Burrowing saves Lake Erie clams

Freshwater unionid clams in North America have been virtually eliminated from waters that are colonized by zebra mussels. Near total mortality has been reported in western Lake Erie[1–4], but we have now discovered a large population of native clams in a Lake Erie wetland that shows little sign of infestation. Field observations and laboratory experiments show that warm summer water temperatures and soft, silt-clay sediments trigger burrowing by clams. This discourages infestation and physically removes any attached zebra mussels.

Vegetation at Metzger Marsh, a 360-hectare wetland along the shore of western Lake Erie, is being restored to counter the effects of high lake levels and loss of a barrier beach by building of a dike and water-control structure to mimick the protective function of the beach. Surveys of biota before dike construction identified a large population of zebra mussels and five live unionids at the site. However, partial drainage exposed a larger clam population than expected.

We collected and relocated 6,000 unionids of 21 species, a similar diversity to that found in the open waters of Lake Erie before the zebra mussel invasion[4], although most species have never been reported as occurring in wetlands. The size (10–240 mm) and age ranges (1–40 yr) of the population indicate that this wetland habitat has successfully supported clams for many years. In addition, every adult female examined was in reproductive condition. We found most unionids in a soft, silt-clay substrate (average organic content 10% and grain size mostly less than 500 μm), under about 1 m of water. Live unionids were not found in areas with coarse, sand-gravel substrates.

Zebra mussels initially invaded this area around 1990, but less than 1% of the unionids found were encrusted with zebra mussels or showed any sign of previous infestation. This indicates that there might be some type of behavioural mechanism by which clams either remained separate from drifting zebra mussel larvae or were able to remove attached zebra mussels. We found that unionids at Metzger Marsh burrowed 2–40 cm into the sediment for at least part of the day, and hypothesized that the soft, silt-clay sediments encouraged burrowing and so protected the clams from infestation.

To test this idea we placed twenty-five thick-shelled *Amblema plicata* and thin-shelled *Leptodea fragilis* of each of two size classes (shell length less than 60 mm and more than 120 mm) in aquaria that contained either soft sediment or coarse sand-gravel from Metzger Marsh. At ambient temperatures (22 °C), there was no difference in the burrowing behaviour of clams in the two substrates. Small clams of both species burrowed completely within 4 h of being placed in the aquaria and large clams burrowed less than 10 mm. At 27 °C, consistent with normal summer temperatures in Metzger Marsh, large clams of both species burrowed as rapidly and as deeply as small clams in both substrates.

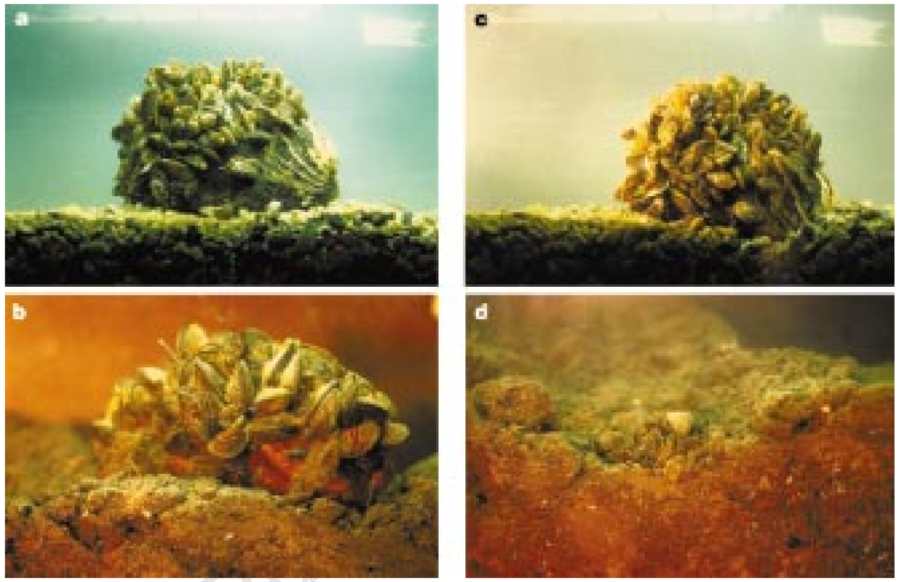

Figure 1 Burrowing of *Amblema* clams encrusted with zebra mussels. **a,b,** Encrusted clams were placed on Metzger Marsh sediments. **c,** After 24 h on coarse sand-gravel, clams burrowed only to the sediment contact with the zebra mussels. **d,** On the soft silt-clay, clams burrowed completely, also burying the zebra mussels.

We tested large *Amblema* specimens (>120 mm) that were encrusted with zebra mussels, collected from Lake Michigan in Green Bay, Wisconsin, under the same conditions in aquaria at 27 °C. The number of zebra mussels on each of 15 animals ranged from 20 to 150. The encrusted clams were unable to burrow successfully in coarse sand-gravel (Fig. 1a, c). The clams burrowed until the first layer of zebra mussels came in contact with the sand but could burrow no further.

The same clams burrowed completely when placed in the soft sediments, carrying zebra mussels under the sediment with them (Fig. 1b, d). Most of the buried zebra mussels died after 24 hours, probably as a result of their inability to tolerate low levels of oxygen[5], as the mortality rate dropped dramatically when the sediments were aerated. The movement of the native clams in and out of the soft sediment also dislodged small clusters of zebra mussels attached to shells.

Native clams seem to have been protected from zebra mussel infestation at Metzger Marsh by the interaction between warm temperatures and soft sediments. Warm water encourages burrowing, but soft sediments are required to allow encrusted clams to burrow. In support of this conclusion, we have since found live unionids or fresh shells at three other Lake Erie wetlands.

These results provide promise that at least some brood stock might be available to recolonize Lake Erie if zebra mussel populations ultimately decline. Wetlands may provide a place for intensive management of native clam stocks, ensuring survival of these animals in the Great Lakes and other regions invaded by zebra mussels[6].

S. Jerrine Nichols
Douglas A. Wilcox
Great Lakes Science Center,
US Geological Survey,
1451 Green Road,
Ann Arbor,
Michigan 48105, USA
e-mail: s_jerrine_nichols@usgs.gov

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