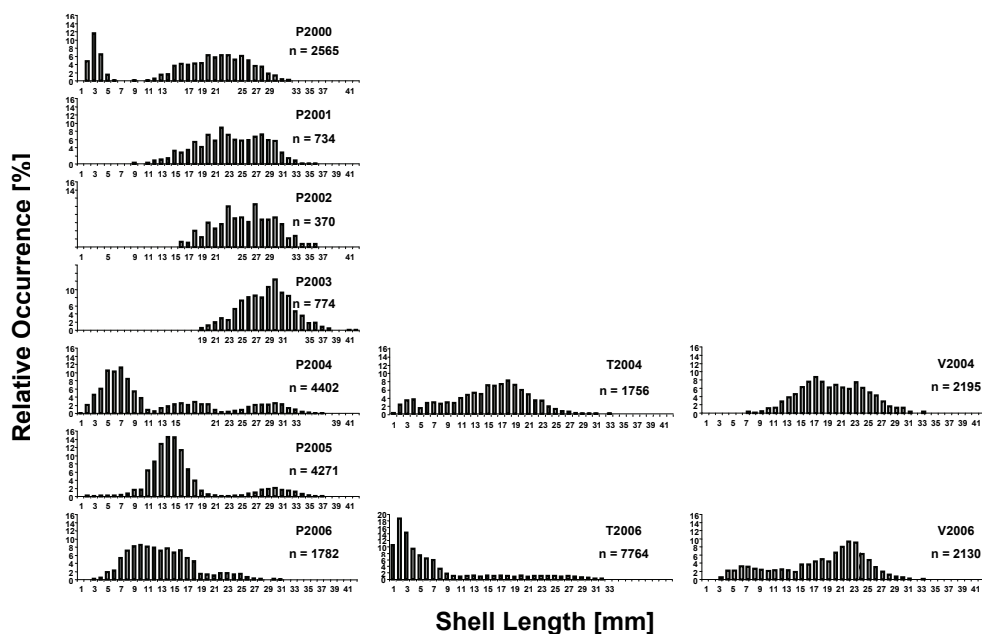


Fig. 1. Population size structures in the selected localities in monitored years [P = Poděbrady; T = Troubky; V = Výkleky]. (The Výkleky population size structures are expressed as an amount of the two sampled depths 2 and 7 m.)

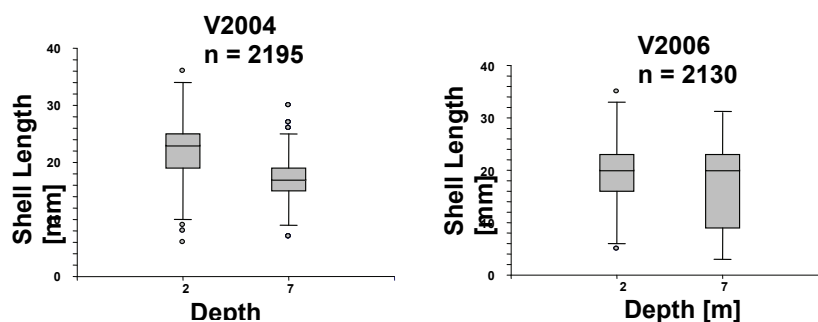


Fig. 2. Depth impact on population size structure in the Výkleky basin.

Tab. 1. Basic characteristics of zebra mussel populations in the studied basins (juveniles 1-10 mm, adults 11-42 mm).

Locality and year	juveniles [%]	average length of adults [mm] / +- SD	max length [mm]
<i>Poděbrady sandpit</i>			
2000	25	22 / 7.3	37
2001	0	23 / 7.7	36
2002	0	26 / 6.2	36
2003	0	29 / 6.8	42
2004	63	22 / 8.3	39
2005	6	17 / 8.8	40
2006	34	16 / 6.1	31
<i>Troubky sandpit</i>			
2004	24	17 / 6.6	36
2006	79	20 / 7.1	35
<i>Výkleky quarry</i>			
2004	2	20 / 7.4	33
2006	18	20 / 7.0	35

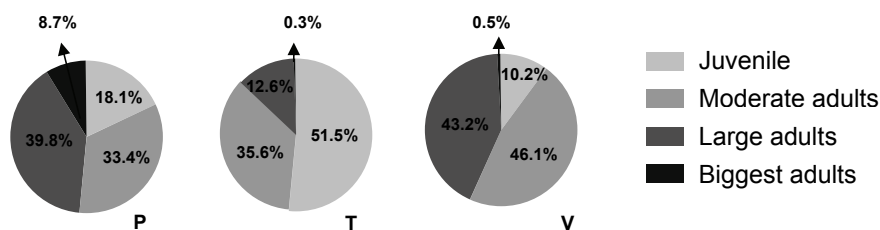


Fig. 3. Average populations size structures in the studied period expressed by percentage of four main size groups (juveniles 1-10 mm, moderate adults 11-20 mm, large adults 21-30 mm, biggest adults 31-42 mm) [P = Poděbrady; T = Troubky; V = Výkleky].

In our study the significant influence of depth on population size structure was found (Fig. 2). Depth impact on growth rate of zebra mussel is well known (Burlakova et al. 2006, Karatayev et al. 2006, Uvírová et al. 2007). In the Výkleky quarry smaller size mussels were found in the deeper parts of basin (Fig. 2).

The maximum shell length for all localities (42 mm at Poděbrady, 36 mm at Troubky, 35 mm at Výkleky) in full corresponded to literature entries (mostly between 30-50 mm) (Karatayev et al. 2006). Year dependent fluctuations in population densities and structure in the Poděbrady basin are typical for invasive species ecology (Lockwood et al. 2007).

Average proportion of age/size groups in the basins shows significant differences between localities (Fig. 3). In the Poděbrady sandpit balanced proportion of all size groups shows established long-presented population in appropriate conditions (but data are averaged, so the year's fluctuations are not visible in that graph). In the Troubky sandpit is the juveniles group strongly dominant (>50%) and percentage of the biggest adults is very low, this fact is typical for "young", growing populations in initial stage of invasion. In the Výkleky quarry proportion of the biggest adults is very low to, but proportion of juveniles (just about 10%) and dominant percentage of medium-sized individuals (11-30 mm) shows on population in

inadequate conditions, rather than on impact of short-presence on this locality. However, for more detailed evaluation and comparison of localities, the next years monitoring will be necessary.

Conclusions

Comparing the three monitored basins, the Výkleky quarry seemed to be less suitable for the zebra mussel populations (low ratio of juveniles = poor reproduction, few of the biggest individuals = slow growth). The most optimal for population development is the old, flooded Poděbrady sandpit. The zebra mussel population dynamics is strongly locality-dependent (sandpits vs. quarry), depth impact on population dynamics is also very strong. It is very important to notify these facts in monitoring and management of this invasive species.

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