Golden Mussel in Brazil: Detection of a dangerous invader

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GOLDEN MUSSELS

Detection of a dangerous intruder

the establishment of invasive organisms
in natural ecosystems is one of the most serious environmental problems today. In Brazil, the case of the golden mussel stands out, a mollusk capable of causing major changes in invaded water systems, in addition to generating economic and social impacts. The implementation of a method that integrates active monitoring of priority areas, high laboratory technology and the sharing of
of information between managers and users of river basins for rapid detection of the presence of this species in Brazilian waters emerges as an efficient option for preventing and combating invasions.

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THE invasion of natural ecosystems by non-native organisms is currently one of the most important causes of biodiversity loss in our planet. The establishment of invasive organisms in a new environment can result in an irreversible change in the structure of their biological communities and lead to the extinction of native species. Episodes of invasion act in conjunction with other components, such as global warming and habitat destruction, thus causing considerable damage to all terrestrial and aquatic ecosystems on the planet.

In a scenario of constant increase in human demands for natural resources,
- the imminent need to preserve our water reserves, given that aquatic ecosystems have suffered major impacts in recent decades.

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in Brazil

Biological invasions by non-native aquatic organisms represent an important factor in environmental transformation, the consequences of which go beyond ecological damage and also include various economic and social impacts. In 2013 alone, in the United States, the losses caused by invasive species were estimated at approximately R$400 billion (US$~130 billion).

A classic example of biological invasion is the introduction of the Nile perch into Lake Victoria in Africa. The entry of this fish, which can reach almost 2 m in length, caused the extinction of more than 200 species of native cichlid fish (small in size) and, consequently, caused the collapse of traditional fishing communities around the lake. In South America, the golden mussel represents a typical example of an invasive species, capable of producing significant changes in the invaded water systems, as well as economic and social impacts.

The golden mussel is a small mollusk measuring approximately 2 cm in length (figure 1). This small invader is responsible for significant environmental impacts, such as the death of native fish and changes in the food chain and water quality. It can cause enormous economic impacts in invaded regions, such as clogging water pumps and pipes, machinery in hydroelectric plants and fish farms, etc. The environmental and economic impacts of this organism occur mainly due to its high reproduction rates and competition for resources. Furthermore, it does not encounter predators, parasites or even environmental changes capable of reducing its population growth in Brazilian waters. Thus, this organism currently represents one of the most serious threats to Brazilian aquatic ecosystems.

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Hitchhiking on ships

First recorded in South America in 1991, the golden mussel is a freshwater bivalve mollusc (which has a shell with two closed parts). Originally, its geographic distribution was limited to Southeast Asia, mainly the Yangtze River in China. In the 1960s, it was first found as an invasive species in Hong Kong and, in 1991, it was found in South America.

This introduction probably occurred through water stored in the bottom of ships to give them stability (called ballast water). This practice is an important route for introducing non-native species worldwide, as a single cargo ship can transport millions of liters of water, which cross states, countries and continents. These waters may contain organisms capable of surviving long-distance and long-duration voyages and which end up invading new environments as the water is released. Currently, a global ballast water monitoring and control program (Globallast) seeks to reduce this form of introducing species into new ecosystems, through management techniques that reduce the survival capacity of these organisms.

Overpopulations of golden mussels (which can reach 200,000 individuals per square meter), combined with the great ability of these organisms to adhere to rigid surfaces of any nature, cause problems with pipe obstructions and increased corrosion of materials. The clogging of pipes in equipment responsible for cooling turbines in a hydroelectric plant, for example, can even lead to the temporary shutdown of the system. These shutdowns cause enormous economic losses, mainly due to the loss of energy that the plant leaves behind.

Figure 1. The golden mussel invasion is currently a of the most serious threats to ecosystems Brazilian aquatics

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of generating and the cost of the worker used to remove and dispose of these organisms.

The high population density of mussels also rapidly changes the presence and abundance of several species of native organisms. With the reduced availability of prey, some fish feed on the mussels, but many of them are unable to digest the shells and die. In addition, the golden mussel has the highest filtration rate (which represents the demand for food) among invasive bivalves, which also includes the zebra mussel, one of the most impactful in North America and Europe. Considering the population contingents, the invasion by the golden mussel
- dourado requires a large volume of plankton for its food, which impacts the entire food chain in the region and can significantly reduce populations of fish and other organisms in the ecosystem that depend mainly on plankton as a food source.

population control

Various strategies have been studied and made available by the private sector for population control of this invader. Among them, the use of ultraviolet light, electromagnetic induction, chlorine dioxide, ozone, sodium hypochlorite and various cytotoxic compounds stand out. Although these combat mechanisms are available on the Brazilian market, all of them still lack regulation by environmental agencies, since they cause significant impacts to the environment (they act unrestrictedly on any aquatic organisms), have high implementation costs and are limited to the industrial area. None of these techniques can be used in open environments and, therefore, they do not represent a solution to the problems arising from the invasion of these organisms.

Strategies for the prevention and rapid detection of invasive organisms have received special attention, as they have demonstrated greater effective potential in mitigating the economic and, mainly, environmental impacts of this phenomenon. Rapid detection

The arrival of an invader is essential, as it allows the environmental manager to control populations while they are still small enough to be eradicated, thus minimizing the chances of a successful invasion. In addition, rapid detection allows the establishment of sanitary barriers to prevent the invasion of new environments.

Rapid detection efforts for golden mussels face two major obstacles. The first is that, due to the organism's great invasive potential, several areas must be monitored, which increases the costs of the activity and, consequently, reduces the capacity for execution. The second obstacle is the difficulty of detecting larvae in low population densities.

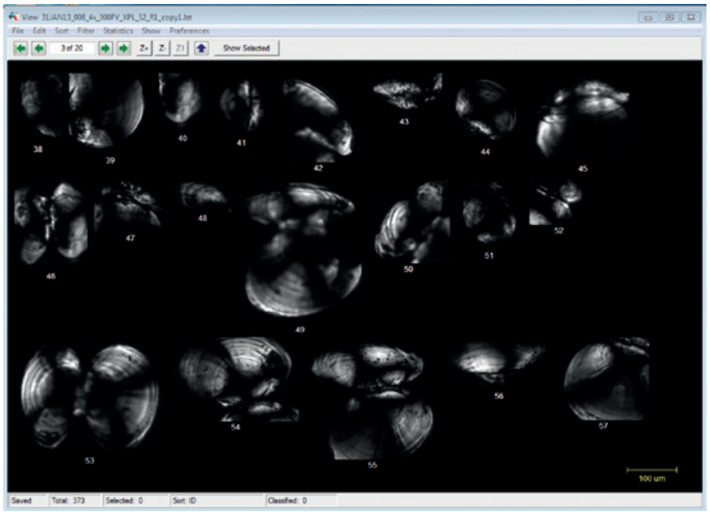

Figure 2. One of the techniques used to identify golden mussel invasion is based on a light phenomenon (called birefringence) that makes it possible to visualize the mollusk larvae, as they stand out against the black background when observed by a special device.

tional in the large volumes of water that make up Brazilian reservoirs, rivers and lakes.

Early detection

In order to overcome these obstacles, research groups have sought to develop an integrated system to quickly detect the presence of invasive species and allow a rapid response in taking containment and control measures by entities interested in the management of rivers, basins and other invaded regions. The Rapid Detection and Immediate Response Program (DRRI), developed by the Center for Bioengineering of Invasive Species in Hydroelectric Power Plants (CBEIH), was based on the early detection program of *Bureau of Reclamation,* US federal government institute responsible for combating invasive species in the US.

The DRRI proposes a set of protocols that begins with an active monitoring network in priority areas indicated by environmental modeling, with water collections in strategic stretches. This modeling is done by computational mathematical models that cross-reference environmental information with biological and ecological information about the organism, indicating areas with a higher probability of invasion. Field teams are sent to these locations to inspect and collect water and sediment for chemical and biological analysis using boats and equipment. In the laboratory, different techniques are used to detect and quantify larvae – commonly found at the beginning of the invasion – in places with low population density. The method combines stereomicroscopy with polarized light, automated visual analysis of fluids and molecular biology techniques, which allows for reliable results with relative accuracy.

tion to the presence and distribution of an invasive aquatic organism.

The identification of larvae by polarized light is based on a phenomenon caused by light (called birefringence) due to the shape of the shell of mollusks (or the carapace present in their larvae) and which makes it possible to visualize the organisms. The larvae stand out against the black background when observed through a type of magnifying glass called a stereomicroscope (figure 2). The use of this technique represented an advance in routine analyses for the detection and counting of mollusk larvae and is particularly helpful when there are samples with a lot of suspended material, as it greatly increases the visualization of the larva among other materials.

For greater accuracy in detecting larvae of invasive mollusks, such as golden mussels and zebra mussels, automated analysis of the particles present in the water is performed. This technique uses equipment consisting of a microscope coupled to a computer with a program that identifies images and a suction pump that establishes a flow. The flow displaces the liquid to be analyzed and allows the equipment to automatically explore the entire sample in search of particles of interest.

– in this case, golden mussel larvae.

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Figure 3. The Rapid Detection and Immediate Response Program (DRRI) is part of the active monitoring of priority areas, high laboratory technology and sharing of information between managers and users of river basins

The method also includes the polymerase chain reaction (PCR) technique, in which small DNA sequences are used that bind only to the DNA of the golden mussel present in the sample. After cycles of temperature variation and the action of an enzyme that copies the DNA, the genetic material of the mussel is amplified. Once the amplification is complete, the DNA of the golden mussel can be visualized and sequenced. The DNA sequence obtained is compared with others previously deposited in an international database. *online* to confirm whether it really belongs to the golden mussel, which allows an invasion event to be confirmed, even if the presence of the adult mussel is not yet noticeable at the water collection site.

Finally, the results are integrated into a system *online* information system, with visualization modules that indicate the locations where invasions have been identified. In the event of detection in new areas, alert protocols are activated and the inspection bodies, companies that use raw water from the identified locations, vadidos and the river basin managers are notified to take immediate action (figure 3).

By using an integrated information system, the DRRI provides the State, companies and all users of watersheds with an efficient model for preventing and combating the golden mussel and can serve as a basis for controlling other invasive species. These actions allow for efficient monitoring of priority areas for conservation and strategic locations for supply and energy generation, ensuring effective mitigation of the impacts of the golden mussel. CH

Suggested reading

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ON THE INTERNET

Page of the Center for Bioengineering of Invasive Species of Hydroelectric Power Plants (CBEIh): www.cbeih.org