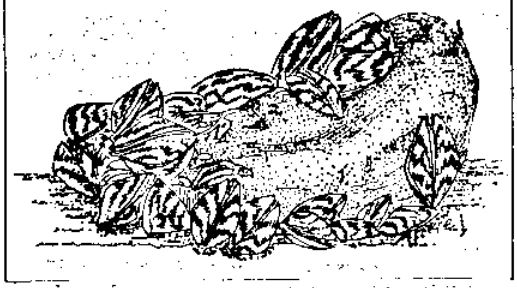
Potential Control of Zebra Mussels Through Reproductive Intervention

A fact sheet produced by Michigan Sea Grant for the Great Lakes Sea Grant Network

Efforts to control zebra mussels have focused primarily on repelling mussels from specific surfaces or killing settled juveniles and adults. However, researchers studying zebra mussel reproduction have unveiled previously unknown facts about zebra mussel physiology which may accelerate the development of other control methods.

Zebra mussels, accidentally introduced into North American waters in the mid 1980s, have spread rapidly to all of the Great Lakes and a growing number of U.S. and Canadian inland lakes and rivers. One reason for the rapid spread of zebra mussels is their enormous reproductive capacity. Recent studies estimate that one female zebra mussel can release at least a million eggs per year.

Researchers are examining mechanisms that regulate zebra mussel spawning and are working on developing species-specific, ecologically safe control methods which target the reproductive cycle of zebra mussels.



Due to the mussels' prolific nature, a possible approach to their control may be to disrupt reproduction. Researchers are examining mechanisms that regulate spawning in this bivalve and are working on developing species-specific, ecologically safe control methods which target the reproductive cycle of zebra mussels.

Cues Regulate Spawning

Bivalves spawn in response to both environmental cues and internal chemical cues. Spawning may be influenced and regulated by water temperature, environmental chemicals (e.g., from phytoplankton), and by chemical pheromones released with sperm and eggs when neighboring animals spawn. These cues ensure that both sperm and eggs are present so that fertilization can occur, and that temperature is appropriate and food is available for larval development.

For example, in western Lake Erie, the zebra mussel spawn peaked in 1989 following a late summer increase in phytoplankton, ensuring adequate food for the developing larvae. However, when the late summer phytoplankton levels were much smaller than usual in 1990, the spawning peak never occurred.

Recent Sea Grant studies have explored the possibility of introducing a chemical into the mussels' environment to override the natural spawning cues and disrupt the natural reproductive process of the mussels. If zebra mussels are artificially activated to spawn when phytoplankton levels are low, there would be little food available for larvae and the offspring would die before settling.

If a chemical applied to mussels in a specific area causes them to spawn, this might trigger a chain reaction between males and females based on pheromones that would spread some distance beyond the initial application site—similar to a row of dominos falling after just one push. Researchers are also investigating a control method to stop spawning entirely.

Chemical Used to Control

The application of chemicals to the waters of the Great Lakes basin to control an exotic species has already proven effective with sea lamprey control. After eight years of testing over 6,000 chemicals, scientists discovered that the chemical TFM controlled sea lamprey populations. When applied to riverine spawning beds, TFM kills sea lamprey during their vulnerable larval stage without harming other fish and with minimal affects on other aquatic organisms.

Recent Sea Grant studies have shown that the chemical serotonin (5-hydroxytryptamine, 5-HT), when externally applied to zebra mussels, overrides the mussels' natural cues and artificially stimulates the reproductive organs of males and females, causing the untimely release of sperm and eggs. However, the degree of

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response to serotonin was affected by water temperature. Animals did not respond to serotonin at 39 degrees Fahrenheit (4 degrees Celsius), however, they did respond at 54, 68, and 81 degrees Fahrenheit (12, 20, and 27 degrees Celsius).

Serotonin is a small molecule made from an amino acid, a building block of proteins. It is found in the brains of most animals, where it is one of hundreds of chemicals that nerve cells use to communicate with each other. It also causes contraction of smooth muscles such as in blood vessels in humans and fish. The role of serotonin in zebra mussel reproduction is the latest in a long list of serotonin functions.

Approximately 13 ounces per quart (387 grams/liter) of serotonin are required to stimulate mussels to spawn. Researchers are investigating other substances which may elicit the same response in mussels at lower concentrations.

Researchers Seek Species-Specific Control

An important question about reproductive control techniques is whether they would have species-specific effects. One problem with field application of serotonin is that it may trigger yet unknown responses in many organisms, including humans. However, a method of adapting serotonin to target zebra mussels may be possible. Research suggests that the receptors that bind serotonin in zebra mussels differ from those found in vertebrates. Therefore, it may be possible to engineer a serotonin-like compound that affects zebra mussels but not fish or people.

Furthermore, other chemicals found within zebra mussels may trigger only zebra mussels to spawn. Using these species-specific chemicals would be an advantage over non-specific toxic chemicals presently used on a limited and restricted basis for zebra mussel control.

As yet, it is unknown whether chemicals that disrupt zebra mussel reproduction would have to be applied throughout an entire lake in order to have an impact on zebra mussels at a particular site. But, to achieve lake-wide control over zebra mussels populations, intervention in reproduction may prove to be a better method than widespread application of molluscicides.

Controlling zebra mussels throughout an entire lake may be particularly important in dealing with their potential impact on fisheries as well as their demonstrated local impacts at water intake sites. Such challenges can only be met by identification and field testing of chemicals that trigger or inhibit zebra mussel spawning.

If you would like additional zebra mussel information contact the Sea Grant program in your state.

Journal Articles

This fact sheet is based on the following journal articles available free-of-charge from:

Michigan Sea Grant Publications
2200 Bonisteel Blvd.
Ann Arbor, MI 48109-2099

The Zebra Mussel (*Dreissena polymorpha*), A New Pest in North America: Reproductive Mechanisms As Possible Targets of Control Strategies, by J. L. Ram, P. Fong, R. P. Croll, S. J. Nichols and D. Wall. Reprinted from *Invertebrate Reproduction and Development*, 22:1-3 (1992) 77-86. MICHU-SG-93-303.

Spawning in the Zebra Mussel (*Dreissena polymorpha*): Activation by Internal or External Application of Serotonin, by J. L. Ram, G.W. Crawford, J. U. Walker, J. J. Mojares, N. Patel, P. Fong, and K. Kyozuka. Reprinted from *J. of Experimental Zoology*, 265:587-598, 1993. MICHU-SG-93-300.

Characterization of Serotonin Receptors in the Regulation of Spawning in the Zebra Mussel *Dreissena polymorpha* (Pallas), by P. Fong, D. Wall, and J. Ram. Reprinted from *J. of Experimental Zoology*, 267:475-482. 1993. MICHU-SG-93-310.

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