OCCURENCE, CONCENTRATION AND SIZE STRUCTURE OF VELIGER ZEBRA MUSSEL LARVAE (*DREISSENA POLYMORPHA PALLAS, 1771*) AT THE MOUTH OF RIVER ODRA

Maria Wolska [1]
Krzysztof Formicki [1]
Kinga-Mazurkiewicz-Zapałowicz [1]

[1] Department of Hydrobiology, Ichthyology and Biotechnology of Reproduction,
The Westpomeranian University of Technology in Szczecin, Poland
kformicki@zut.edu.pl

Abstract

Research was conducted in 2007-2008 on the density and size structure of *Dreissena polymorpha* larvae occurring as meroplankton at the mouth of the Odra. In both years, the highest number of larvae was registered in July. In the first year of research, one clear peak concentration of larvae (1 490.0 per dm^3), at the beginning of this month, was observed. In the second year, the number of larvae was significantly fewer (508.2 per dm^3), and a not so clear peak was registered in late July. Resettling *Dreissena polymorpha* larvae appeared in large numbers in late June, early July and mid August.

Keywords

Odra River, larvae *Dreissena polymorpha*, population dynamics, abundance, size length

INTRODUCTION

Dreissena polymorpha Pall, Eulamellibranchia mussel leads a settled life, and only during the larval stage does it live in the depths of water. Among mussels found within the country, only the zebra mussel has this kind of pelagic larvae. Time of appearance is associated with the breeding period of this species. Dreissena starts breeding in the first half of summer, when water temperatures rise to 12 – 15 ° C; this process continues until late summer. The largest concentration of larvae was registered at 20 – 22 ° C (Borcherding 1991). Viler larval stage lasts, depending on environmental conditions, for two to four weeks. After "plankton" period, veligers settling on the ground are transformed into sedentary mussels. Literature give varying sizes of larvae moving to sedentary stage - the length of the largest veliger larvae, still in plankton stage, measuring 170 to 275 µm (Borcherding and De Ruyter van Steveninck 1992, Lewandowski 1999, Hillbricht -Ilkowska and Stańczykowska 1969), is assumed to be maximum length. Mortality of zebra mussel during larval development can be from 20 to 99%, even at times reaching 100%. Highest mortality occurs during the transition to a sedentary life (Stańczykowska 1977, Sprung 1989).

When *Dreissena polymorpha* occurs in high concentrations, they could constitute one of the important purifying elements of highly fertile waters of over-developed phytoplankton (Wiktor 1969, Stańczykowska 1968, Caraco et al., 1997). The highest recorded concentration in Europe was 114 thousand/m^2, registered in the 60's in the Szczecin Lagoon (Wiktor 1969), belonging to Odra estuary. Such a large population of zebra mussels was able to filter the entire volume of water within 36 days, capturing 53 tons of suspensions per hour. For this reason, research studies on its development are particularly important (Piesik 1992, James et al. 1997, Pace et al., 1998).

In recent decades, there has been a sharp decline in zebra mussel concentrations in many reservoirs, such as in the Szczecin Lagoon (Wolnomiejski and Woźniczka 2008) – in 2007 the German side recorded approximately 3950 specimens per m^2, while the Polish side registered 4700 specimens per m^2. This is due primarily to increase in trophic level and to pollution, and transformation of region where *D. polymorpha* is found (Lewandowski 1999).

The importance of zebra mussel is also associated with the circulation of nutrients, increased food resource for fish, crabs and birds (Caraco et al., 1997, Cleven and Frenzel 1992, Prejs et al. 1990), and their covering of hydraulic equipment, making their operation difficult and sometimes impossible (Szlauer 1974, 1979).

Rotifera, Cladocera and Copepoda have written the most on studies of zooplankton of the river. Meanwhile, in large, lowland and free-flowing rivers, the periodically appearing *Dreissena polymorpha* larvae, often neglected in the designation and counting (Wolska and Mazurkiewicz-Zapałowicz 2006), have a significant share in zooplankton. Given the significance of this mussel, study of changes in its concentration should also cover larval stage, because results of such research could help answer the question as to whether the general deterioration of environmental conditions is the cause of population decline or whether it is due problems with settlement (lack of proper substrate).

MATERIAL AND METHODS

Research material was collected from the left bank of west branch estuary of Odra (Domiąża), at the height of the northern headland of the island of Długi Ostrów (km 755).

Tests on *Dreissena polymorpha* larvae were carried out between 2007 and 2008, from April to November. Zooplankton samples (including *Dreissena* larvae) were collected every two weeks, using a 5-liter sampler. One sample comprised of 10 full loads of this sampler, drawn along the whole cross-section of the river, from different depths. Therefore, a single sample consisted of zooplankton drained from 50 dm^3 of water. The material were thicken in a net with mesh of length 0.044 mm, and then preserved in 4% formalin solution. The concentration of *Dreissena* veligers present in the zooplankton was calculated using standard methods (120 ×; Microscope Nikon Eclipse E200).

The length of larvae was measured in each sample - 50 individuals for high-density samples, all individual for low-density samples. Measurements of larvae were made using Multi Scan v.4.0 CSS program for computer image analysis.

Using multiparameter field meter, HACH and HACH DR890 colorimetric meter measurements of water temperature, pH, dissolved oxygen content, amount of suspension, nitrates and phosphates were carried out. Phytoplankton biomass was estimated by assessing the quantity of chlorophyll "*a*" determined according to Polish Water Quality Standards – measurement of biochemical parameters – Spectrometric determination of concentration of chlorophyll a (ISO 10 260).

Using linear correlation coefficient, the strength of correlation between designated physicochemical parameters and density of *Dreissena* larvae was determined. Correlation significance at $p \leq 0.05$ was also estimated.

RESULTS

Veliger larvae were found in plankton from 8 May (water temperature, 13.1 °C) to 8 October (water temperature, 9.5 ° C). Peak concentrations were recorded in July of each year, but the maximum values in both years varied much (Fig. 1).

In 2007, the maximum density of larvae was recorded on July 4 – temperature 21.5 °C, then some 490.0 larvae per 1 liter of water were registered. Very high concentration had been recorded just two weeks earlier (1107.5 larvae per liter). In late July, the density had drastically dropped to just 114 larvae per liter.

In 2008, the density distribution was different. Generally, larvae population had significantly dropped, while the density over the whole season changed stepwise. There were two peaks of comparable size – in the middle of June (June 19 – 444.9 larvae per liter of water) and at the end of July (July 31 – 508.2) under temperature of around 21.3 °C.

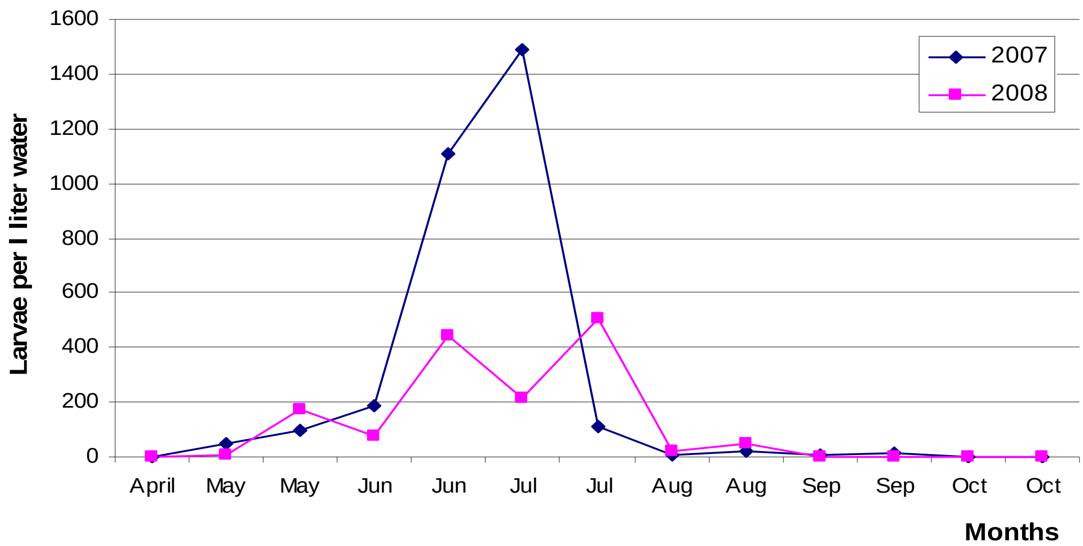

Fig. 1. Seasonal changes in the density of population of *Dreissena* polymorpha larvae in the mouth of the River Odra

The length of larvae found in plankton, in both these years, ranged from 80 µm to 263 µm. In 2007, the largest number of larvae had length in the range 95 to 117 µm, larvae in this range constituted 53% of all larvae (Table 1). The larvae of smallest lengths were only observed in May, early June and late September, but were completely missing during the period of maximum concentration, up to 37% of the larvae were of length not shorter than 170 µm. Such large-size specimens were found only up to early September.

Table 1. Per cent of various length *D. polymorpha* larvae at the mouth of the River Odra in 2007

Larval length [µm]	09.05	19.05	11.06	20.06	04.07	18.07	29.08	12.09	26.09	Mean %
80	45		2				28			8
88	15	4	22				26			7
95	35	8	8	2		14	16	6		10
102	5	14	14	2	8	10	12	50	40	17
110		24	16	6	19		10		30	12
117		22	22	6	26	18	6	8	30	15
124		16	8	10	8	10		8		7
131		10	4	14		10				4
139		2	4	12	2	8				3
146				12		4		22		4
153				2		10				1
161				10		6				1
168				2		2				1
175					8					1
183						2		6		1
190					22					2
197				10	2					1
204				8	1	2	2			1
212				4		2				1
219					4					0
226										0
234										0
241										0
248										0
256										0
263						1				0
Total	100	100	100	100	100	100	100	100	100	

The size distribution of zebra mussel larvae in 2008, was a little different (Table 2). The highest percentage was that of specimens of length 88 – 95 µm (total 43%).

In the periods of maximum occurrence, a large proportion of small-size larvae was noted. Highest percentage of larvae of length >170 µm was recorded in August (21%), in late June (19%) and July (16%). They appeared sporadically after this period.

Table 2. Per cent of various length *D. polymorpha* larvae at the mouth of the River Odra in 2008

Larval length [µm]	08.05	18.05	05.06	19.06	03.07	31.07	16.08	11.09	25.09	08.10	% Mean
80	48	2				4		8	16		8
88	36	26		4		28		6	44	100	24
95	6	38	30	54	2	19	12	6	13		19
102	10	2	26	4	4	10	5	12	10		8
110		18	10	6	38	4	13	8	10		11
117		14	30	2	12		6				6
124					2		6	14	4		3
131				6	4	5	10				3
139				2	2	4	5	8	3		2
146				2	8	2	5	8			3
153			4		8	4	9	10			4
161							6				1
168					8	4	2	8			2
175				2	8		4				1
183				2	2	4	3				1
190				2	2		1	2			1
197				4		4					1
204							4				0
212				6			1				1
219						4	2				1
226						4	3				1
234				2			3				1
241											0
248											0
256				1							0
263	100	100	100	100	100	100	100	100	100	100	100

Correlation coefficients between selected water physicochemical parameters and concentration, showing positive effects of temperature, of suspensions and amount of chlorophyll "*a*" on the population of *Dreissena* larvae in the two years of research, but only if the temperature dependence were statistically significant (Table 3).

Table 3. Correlation coefficient between concentration of Dreissena polymorpha larvae and selected water physicochemical parameters

Abundance larvae	Temp.	pH	O2	suspensions	NO3	PO4	chlorophyll a
2007	0.4869 ●	-0.2366	-0.1163	0.2520	-0.0907	0.0513	0.2213
2008	0.5029 ●	-0.2091	-0.0430	0.3261	-0.1290	0.0487	0.3530

● Significant correlations: $p < 0.05$

In the case of tests on the western branch of Odra, there was sporadic incidence of sedentary *Dreissena polymorpha* mussels.

DISCUSSION

Results obtained from research provided information on the concentration of one of the most important components of Potamoplankton, of which *Dreissena polymorpha* larvae are, as well as on effects of selected environmental factors.

In this study a number of occurrence of meroplankton zebra mussel larvae was found. In both years, the highest concentration was registered in July (up to 1 490.0 per dm^3). Previous studies have shown that *D.polymorpha* larvae constitute the second largest group in the zooplankton concentrations at the mouth of River Odra (Wolska and Mazurkiewicz-Zapałowicz 2006). In the last decade, Rotatoria which constituted, on average, 68% of the overall density, strongly dominated the zooplankton. Second group, in terms of population size, constituted *Dreissena polymorpha* larvae whose share, on average, was 25% (from 2% to 63%). Crustaceans accounted for only 7% (Copepoda - 5%; Cladocera - 2%). Veliger *Dreissena polymorpha* larvae was found in the plankton from May to October. Maximum concentration (from 280.0 to 1532 specimens per dm^3) was recorded in July of each year. Results of our present study indicate a very high similarity of maximum densities and period of their occurrence. This could point to stable conditions that prevailed in the estuary of the Odra during the last ten years.

Studies of population of zebra mussels larvae in one of Odra River canals, conducted in 1973, showed presence of larvae from May to early September, maximum population density of 405 individuals per dm^3 was registered in May, temperature 21 °C. The following year, larvae appeared dring similar period, but were far fewer in number (maximum 38 individual per dm^3) (Szlauer 1974). In our study conducted in 2007, zebra mussel larvae appeared from May to September, and in 2008 from May to October. Over the whole period, there was a marked fluctuation in the density of larvae, only that maximum density was always registered in July. The highest number of larvae was registered in 2007 - up to 1 490.0 per liter. It has to be admitted that this was a very “fertile” year for the larvae. It should not be concluded that this is due to one of the physicochemical parameters considered, although it has been shown that temperature significantly affects the density, identical temperature codnitions were registered in the year that followed, however, the density noted was significantly lower. In 2007, when steep increase in density was registered and the smallest larvae were missing, larvae could have come from the Szczecin Lagoon. While the small peaks in population registered in 2008 may suggest larvae having originated mainly from the local population.

High numbers of larvae population, comparable to numbers that we registered in 2007, are not uncommon in European rivers. In one of the tributaries of the Rhine, in River Neckar, in May 1990, temperature 17 ° C, a maximum of 1852 specimens per dm^3 were registered (Borcherding and De Ruyter van Steveninck, 1992). Record numbers of larvae in River Moselle (a tributary of the Rhine) was over 4 500 per dm^3 (Borcherding and De Ruyter van Steveninck, 1992, by Rech and Kinzelbach 1985). In many rivers noted densities are much lower, for example, in five Irish rivers a maximum of 51 larvae per liter was registered (Lucy et al., 2008). The highest number of larvae registered in the Szczecin Lagoon was up to 760 specimens per dm^3 (Wiktor 1969).

The high fluctuation in the number of *Dreissena* larvae at the mouth of Odra is not an exceptional phenomenon, on the contrary – this phenomenon is common and fairly regular Lewandowski (1982). The reasons for this is believed to be in the sometimes mass extinction of older species, thus reducing the number of growing individuals and subsequently a decline in production of larvae in year that follow (Lewandowski, 1982, for Micheejev 1969). Overwhelming ratio of too small, still incapable of breeding, specimens in the sedentary population (Sprung 1992) may also contribute to fewer number of larvae. It could happen that, quite by accident, in a given reservoir some growing season could proved to be extremely unfavorable for the development of larvae, for example, due to too low water temperature, strong winds moving larvae to unfavorable sedentary grounds or massive development of fish fries that feed, at certain a period of life, on plankton larvae. In 1976, at lake Majcz Wielki, the number of larvae reached 150 per dm^3, but suddenly dropped to just two individuals a year later. A similar situation was observed in Uciński reservoir: in 1957, a maximum of 10 larvae per dm^3 was registered, the following year the number shot to 390 (Lewandowski 1999).

The journey time down in rivers is much shorter than the duration of *Dreissena polymorpha* planktonic life phase. Veligers, while drifting (at 18 – 21 °C), grow some 7.6 μm per day. Hence the reason why larvae in rivers usually come from lakes and reservoirs within the river-lake systems (Borcherding and De Ruyter van Steveninck, 1992, Stoeckel et al., 2004). Larvae appearing at the mouth of River Odra come from the local mussel shoals as well as from nearby Szczecin Lagoon, from where, during strong north winds, along with back current, they get to the river (Szlauer 1974). In this study the presence of sedentary zebra mussel was registered sporadically. In the region covered by our study, they appeared on a bridge’s concrete supports and on *Anodonta* shells as well as stones hidden behind bridge pillars. Sporadic occurrence of sedentary individuals in the open bed of the Odra estuary had already been noted in 1970's (Szlauer 1974). At the same time, very large clusters (10 500 specimens per m^2) were found at the "Police" Chemical Plant pumping station.

The upper limit of size of larvae moving to sedentary life constitutes the length of the largest veligers still in the plankton. Szlauer (1974), in his research studies, observed three batches of larvae settling into sedentary life (postveliger stage) on the barriers. The first batch in the second half of May, the second – the first half of July, third – in September. They highest number of mussels surviving the winter period were from those that settled in September. It should be assumed that they were less exposed to press from predators. The largest drop in mussels population was registered shortly after settling. From our studies, it was shown that at the mouth of Odra River, the highest number of so-called settling larvae were registered from late June to late August. After this period, they were only sporadically registered. Larvae of smallest size, found in samples from mid-September, did not have chance to settle.

Theoretical studies on the significance of mussels filtration in aquatic ecosystems have been applied in a practical assessment of pollution of rivers. In water quality monitoring stations, changes in filtering activity of mussel are the first clear signs of deterioration of their environmental parameters. With respect to saprobic index system, in monitoring of quality of flowing water, Zebra mussel is one of the dominant macro-benthic species found in loaded waters – saprobic index – 2.2. Zebra mussel, like other dominant species, represents the type of ecologically neutral and eurytopic species. It tolerates only small deficits in oxygen, but admits some degree of chemical pollution. So, in the case of rivers heavily loaded with biodegradable material, in addition to standard recording of physicochemical parameters and calculating the density of only certain species of tolerant nature, it justifiable to include basic studies of reproduction, growth and natural mortality of zebra mussel in the monitoring of rivers (Neumann and Jenner 1992, for Friedrich 1990).

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Рецензент доц. Клавдиев А.А.