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Seasonal variability of *Mytilopsis leucophaeata* larvae in the harbour of Antwerp : implications for ecologically and economically sound biofouling control

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Mytilopsis leucophaeata Conrad, 1831, the Brackish Water Mussel, is a mytiliform bivalve (Mollusca, Bivalvia, Veneroida, Dreissenidae), which produces strong byssus to attach to hard substrates. *Mytilopsis leucophaeata* is a typical estuarine species, and thus resistant to a wide range of oligo- to mesohaline conditions (1). The species originates from the southern coast of the U.S. to Tampico, Mexico (2).

In 1835, it was first detected in Europe, in the harbour of Antwerp (3). After a period of apparent absence, *M. leucophaeata* is currently found along the coast of the North Sea from Germany into France and recently in Great Britain (4). Ballast water discharges from ships were identified as a major vector in the transfer of nuisance aquatic species, such as *M. leucophaeata*, from one area of the world to another. The fact that the species was not detected in Belgian waters over more than 50 years does not necessarily indicate the absence of *M. leucophaeata* along the European coast. Because of the morphological resemblance with the closely related *Dreissena polymorpha*, the Zebra Mussel, species-confusion may have arisen. When *M. leucophaeata* became an economic problem in the nineties as an important industrial fouler, attention was brought back to this relatively unknown species.

Any surface exposed to untreated water provides an opportunity for the settlement and subsequent growth of organisms. Because of the high temperature and the constant supply of food and oxygen, cooling water systems are an ideal habitat for *M. leucophaeata*. Given these perfect conditions, settlement occurs readily and growth can be rapid until it causes fouling at the heat exchangers and the tubes in the conduits and finally leads to the failure of the operational systems. This phenomenon is known as biofouling (5). Of all organisms causing fouling in cooling systems, mussels are known to cause the most serious problems (6).

The freshwater Zebra Mussel *D. polymorpha* causes major fouling problems in freshwater lakes and great rivers in the U.S.. Hence, the biology and possible control methods of the species are well examined throughout the years. Brackish water species, on the other hand, are far more resistant to environmental changes, which makes them particularly robust fouling species. The most effective and cheap control measure is the use of chlorination. It was only when the legislation on biocide draining became stricter (VLAREM II, 4.2.4., VLAREM II, annex 2.3.1.), that the magnitude of the biofouling problem by *M. leucophaeata* in the harbour of Antwerp became clear. In the near future, specific research on cooling water draining will be conducted and standard concentrations will be lowered. When the legislation on biocide draining in Belgium will get stricter, the use of merely chlorine will no longer be effective against biofouling. Other, (more expensive) methods have to be searched for to prevent fouling problems, caused by *M. leucophaeata*.

Adult mussels can shut their protective shell valves and stop byssus production to isolate their body from changes in the external environment (7), such as biocide-passage. The planctonic larvae and plantigrades are the most vulnerable life stages, and thus susceptible to the biocides. Hence, knowledge on the cyclic presence of *M. leucophaeata* larvae provides a basis for an ecologically and economically proper use of these detrimental chemicals (8).

The occurrence of D-shaped larvae of *M. leucophaeata* in relation to temperature (°C) and salinity (PSU) was investigated in the cooling system of BASF, Antwerp in the period 2000 – 2003. As such, the recruitment period(s) of *M. leucophaeata* were determined.

Three replicate quantitative plankton samples were taken by sieving 50 l water over a 63 µm mesh sieve. From 4 February 2000 until 20 December 2000, veliger densities were monitored on a weekly basis. From March 2001 on densities were monitored weekly from spring untill late autumn, but in wintertime, in absence of larvae, a biweekly monitoring interval was chosen. Environmental variables were monitored weekly all year long. Plankton samples were preserved in 70% ethanol and veliger abundance was expressed as number larvae per cubic meter.

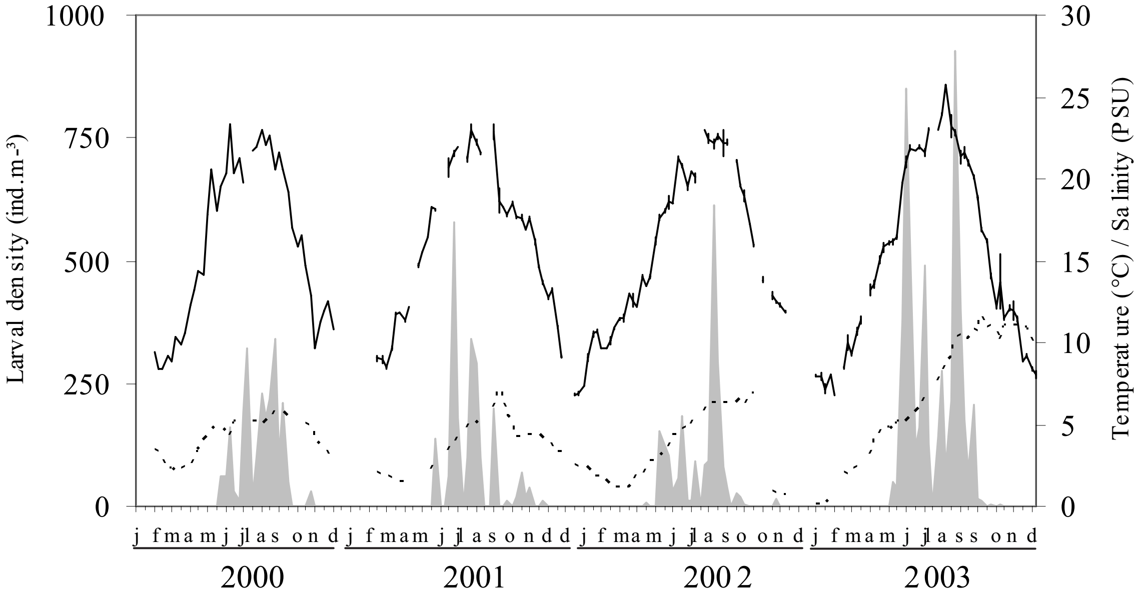

Fig. 1. – Seasonal variation in larval arrival of *M. leucophaeata* in the cooling water system at BASF, Antwerp (full line: temperature (°C), dashed line: salinity (PSU), grey shaded: larval density (ind./m³)).

Results indicated that in all years spawning began end of May – early June and lasted for about five months (Fig. 1). In 2000 larvae first appeared in the plankton at 3 June, in 2001 at 6 June, in 2002 at 21 May and in 2003 at 20 May. Temperature at first detection ranged between 16.2° C and 19.5° C, salinity ranged from 2.6 to 4.9 PSU. Annual and geographic variation in temperature has been identified as the primary factor triggering reproduction of *D. polymorpha* where veligers typically appear in the water at temperatures above 12° C. The intensity and duration of reproduction is believed to be controlled by an interaction of environmental factors (9), such as temperature, food availability and salinity. The variability in environmental factors indicates that for *M. leucophaeata* a threshold condition for spawning, like for *D. polymorpha*, does not seem to exist.

In all years, two or more distinct larval peaks could be observed. In 2000, 2002 and 2003 the highest peak occurred at the end of August-September (2000 : 340 ind./m³ at 7/9 ; 2002 : 613 ind./m³ at 20/8 ; 2003 : 927 ind./m³ at 26/8) at an average temperature of 21.4° C ± S.E. 0.4° C and salinity ranging from 5.1 PSU in 2000 to 10.3 PSU in 2003. In 2001, highest densities (580 ind./m³) were recorded earlier, at 3 July, when the water was 21.6° C and 3.9 PSU. After this peak, two smaller but distinct peaks were detected. The last peak occurred at 4 September and coincides with the highest peaks in the other years. Dreissenidae are sequential spawners, and the duration of larval production in *D. polymorpha* can vary from 6 to 52 weeks (10). The seasonal flexibility in larval production patterns indicates that adults carry ripe gametes for a very long time. After initial spawning, the exposure to ripe eggs and sperm in the water column often triggers gamete release by other ripe mussels, as such creating variability in recruitment.

In 2000, 2002 and 2003 larval densities declined after the highest peak and no veligers were found later then 19 November with average temperature 13 °C ± S.E. 0.4° C. Again, salinities were highly variable, ranging from 0.8 PSU in 2002 to 10.1 PSU in 2003. In 2001 last veliger densities were found on 20 November (13.7° C, 4.2 PSU). For *D. polymorpha,* 12 °C is the minimum temperature allowing gonad maturation and no veligers will appear in the water column at lower temperatures (11). Data show that for *M. leucophaeata*, this threshold temperature for gamete maturation may be 13° C ± S.E. 1° C.

The densities of larvae showed a high year-to-year variability, with moderate values in 2000-2002 (yearly average densities 2169 ind./m³ ± S.E. 78 ind./m³) and high values in 2003 (yearly densities 5273 ind./m³). This could indicate that the adult stock in the dock of BASF, Antwerp is still expanding. But although major differences in densities between months and years were found, the period of larval occurrence was markedly similar. The strict timing of larval presence of *M. leucophaeata* is a first indication that knowledge of the bivalve's life cycle can be an important tool in the combat against biofouling. To prevent new biofouling, a pointed dosage of biocides during the period of larval presence would be as effective as a continuous dosage throughout the year. A pointed dosage will decrease the amount of biocides needed, allowing to (1) meet the VLAREM II criteria on the use of biocides and (2) explore the use of ecologically less harmful, but more expensive biocides.

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